

Assessment of the Enablers and Strategies that Promote Effective Integration of Digital Technologies (DTS) for Sustainable Housing Practices in UK.

Kenneth Chidebere Ezebuilo

University of Salford, Manchester, United Kingdom

Abstract: This research work investigates the enablers and strategies that promote effective integration of digital technologies (DTs) for sustainable housing in the UK. It engages qualitative research techniques in investigating the application of DTs for promoting sustainable housing practices in the UK, with a view to highlighting the key DTs driving sustainable housing initiatives in UK. The study adopted Thematic Analysis assumptions in its data analysis. The method of data collection were through semi-structured interviews as primary sources. Other information were drawn from extensive literature reviews of journals, textbooks, printed publications, internet sources and write-ups relevant to the study, from secondary sources. The result from the data analysis shows that there are various DTs that aid sustainable housing practices. To acknowledge the roles these DTs play in promoting sustainable housing practices in the building industry, the knowledge of their application and in-depth understanding on their use is critical. The researcher concluded that the integration of digital technologies (DTs) for promoting sustainable housing practices in the UK hinges on identifying and leveraging key enablers such as robust policy frameworks, industry collaboration, and ongoing innovation in technology. Effective strategies encompass the adoption of smart building systems, the use of data analytics for optimizing resource efficiency, and fostering a culture of sustainability through education and stakeholder engagement. These elements collectively drive the transition towards more sustainable housing, ensuring long-term environmental and economic benefits. One of the recommendations was that focus should be made on developing comprehensive training programs for stakeholders, including architects, builders, and policymakers, to ensure they are well-versed in digital technologies (DTs) and their applications in sustainable housing. This will facilitate better integration and utilization of these technologies.

Keywords: Enablers, Strategies, Effective Integration, Digital Technologies, Sustainable Housing Practices and UK.

INTRODUCTION

Sustainable housing encompasses various dimensions, such as functional, economic, social, cultural, environmental, and ecological. It must meet the criteria of economic viability, social acceptability, technical feasibility, and environmental compatibility (Choguill, 2007). Also, Guertler and Smith (2006) include construction quality, affordability, psychological impacts, and eco-efficiency as factors to be considered under sustainable housing. Moreover, the UN-HABITAT (2012) establishes a multifaceted description, characterizing sustainable housing as homes that are healthy, durable, safe, affordable, and environmentally friendly. These homes should be resilient to natural disasters, equipped with efficient energy and water systems, and

integrated into their communities while enhancing social, cultural, and economic aspects. The working definition of sustainable housing in this work is taken to include homes that offer decency, security, privacy, healthiness, should be able to meet the criteria of affordability, legal tenure, habitability, accessibility, and proper integration with services and infrastructure. To achieve these objectives and incentivize improvements on energy efficiency within the building sector, the Code for Sustainable Homes (CSH) was introduced in 2007 by the UK government (Department for Communities and Local Government (DCLG), 2013a). However, very few homes meet these standards, particularly within the private sector (DCLG, 2013b). The failure of house builders to deliver zero carbon homes in anticipation of the 2016 Regulations, underscores the challenges and gaps in the current approach to sustainable housing development in UK. Thus, there is urgent need for transformative action within the construction sector to align with sustainability goals and mitigate their detrimental effects on the environment.

Digital technologies (DTs), encompassing electronic instruments, systems, devices, and resources for data creation, storage, or processing, have gained recognition from scholars as essential tools for enhancing sustainable housing practices. Identified DTs for promoting sustainability in housing, include smart home solutions, Building Information Modelling (BIM), Internet of Things (IoT), Big Data (BD), among others (Al-Emran&Griffy-Brown, 2023; Rane, 2023). These technologies offer various benefits, such as optimizing energy consumption, minimizing waste, facilitating collaboration in design and construction, collecting real-time data for analysis, and providing accountability in sustainable housing data. However, it is also essential to note their negative effects, as shown in Al-Emran and Griffy-Brown (2023). Therefore, gaining a comprehensive understanding of how these technologies could be effectively used by individuals and organizations is crucial for achieving improved sustainable housing practices.

STATEMENT OF PROBLEM

The integration of digital technologies (DTs) in promoting sustainable housing practices in the UK faces several challenges that hinder its effective implementation. Despite the potential of DTs to enhance efficiency, reduce environmental impact, and improve the overall sustainability of housing projects, there is a lack of clear enablers and strategic frameworks guiding their adoption. The absence of standardized approaches, combined with insufficient stakeholder awareness and engagement, creates barriers to leveraging DTs for sustainable housing. This article aims to identify and analyze the key enablers and develop robust strategies to facilitate the effective integration of DTs,

OBJECTIVE OF THE STUDY

1. Determine the enablers and strategies for effective integration of DTs for promoting sustainable housing practices in UK.

RESEARCH QUESTION

1. What are the enablers and strategies for effective integration of DTs for promoting sustainable housing practices in UK?

CONCEPTUAL REVIEW

Sustainable housing aims to reduce energy and water use, employ ecologically friendly building materials, and incorporate renewable energy sources like solar panels (Department of Communities and Local Government (DCLG), 2006; Almusaed&Almssad, 2022). Choguill (2007) asserts that for a housing to be considered sustainable, it has to be affordable, socially acceptable, technically practicable, and environmentally suitable. Almusaed (2004) emphasizes the use of environmentally friendly materials, recycling systems, and clean energy in sustainable housing. Sustainable housing ideology can be traced back to the 1987 Brundtland's report and 1992 Rio Earth's definition of sustainable development, which is meeting the needs of the

present generation without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987).

DTs, which are electronic instruments, systems, devices, and resources that create, store, or process data have been identified by many scholars as vital means of improving sustainable housing. Some of these DTs identified include among others, smart home solutions, BIM, IoT, and BD (Al-Emran&Griffy-Brown, 2023; Rane, 2023). They assert that smart technologies optimise energy consumption and minimise waste, BIM allows collaboration in design and construction, IoT devices collect real-time data for analysis, while BD provides insight from sustainable housing data through analysis. Though this study supports their ideas, it agrees with Al-Emran and Griffy-Brown's (2023) claim that modern DTs have both positive and negative effects on sustainability. As a result, getting a full understanding of how these technologies could be used by individuals and organisations is critical for achieving improved sustainability outcomes.

From the above considerations, it is gathered that evaluating the use of DTs for promoting sustainable housing initiatives in the UK is critical because, it will help in determining the actual effect of DTs on sustainability metrics such as energy consumption, carbon emissions, and resource efficiency. Its evaluation will help identify technical, economic, environmental, and social hurdles to the successful implementation of DTs for sustainable housing projects in UK. Understanding these difficulties will enable policymakers and industry stakeholders in the UK to devise strategies and incentives to address them.

Enablers and Strategies for Effective Integration of DTs for Promoting Sustainable Housing Practices

Enablers, in the context of gaining effective integration of DTs for promoting sustainable housing practices, provide legal power or enabling resolution to achieving a successful integration strategy for promoting sustainable housing practices through DTs. Also, it investigates the roles of government policies, industry collaboration, research and development initiatives, capacity building programmes, public awareness campaigns, regulatory frameworks, incentives, and monitoring mechanisms to provide insight into the key components of a successful integration strategy for promoting sustainable housing practices through DTs in UK and across the globe. Hart, Adams, Giesekam, Tingley and Pomponi's (2019) classification of circular economy enablers in the built environment concept was employed to conduct an in-depth examination and understanding of the enablers driving the use of these DTs to promote sustainable housing practices. The classification includes cultural, regulatory, financial, and sectoral enablers, which are discussed below:

- **Cultural Enablers:** Cultural enablers encompass leadership, environmental culture, teamwork, and a system thinking approach, all of which contribute significantly to the use of DTs for promoting sustainable housing practices (Hart et al., 2019). Hart et al. (2019) study holds that strong leadership at all levels enables for supportive policies, resource allocation, and the establishment of goals to prioritise sustainability in housing projects, which is critical for promoting the adoption of DTs for sustainable housing practices. It is gathered from their study that organisations that promote an environmental culture based on leadership, resource efficiency, and innovation are more likely to adopt DTs for sustainable housing. The collaboration among stakeholders, such as architects, engineers, developers, policymakers, and community members, is critical for the successful application of DTs for sustainable housing. Besides, effective teamwork makes it easier to share knowledge, co-create solutions, and align interests around common sustainability goals. However, a systems thinking approach takes into account the interconnection of many components in the housing environment. It focuses on comprehensive solutions that address the social, environmental, and economic dimensions of sustainability. By adopting a system thinking mentality, stakeholders can gain a deeper understanding of the intricacies of sustainable housing and use DTs to optimise overall system performance. In this regard, cultural enablers foster a

climate that encourages innovation, collaboration, and continuous improvement in the quest of sustainable housing solutions worldwide, especially in UK.

- **Regulatory Enablers:** Regulatory enablers are tagged by scholars like Haines and Mitchell (2014) as crucial driver of DT implementation for enhancing global sustainability. Hart et al. (2019) defines regulatory enablers as policy support, regulatory reform and incentives that support skills development and innovation, the establishment of metrics for measuring sustainability and embodied the removal of obstructive regulations, and tax breaks on refurbishment projects and other fiscal incentives. In general, these regulatory enablers establish the required structure and incentives to encourage the incorporation of DTs into sustainable housing practices. Through aligning regulatory policies with environmental objectives, governments can create an environment conducive to innovation and collaboration in the building industry, eventually accelerating the transition to more sustainable housing options in UK and globally.
- **Financial Enablers:** Financial enablers (FEs) are part of the circular economy enablers in the built environment used to access and understand the use of DTs for promoting sustainable housing practices. Studies such as Haines and Mitchell (2014) and Wilson, et al. (2015) have revealed access to supportive financing channels and specific strategies, which are vital drivers for the integration of the use of DTs to promote sustainable housing practices. Such supportive financial channels include among others, public co-funding of large-scale projects and preferential permitting for developers who commit to digitally enabled sustainability certifications. Also, Hart, et al. (2019) contend that FEs promote the use of DTs and sustainable practices in housing projects by incentivizing cost-effective solutions, aligning financial interests with environmental goals, and leveraging collaborative approaches to overcome barriers. These enablers help to ensure the economic feasibility and long-term sustainability of DT-based housing projects in the UK.
- **Sectoral Enablers:** Hart et al. (2019) define sectoral enablers (SEs) as initiatives within the construction industry that aim to facilitate the integration of DTs for promoting sustainable housing practices through improved evidence-base and communication, clear vision and frameworks, collaboration and design tools, research and development, and reverse logistics infrastructure. They also observed that SEs work to develop a strong evidence basis through enhanced case studies and transparent information dissemination. That notwithstanding, these programmes enable industry stakeholders and policymakers understand the benefits and practicality of implementing such technologies. Again, SEs collaborate to define effective frameworks and principles for incorporating DTs into housing developments, providing guidance and direction to industry professionals.

Hart et al. (2019) in their own contribution, state that SEs help research and development initiatives focus at identifying novel DTs, materials, and building processes that could enhance the sustainability performance of housing projects. In their findings, SEs encourage the creation of standards and assurance schemes that create guidelines for the use of DTs in building construction while assuring compliance with legal requirements and industry best practices. Besides, SEs work to build reverse logistics networks, such as materials marketplaces and recycling facilities, aid effective collection and repurposing of materials following demolition and renovation activities. Hence, SEs play an important role of supporting the adoption of DTs to promote sustainable housing practices by offering guidance, support, and resources to industry stakeholders. These initiatives help to overcome implementation bottlenecks and expedite the global shift for more sustainable and environmentally friendly housing solutions in the UK.

EMPIRICAL STUDIES

Shabha, et al. (2023) use interpretivist beneficial technologies to investigate a qualitative assessment of the impact of smart homes and environmentally beneficial technologies on the UK 2050 net-zero carbon emission target. They gathered their data for the study through a semi-

structured survey that was administered to two groups which are professionals knowledgeable about smart home technology and users of smart home systems. Their findings reveal that there is an urgent need for renewable, low-carbon energy sources to address the significant carbon emissions associated with UK households, which currently stand at approximately 5 tons annually per household. They also observed that achieving carbon emission reduction targets requires a multi-faceted approach involving both public and governmental involvement, in addition to the use of smart meters within households. As such, they recommend collaborative efforts from all stakeholders and policy interventions as measures to address environmental sustainability challenges.

Shabha, et. al.'s study is related to this present research work as both studies focus on assessing the synergetic effect of DTs and sustainable housing on the UK 2050 net-zero carbon emission target. The two studies are qualitative research work. As well, both studies have the same geographical location - UK. However, their choice of research topics are not the same. While the present research topic is on the 'application of DTs for promoting sustainable housing in the UK' Shabha et al.'s own is on 'a qualitative assessment of the impact of smart homes and environmentally beneficial technologies on the UK 2050 net-zero carbon emission target.'

METHODOLOGY

This study adopts and adapts Saunders, Lewis, and Thornhill's (2009) concept of the research onion. This study adopts an interpretivism research philosophy. Saunders et al. (2009) identify different types of research strategies, which are experimental, surveys, case studies, action research, grounded theory, ethnography, and archival research. This study adopts qualitative research technique. This study uses both primary and secondary data sources. Semi-structured interview with four AEC experts that specialised in DTs and sustainable housing were employed to serve as the primary data sources for this project, as well as the instrument for data collection. After gathering the data for the study through semi-structured interview and case studies, the researcher confirms facts; the researcher also transcribes, collates, categorises, juxtaposes them, and then, subject them to analysis, using thematic analysis (TA) assumptions.

CASE STUDIES ANALYSIS

Enablers for the Integration of DTs

The Forge project as viewed by UKGBC (2022) got government funding and support in form of financial incentives and regulatory frameworks to encourage the adoption of advanced DTs and sustainable practices, hence, accelerating progress towards net zero carbon buildings and climate resilience. The project's receipt of government funding, which aligns with Hart et al. (2019) study, portrays the importance of public-private partnerships with Government in driving the application of DTs for promoting sustainable housing both in the UK and across the world. Also, the project adoption of innovative construction methods such as (DfMA and reversible joint design) facilitated the application of BIM, IoT, digital twins, among others, in reducing material waste, embodied carbon emissions, and construction time. Therefore, through learning from challenges, optimizing processes, and sharing lessons learned, the Forge project team was able to drive positive change in the application of DTs to advance the project's sustainability agenda, which is applicable to other sustainable housing project in the UK and beyond.

4.2.3 Enablers for the Integration of DTs

The integration of DTs into the 80 Charlotte Street Project was enhanced by detail planning, early stakeholder engagement and collaboration, which helped in ensuring that sustainability goals and digital technology requirements were clearly defined from the outset (UKGBC, 2022). Furthermore, the project through Derwent London also leveraged on investment in research and development, as well as specialized expertise and partnerships, to explore innovative solutions such as the use of pre-fabrication and off-site manufacturing; and technologies that could enhance the sustainability and efficiency of the building project (UKGBC, 2022). This proactive

approach to innovation helped in the identification and adoption of cutting-edge DTs such as IoT, big data, cloud computing, and AI, which are consistent with Hart, et al.'s (2019) study. It helps also to improve the project's energy efficiency, carbon emission reduction, and environmental sustainability.

FINDINGS AND DISCUSSION

Enablers and Strategies for the Effective Integration of DTs For Promoting Sustainable Housing in UK

The findings of this study disclose that the successful integration of DTs for promoting sustainable housing practices in the UK and beyond hinge on several key enablers and strategies. These enablers include cultural, regulatory, financial, and sectoral aspects. Consequently, the Forge project and the 80 Charlotte Street project case studies exemplify the importance of these enablers in driving the adoption of DTs for sustainable housing practices in the UK. Government funding and support accelerate progress towards net-zero carbon buildings and climate resilience, showing the importance of public-private partnerships. Also, detailed planning, stakeholder engagement, and investment in research and development, as emphasized by the 80 Charlotte Street project case study, facilitate the adoption of innovative DTs to improve building sustainability and efficiency in the UK.

The results of this study's interviews are in line with the above identified enablers and strategies for the effective integration of DTs for promoting sustainable housing in the UK. P1 and P2 state respectively that:

...educating stakeholders about the benefits and advantages of new technologies helps them understand the potential value they can bring to the projects...Also, fostering a culture of innovation and openness to new tools and features encourages continuous improvement and ensures that advancements in technology are readily embraced rather than met with resistance (P1).

...it entails promoting competition among software providers to mitigate monopolistic pricing practices. This could be achieved through government incentives aimed at encouraging innovation and diversity within the industry, similar to those seen in the computer hardware market. Also, government funding initiatives should prioritize sustainable building practices, potentially through mandates requiring a certain percentage of new construction projects to meet high sustainability standards...(P2).

While P3 and P4 hold that:

...one effective strategy in overcoming these barriers to the integration of DTs in sustainable housing projects in the UK involves implementing a compensation scheme that incentivizes sustainable design practices. This scheme could offer tax breaks or reductions in professional service fees for companies that demonstrate their designs meet specific sustainability criteria...(P3).

...overcoming these challenges involves increasing awareness and promoting the benefits of these technologies within the industry. This can be achieved through targeted promotion efforts aimed at construction professionals and companies, highlighting the potential advantages and impacts of digital tools, particularly those related to AI...(P4).

This study agrees with the above identified enablers and strategies for the effective integration of DTs for promoting sustainable housing in the UK. Additionally, this study supports P1, P2, P3 and P4 views that understanding and adopting these enablers and strategies are important for effective integration of DTs for sustainable housing practices in the UK and beyond. Also, promoting cultural, regulatory, financial, and sectoral enablers, stakeholders can overcome implementation barriers and expedite the transition to more sustainable housing solutions,

thereby accelerating progress towards net zero carbon buildings and climate resilience goals in the UK and on a global scale.

CONCLUSIONS

The integration of digital technologies (DTs) for promoting sustainable housing practices in the UK hinges on identifying and leveraging key enablers such as robust policy frameworks, industry collaboration, and ongoing innovation in technology. Effective strategies encompass the adoption of smart building systems, the use of data analytics for optimizing resource efficiency, and fostering a culture of sustainability through education and stakeholder engagement. These elements collectively drive the transition towards more sustainable housing, ensuring long-term environmental and economic benefits.

RECOMMENDATIONS

1. Focus should be made on developing comprehensive training programs for stakeholders, including architects, builders, and policymakers, to ensure they are well-versed in digital technologies (DTs) and their applications in sustainable housing. This will facilitate better integration and utilization of these technologies.
2. There should be establishment of collaborative platforms that bring together technology providers, housing developers, and environmental experts. This will promote knowledge sharing, align technological solutions with sustainability goals, and accelerate the adoption of innovative practices in the housing sector.

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