

Towards a smart, sustainable and resilient built environment

The concept of “Sustainability” has been conventionally defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Even though the essence of sustainable development is clear and widely used in the scientific literature, the exact interpretation of the concept of “sustainable” is still open to debate. Smart and resilience can be considered as the two central concepts often cited to achieve sustainability; however, the interrelationship and interdependence between these two concepts are not often evident. This has led to the questions of “is the smart built environment always resilient?” or “is the resilient built environment always smart?” and “what more is needed for sustainability?” This indicates that there is great scope and potential to further explore the concepts and interplay of smart, sustainable and resilient in the context of the built environment.

This special issue (SI) attempts to develop a platform to integrate the concepts such as smart, innovation, technologies, green, energy efficiency, carbon reduction, sustainability and resilience in the context of buildings and other built infrastructure. As such new insights into the triple concepts of smart, sustainable and resilient built environment are brought “under one umbrella” in this special issue, which in turn has potential to offer a significant contribution to the existing body of knowledge.

The special issue consists of 18 papers providing insights into diverse themes within the environmental, economic, social and cultural dimensions of smart, sustainable and resilient built environment. The papers are ordered based on their research focus, where the first two papers (papers 1–2) are based on literature review on smart, resilient and sustainable construction. The next three papers (papers 3–5) focus on sustainable water management and waste management practices. Papers 6 and 7 consider capacity development of the contractors who are one of the key stakeholders contributing to sustainable construction. The next five papers (papers 8–12) discuss various sustainability aspects of buildings from different countries. Thereafter, four papers (papers 13–16) discuss the aspects related to resilience, followed by two final papers (papers 17–18) that review the circular economic concepts in building construction.

The first paper by Khatibi *et al.* proposed two frameworks as smart resilient city (SRC) and resilient smart city (RSC) to enhance both smartness and resilience of a city; their research adopted a systematic review using a meta-synthesis technique. The authors suggest that smart cities are not always resilient, and vice versa; they proposed two frameworks to evaluate and enhance either resilience or smartness. As such, this paper attempts to integrate both smart and resilient concepts within the city development process, which is a core theme of this special issue. The second paper by Hewa Welege *et al.* provided a review on the application of social network analysis (SNA) in sustainable construction and built environment. The authors claim, despite the popularity of SNA, there is lack of thorough understanding of optimal SNA applications. Hence, through this paper, the past applications of SNA in the field of sustainable construction and built environment have been critically reviewed by adopting comprehensive bibliometric and methodological reviews. This paper therefore provides useful insights for future researchers to comprehensively identify and compare the applications of SNA techniques in construction and built environment management from a sustainability viewpoint.

Irrigation, which is the artificial application of water to the soil through various systems, is one of the key contributors to the built environment. The third paper by Sirimewan *et al.*



argues that achieving sustainable irrigation while conserving the natural eco-system are two complex and challenging objectives of sustainable water management (SMW) in the context of developing countries. The paper revealed the issues in SWM of irrigation system in terms of efficiency of irrigation infrastructure, equity of water distribution, environmental integrity and economic acceptability. Qualitative expert interviews were conducted and were analysed using code-based content analysis. Presenting the deficiencies in the SWM could help the policymakers to devise appropriate strategies to achieve sustainability in the irrigation sector.

The fourth and fifth papers explore barriers to implement sustainable strategies to waste management using PESTEL (political, economic, social, technical, environmental and legal) framework. Though many countries have adopted waste-to-energy (WtE) as a successful solution for both energy and waste crisis, the Sri Lankan Government decided to limit the number of such projects to two. Dissanayake and Kumarasiri have therefore analysed the barriers to the implementation of WtE projects in Sri Lanka. Exploratory case studies on the two WtE megaprojects initiated in Sri Lanka were conducted using qualitative semi-structured interviews. Waste trading (WT) is also considered as a sustainable strategy for improving resource utilisation, though it is impeded by several barriers. In addressing this, Ratnasabapathy *et al.*, explored a wide range of barriers to the WT practices in the context of construction and demolition (C&D) waste in Australia. A triangulation design approach was used, comprising quantitative and qualitative methods in the form of literature review, questionnaire survey and expert interviews. The findings of both the papers could enable relevant stakeholders to make informed decisions in developing appropriate strategies to address the barriers identified, which in turn would lead to better waste management practices and long-term sustainability.

Stakeholders of the construction industry play a major role in creating smart, sustainable and resilient built environment. In this regard, the sixth paper by Dewagoda *et al.*, focused specifically on a knowledge value chain (KVC) framework for contracting organisations who are one of the key contributors to sustainable built environment. The authors conducted 15 expert interviews and three case studies, and resulting KVC framework can be used by contracting organisations to gain a competitive advantage in business. Further, Ranadewa *et al.*, in the seventh paper investigated the development of capacities necessary for enabling lean for small and medium contractors (SMCs). SMCs, who constitute the largest sub-sector of the construction industry, have a comparatively low rate of adoption of lean principles. The authors have developed a novel lean enabling human capacity building framework that identified at individual, organisational and environmental level strategies for SMCs that are based on the code-based content analysis performed with 24 expert interviews.

The next five papers discuss various aspects of sustainability that are related to buildings from different countries. The eighth paper by Tennakoon *et al.* looked at suitable procurement method for steel building construction in Sri Lanka by adopting an abductive research stance. The authors claimed that short construction period and higher constructability of design were the two top factors influencing the procurement selection. Steel-framed buildings provide a good structure for smart building systems as they provide sufficient space for information technology to be embedded within the building and allow access for maintenance and repair. Furthermore, as steel is 100% recyclable, it can greatly contribute to sustainability too. The ninth paper by Agyekum *et al.* examined occupant's satisfaction with indoor environmental quality (IEQ) of a green-certified building in Ghana, where a quantitative survey was conducted within a single case study. The authors have analysed the views of 300 respondents against 15 IEQ parameters and have presented a gap analysis of the respondents' perceived importance and satisfaction with the IEQ in respect of the case study building. The tenth paper explores the viewpoints of building code users regarding building code amendments in New Zealand. New Zealand has experienced several

disasters hence continuous use of the building codes as a measure to reduce natural hazards impact requires regular amendments. However, Amarachukwu and Wilkinson claim that the frequent amendments in building codes pose practical difficulties among the building code users, hence considering the user viewpoints are vital. Accordingly, the study evaluated the opinions of New Zealand's building code users regarding the frequent amendment, by using 116 questionnaires. The paper concludes that by implementing the code users' opinions encourages disaster resilience through effective application of the building code requirements in design and construction. With increased focus on creating sustainable buildings to reduce both operational and embodied carbon (EC) of buildings, the eleventh paper by Rodrigo *et al.* aimed to analyse typical EC and cost profiles of school buildings within Australia to understand which building elements need more attention. Five case studies were analysed in-depth, where the data analyses incorporated elements of quantitative study based on document survey. As such, while exploring the carbon-cost profile of Australian school buildings, the study also highlights the importance of reducing EC in the elements that were identified as typical carbon hotspots. The twelfth paper by Montaser Koohsari and Heidari presents an approach to optimise window size by integrating energy and lighting analyses by considering occupants visual satisfaction in Iran. Accordingly, the authors proposed optimum ranges for aspects such as useful daylight illuminance (UDI), window to wall ratio (WWR), window width to height ratio (WHR), etc. The research was conducted by creating a simulation model, where the parameters for visual, energy and thermal performances were integrated and tested.

The next set of four papers is related to resilience. In the thirteenth paper, Ghanbarzadeh Ghomi *et al.* discuss the sustainability of housing in a post-disaster context, where the authors propose the conceptual living-transforming disaster relief shelter (LTFDR-shelter) approach to transform temporary shelter into a more permanent dwelling. Three case studies of permanent post-disaster housing were selected within which 120 questionnaires were administered to evaluate the performance related issues of post-disaster housing. The applicability of proposed LTFDR-shelter has been discussed as an efficient tool to adequately improve the identified factors by employing living technology in the built environment. The fourteenth paper by Ekanayake *et al.* is a review paper where the paper reviews the state-of-the-art literature of supply chain resilience (SCR) using bibliometric approach. The authors used CiteSpace software to perform the bibliometric approach so that the analysis can be comprehensive, systematic and accurate. The authors produced a SCR research map that they believe will inspire new knowledge creation, identify further research and boost the performance of SC by triggering smart and sustainable practices. The next paper focuses on physical infrastructure resilience which is intrinsically linked to the built environment and community resilience. Accordingly, Tariq *et al.* proposed a novel technique to achieve consensus among stakeholders on the definitions, objectives and indicators for measuring physical infrastructure as a key dimension of community disaster resilience. Q-methods' approach was used to operationalise the measurement of physical infrastructure resilience; it used a mixed method approach with 84 participants across four countries. The physical infrastructure capacity assessment tool (PI-CAT) has the potential to be used to identify effective investments that will enhance community disaster resilience. The sixteenth paper from Faremi *et al.* investigated the extent to which defects in coastline buildings are influenced by the climatic conditions within the coastal zones. The research was based on both desk study and a cross-sectional field survey with 102 facilities and maintenance managers from coastline buildings. The result shows a positive significant correlation between climatic conditions and defects in coastline buildings. The authors further believe this study would assist construction stakeholders in improving resilience of coastline buildings.

The last two papers of this special issue focus on circular economy (CE) principles in buildings. Circular economy concepts underpin a systemic approach to economic

development designed to benefit businesses, society and the environment. It is one of the strong contributors to the sustainability as it reduces the dependence of natural resources. In this regard, Tennakoon *et al.* presents the principles of CE as an avenue for enhancing environmental sustainability during the pre-construction stage within Sri Lankan construction projects. A qualitative approach was used with semi-structured interviews with experts. Findings proposed the activities to be implemented during the pre-construction stage under 6R principles (reduce, reuse, recycle, redesign, reclassification and renewability). The authors believe that adopting those activities would enhance the environmental sustainability of construction projects. The last paper by Munaro and Tavares explore the challenges and opportunities in adopting a materials passport (MP) tool in the building sector to promote the circular economy concept. MP is a tool to track the circular potential of materials, products and systems by providing accurate information for recovery and reuse. The study was based on systematic literature review, where the authors employed both descriptive and thematic analysis. The study developed an MP model to enable the management of the building materials at different stages of building's lifecycle.

The above overview clearly indicates that this special issue has attracted an exciting set of papers covering the key areas related to smart, resilient and sustainable built environment from different dimensions such as economic, environmental, social and technical. This special issue reflects the truly global nature of the sustainability challenge and includes research papers that cover issues pertaining to a wide range of countries namely, Australia, Brazil, China, Ghana, Hong Kong, Iran, Malaysia, New Zealand, Nigeria, Sri Lanka and the UK. The authors of the papers also represent several different institutions within or across countries, thereby highlighting the collaborative and inter-disciplinary nature. It is anticipated that the research gaps, knowledge, barriers and strategies presented in the research papers of this special issue will collectively contribute to the body of knowledge and will inform interested readers and relevant stakeholders, including practitioners, policy makers, academics, research students and society at large to adopt best practices and to develop further research in achieving a smart, sustainable and resilient built environment, locally and globally.

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Menaha Thayaparan

Department of Building Economics, University of Moratuwa, Moratuwa, Sri Lanka, and

Andrew Ross

Department of Building Environment, Liverpool John Moores University, Liverpool, UK