# HARNESSING EMERGING TECHNOLOGIES FOR A RESILIENT AND SUSTAINABLE CONSTRUCTION INDUSTRY

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## SUMMARY

The construction industry is increasingly shaped by emerging technologies such as Artificial Intelligence (AI), 3D printing, and digital tools, with growing implications for project efficiency, cost management, and sustainability. This paper examines how these innovations contribute to resilient and sustainable infrastructure delivery, with a particular focus on the African context characterised by economic volatility, skills shortages, and regulatory constraints. A qualitative approach is adopted, drawing on global case studies, professional practice, and industry experience. The study reviews applications of AI in planning, safety, and cost prediction, evaluates early examples of 3D-printed construction, and examines sustainability strategies rooted in traditional and local building practices. Findings indicate that AI enhances productivity through automation and data-driven decision-making while complementing professional expertise. Although 3D printing remains limited in Africa, it shows potential for affordable mass housing, as demonstrated by pilot projects in Malawi. Sustainability is presented as a holistic concept encompassing environmental, social, and economic dimensions, supported by indigenous methods such as natural ventilation, local materials, and adaptive reuse. The paper concludes that emerging technologies can reposition the construction industry as a driver of sustainable and resilient development in Africa, provided innovation is aligned with enabling regulations, targeted training, and supportive Public-Private Partnerships (PPPs).

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## 1. INTRODUCTION

Technology has been used to advance human activities for many years. The progress in technology has also been applied across different industries to maximise their benefits. In the construction industry (CI), the use of technology to improve construction operations has gained prominence, especially due to recent epidemics and pandemics the world has faced, ranging from Ebola to Covid-19 and, most recently, Monkeypox.

However, despite the CI being one of the oldest industries, it is still considered one of the most conservative in the world, where the adoption of technology is still at a low ebb. The approaches, techniques, and tools applied for its operations are often traditional. New methods and technologies are often not embraced as rapidly as in other industries. Technological advancement and the adoption of digital tools applied for the enhancement of construction operations and processes are often neglected.

Digitalisation of the CI is therefore slow and not as popular as it should be, especially in Africa, despite its adoption in other countries of the world such as Singapore, Malaysia, United Arab Emirates, United Kingdom, China, and Canada. The popularisation of digitalisation in manufacturing, information technology, financial services, entertainment, and the media has also not been reflected in the CI. Africa is therefore not benefiting from the opportunities the digital world brings to the CI despite being the second biggest continent in the world, with an area covering about 30.3 million km² and a population of about 1.216 billion (Wikipedia, no date).

Most African countries are considered developing compared to countries of other continents, especially in Europe and Asia. Europe, for instance, is described as the most developed continent in the world (Shvili, 2021), with all the countries within Europe classified as developed, while most African countries are classified as least developed countries (LDC) (Pariona, 2019).

Furthermore, within Africa, some countries are considered more developed than others, with Mauritius, Seychelles, Algeria, Tunisia, Botswana, Libya, South Africa, Egypt, Gabon, and Morocco listed as the top ten most developed countries in Africa (World Population Review, 2022). However, Nigeria, despite having a population of about 216 million (Worldometer, no date) and ranked the second-largest economy in Africa with a GDP of $1.14 trillion (Egscholars, 2022), is still a developing country alongside others, including Ghana, Benin, Cameroon, Togo, Kenya, Uganda, Rwanda, and Tanzania (Worlddata, no date).

Several definitions have been given to “digitalisation”. Gartner (2022) defined digitalisation as “the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business”. It is the process of changing data into a digital form that can be easily read and processed by a computer (Oxford Learner’s Dictionary). Similarly, Veldhuizen et al. (2019) defined digital construction (DC) as “utilising digital technologies to construct more efficiently with higher quality”.

Digitalisation in the CI can therefore be described as the application of digital tools to enhance construction processes and operations. Regardless of the definition provided, it facilitates the construction process, making it easier, faster, safer, more sustainable, and more efficient. This offers a lot of opportunities for the future of youth in Africa whose interest lies in the use of digital technologies. The United Nations asserts that “Africa has the youngest population in the world, with 70% of sub-Saharan Africa under the age of 30. Such a high number of young people is an opportunity for the continent’s growth – but only if these new generations are fully empowered to realise their best potential” (no date). The African youth, with their high numbers, are an advantage to the CI if they have the right training to explore the opportunities that DC brings.

## 2. TRENDS IN DIGITALISATION

### 2.1 Artificial Intelligence (AI)

Artificial Intelligence (AI) is defined as “the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings” (Copeland, no date). In other words, AI enables machines to think like humans. According to Great Learning Team (2022), AI is the simulation of natural intelligence in machines programmed to learn and imitate human actions. AI applications in construction are vast, tackling safety issues, labour shortages, cost and time overruns, design optimisation, risk mitigation, project planning, productivity improvements, and post-construction management (Rao, 2022).

### 2.2 Virtual Reality (VR)

Virtual Reality (VR) utilises wearable devices, typically worn on the eyes, to access a virtual world that appears real to the wearer (University of Toronto, 2021). It is increasingly popular in Africa, but primarily for recreational purposes. VR in construction offers immersive project visualisation, training, safety management, and early-stage design adjustments (Brooks, 2022).

### 2.3 Drones

Originally used in warfare, drones now provide aerial photographs and videos of construction projects, assisting in monitoring, hazard detection, cost and time savings, and remote site access (Imperial War Museum, 2022; Wingtra, no date).

### 2.4 3D Printing

Also known as additive manufacturing (AM), 3D printing allows sequential layering of materials to create 3D shapes (Designing Buildings, 2022). In construction, 3D printing reduces time, waste, and costs, as demonstrated by projects in Shanghai ($5,000 houses) and Malawi ($10,000 homes completed in 12 hours) (Ennomotive, 2021; Fleming, 2021). Africa faces debate over 3D printing's suitability due to abundant labour and unemployment.

### 2.5 Robotics

Robots support inspection of sewers, tunnels, high structures, and material handling, improving safety, efficiency, and sustainability (ABB, 2021; METI, 2019). Humanoid robots like HRP-5P demonstrate potential for hazardous tasks and labour shortages.

### 2.6 Smart Buildings

Smart buildings optimise energy, comfort, and operational efficiency (Zhou & Yang, 2018). Africa has minimal smart buildings, limited to security systems, fire detection, and energy monitoring.

### 2.7 Smart Cities

Smart cities integrate technology to manage traffic, waste, crime, and environmental issues. Lagos, Nigeria, deployed limited smart solutions, but opportunities remain for broader application.

### 2.8 Digital Twins

Digital twins simulate real-world structures for lifecycle management, decision-making, and urban planning, improving cost estimation, schedules, and performance prediction (IBM, no date; Africa Surveyors News, 2022).

### 2.9 Metaverse

The metaverse is a virtual world enabling interaction and real estate opportunities. Companies like Gucci are already investing in digital land, representing new paradigms for construction stakeholders (Lee, 2022; Finn, 2022).

## 3. FACTORS AFFECTING DIGITALISATION IN AFRICA

- **Lack of awareness:** Limited understanding beyond basic devices.
- **Poor power supply:** Inconsistent electricity undermines digital operations (Adegoke, 2018).
- **Limited digital training:** Few affordable and accessible facilities; dependence on foreign expertise (The African Courier, 2021).
- **High infrastructure cost:** Equipment is imported, consuming scarce foreign exchange (Lotzof, 2020).

- **Limited research:** Most research confined to South Africa; other countries lag in empirical evidence for benefits (UNCTAD, 2017).

## 4. CONSEQUENCES OF DIGITALISATION

Digitalisation raises concerns over job displacement, cybersecurity risks, and ethical challenges. However, evidence suggests that more jobs may be created through new digital roles, innovation, and productivity expansion.

## 5. RELATIONSHIP BETWEEN DIGITALISATION AND SUSTAINABILITY

Digitalisation supports sustainability through reduced material waste, lower emissions, improved safety, and efficient resource use. Smart technologies enhance environmental, social, and economic balance.

## 6. CONCLUSION

Emerging technologies present a strategic opportunity to reposition Africa's construction industry for resilient and sustainable development. This requires addressing power, training, research, and regulatory gaps.

## 7. RECOMMENDATIONS

Governments and stakeholders in the construction industry should ensure a stable power supply, strengthen digital regulations, expand professional training, support research, and promote Public-Private Partnerships (PPPs) to accelerate digital transformation.

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## BIOGRAPHICAL NOTES

Babatunji Adegoke is a construction and infrastructure professional with over 15 years' experience in project delivery and management across civil engineering, real estate, and infrastructure developments. He holds a Bachelor's degree in Civil Engineering and a Master's degree in Construction Management from the University of Lagos, Nigeria, and has managed multi-million-dollar projects for public and private sector clients.

He is a Chartered Surveyor (MRICS) and a corporate member of the Nigerian Institute of Quantity Surveyors (MNIQS), Nigerian Society of Engineers (MNSE), and Nigerian Institution of Civil Engineers (MNICE). He is also a Project Management Professional (PMP), a Registered Engineer and Quantity Surveyor in Nigeria, an Accredited Engineering Valuer, and an Associate of the Public–Private Partnership Association of Nigeria.

Babatunji is a FIG mentor for Africa and an RICS APC Assessor and Counsellor. He is a regular speaker at international and regional conferences and has published widely on digital construction, AI and sustainability, public–private partnerships, and infrastructure development in Africa. His work reflects a strong commitment to professional standards, capacity building, and the delivery of resilient and sustainable built environments.

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