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Editorial Article

Digital Pathways – Sensing, Simulating, and Certifying the Built Environment

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Abstract

Digital technologies now shape how cities are understood, represented, and regulated. This editorial article frames the five contributions of ABC2: Journal of Architecture, Building, Construction, and Cities (2026-04) within that shift. The issue advances along three connected fronts or themes. The first is diagnosis. Integrated evaluation frameworks and satellite observation reveal where urban systems are fragile and who carries the heaviest burden and required coordination, from pandemic resilience in Cairo and Alexandria to heat exposure in southern Tehran. The second is representation. A single photograph becomes a textured 3D building model, and game engine platforms carry entire cities into real-time digital twins that inform planning and governance. The third is assurance. Image recognition and digital traceability turn construction compliance into a continuous, verifiable record embedded within manufacturing. Overall, the articles demonstrate that digital tools earn their value when they serve equity, transparency, and sound governance. They also suggest caution. While models simplify and algorithms carry assumptions, regulation seems to lag technical capability. The issue therefore treats digitalisation as an institutional project as much as a technical effort. It calls for data systems, simulation platforms, and verification frameworks that remain accountable to the people and places they represent, in direct support of the Sustainable Development Goals. These themes extend an editorial trajectory that has developed across earlier issues of the journal, moving from the convergence of technology, safety, and regulation toward the translation of sustainability into situated action. For researchers, the issue models methodological breadth across statistical, computational, and interpretive modes of inquiry. For practitioners and policymakers, it identifies where digital evidence is ready for adoption and where institutions must still catch up.

Keywords: Urban resilience; Digital twins; Remote sensing; AI-based modelling; Off-site construction; Regulatory compliance; Sustainable Development Goals

Highlights

- Positions diagnosis, representation, and verification as connected digital pathways for the built environment.
- Shows how data-driven evidence exposes inequity and guides resilient, climate-responsive planning in the Global South.
- Argues that digital tools require formal institutional recognition and accountable governance to deliver lasting change.

1 The Built Environment in the Age of Digital Evidence

The built environment sits at the centre of contemporary sustainability discourse, while consuming a large share of global resources and generates a substantial portion of emissions. It also shapes health, opportunity, and daily life for a majority of the world's population. Cities in the Global South face these pressures with fewer resources, denser settlement patterns, and weaker institutional capacity. Climate challenges, health crises, and embedded inequality combine together in such contexts to exacerbate the challenges.

Nonetheless, a profound shift is under way in how these challenges are studied and managed. Evidence about cities and buildings is becoming increasingly digital. Satellites measure surface temperature street by street. Statistical frameworks rank the drivers of urban resilience. Photographs become 3D models. Game engines render entire metropolitan regions in real time. Cameras and digital identifiers record how buildings are designed, manufactured and assembled. The question is no longer whether digital evidence exists, it already does. The question is whether it is trustworthy, equitable, and institutionally recognised.

International frameworks such as the United Nations Sustainable Development Goals (SDG) give this question direction (UN, 2015). Goals addressing health (SDG 3), industry and innovation (SDG 9), reduced inequalities (SDG 10), sustainable cities (SDG 11), climate action (SDG 13), and effective institutions (SDG 16) depend on credible data and accountable systems. Scholarship on socio-technical transitions makes a further point. Technologies transform practice only when institutions, skills, and governance evolve with them (Geels, 2019). Digital tools without institutional support remain demonstrations. Institutional reform without evidence remains rhetoric.

This concern is not new to the journal. Previous editorials have approached it from complementary angles. The second issue of 2025 examined the convergence of technological innovation, safety management, and regulatory adaptation in a fragmented industry (Rahimian & Salama, 2025). The opening issue of the present volume 2026 argued that sustainable transitions emerge from the alignment of human experience, digital innovation, and professional practice rather than from technical capability alone (Salama & Rahimian, 2026). The issue that followed carried the argument further, tracing how sustainability moves from systems awareness into situated action across materials, digital construction, and pedagogy (Rahimian & Salama, 2026). The present issue extends this editorial trajectory or direction into the question of evidence itself. It asks what makes digital knowledge about cities credible, and what institutions must do to act on it.

This issue of ABC2 (2026-04) brings these threads together through its five contributions which span urban diagnostics in Egypt and Iran, AI-based building reconstruction in Turkey, city-scale digital twins across Asia and the Middle East, and regulatory innovation in Australian off-site construction. Three cross-cutting themes connect them. The first concerns diagnosis, where data reveals vulnerability and guides priorities. The second concerns representation, where digital counterparts of buildings and cities inform decisions. The third concerns assurance, where digital records become the evidence base for regulatory compliance. Reading them together demands methodological breadth, across statistical, computational, and interpretive modes of inquiry (Salama, 2019). Each theme or concern is discussed subsequently below.

2 Reading the Vulnerable City: Data as Diagnosis

Sound intervention begins with sound diagnosis. Two articles in this issue demonstrate what rigorous urban diagnosis looks like in the Global South. Both replace assumption with measurement and, in essence, place equity at the centre of the analysis.

Younan et al. (2026), in *Advancing SDGs-Driven Urban Resilience Pathways in the Global South*, examine pandemic resilience in Cairo and Alexandria through an integrated PSR-VIKOR framework. The study links bibliometric mapping, qualitative policy review, statistical association testing, and multi-

criteria decision analysis into a single analytical chain. The findings are instructive, where environmental sustainability and governance coordination emerge as the strongest drivers of resilience and mobility and social-spatial inclusivity act as key mediators. Housing inequality carries a weaker yet significant role. The authors draw a sharp conclusion from this pattern. Systemic frameworks do not deliver equity on their own. Equity can be sidelined unless it is explicitly institutionalised. Resilience planning in Egyptian metropolitan regions remains vertically strong at the national level and horizontally weak at the neighbourhood scale. Interoperable data platforms and metropolitan analytics are needed to close that gap. Research on semantic interoperability shows how sensor and building data models can be aligned for exactly this purpose (Okonta et al., 2025). Notably, this work speaks directly to a diverse set of SDGs, including SDG 3, 10, 11, 13, and 16.

Gholami et al. (2026) bring the same diagnostic discipline to a single neighbourhood. Their article, *Urban Heat Island Vulnerability Assessment Using Remote Sensing and Land Surface Temperature Analysis*, examines Southern Mehrabad in Tehran, a socioeconomically vulnerable district beside a major airport. Ten years of Landsat imagery expose persistent thermal hotspots in commercial and industrial zones. A strong inverse correlation between vegetation and surface temperature quantifies the cooling value of green cover. Every 0.1 increase in NDVI lowers average surface temperature by roughly 2.1°C. The method matters as much as the result. Free satellite data, cloud-based processing, and field validation produce a replicable diagnostic for under-resourced cities anywhere. Scarce adaptation budgets can then flow to the places where heat exposure is most acute.

Collectively, these studies define a diagnostic ethic for urban research. Vulnerability is spatial, measurable, and unevenly distributed. Data infrastructure is therefore a matter of justice. Cities that cannot see their own inequities cannot correct them. Diagnosis should also stay close to lived experience. Technology-enabled co-assessment of urban open spaces shows how residents can evaluate the places they use every day (Salama & Patil, 2024; Patil et al., 2024). Assessments of market-driven sustainable neighbourhoods carry a related caution about metrics that drift away from the people they claim to serve (Dessouky et al., 2023).

Diagnosis of this kind is never a purely technical effort. It changes the terms of urban governance. Once a resilience ranking or a heat map enters the public record, priorities become contestable and budgets become answerable to evidence. The value of such work therefore is predicated on how openly it is produced. Both studies rely on transparent frameworks, accessible data, and findings expressed in terms that municipal decision-makers can act upon. That combination turns measurement into a civic instrument rather than an academic product, and it sets a standard worth repeating across future submissions to the journal.

3 From a Single Photograph to the City-Scale Twin

The second theme concerns representation. Digital models of buildings and cities now mediate how professionals document heritage, test designs, and govern urban systems. Two articles trace this trajectory across radically different scales.

Aş Çemrek et al. (2026), in *A Photo to 3D Workflow for Generation of LOD3 Digital Building Representations*, propose a sequential AI workflow that turns a single architectural photograph into a textured 3D mesh. Gemini Flash 2.5 first normalises the image. Hunyuan3D 2.1 then reconstructs the geometry and materials. Sixteen early Republican and Ottoman buildings in Turkey serve as the test set. The results carry real promise for heritage practice. Buildings with only one surviving photograph can gain a digital counterpart in minutes. The authors are equally clear about limits, where unseen facades are predicted, not observed. The outputs are plausible representations, suitable for visualisation, comparison, and archiving. They are not survey-grade documents. This honesty about fitness for purpose is a model for how AI-generated content should enter architecture and built environment scholarship.

Najafi (2026) scales the same logic to the metropolis. From Games to Smart Cities traces how rendering pipelines, physics engines, AI agent systems, procedural generation, and multiplayer networking migrated from entertainment into the digital twins that now govern Shanghai, Singapore, Dubai, and Riyadh. The construction literature anticipated this exchange. Game-like BIM applications already support project monitoring and participatory housing design (Pour Rahimian et al., 2020; Potseluyko et al., 2022). The proposed Game-City Continuum maps this convergence across fidelity, agency, and connectivity. The argument cuts in both directions, where game technology gave cities photorealistic, real-time governance platforms, and urban simulation now feeds authenticity back into gaming. The article closes with a warning that deserves wide attention. Game design encodes assumptions of top-down control and simplified social behaviour. Adopting these platforms without critical reflection is important to be viewed as a risk when writing those assumptions into urban governance. Transparency, equity of access, energy cost, and data sovereignty must be addressed as governance questions, not technical afterthoughts or add-ons.

The two articles demonstrate that representation is never neutral. Every model simplifies. Every pipeline embeds priorities. Yet, the scholarly task is to make those simplifications explicit and to match each representation to a purpose it can honestly serve. In essence, the movement from photograph to metropolitan twin also belongs to a longer arc in digital design and construction research. Scholarship on Industry 4.0 established that digital value arises from integration, when modelling, simulation, and data flow across the whole process of designing and delivering buildings rather than sitting in isolated tools (Rahimian et al., 2021). The two articles confirm that lesson at new scales. A reconstruction pipeline matters when its outputs feed archives, conservation decisions, and comparative study. A city twin matters when its simulations connect to planning procedures and public deliberation. Representation earns its place through integration with real decisions, not through visual spectacle.

4 From Tools to Institutions: Verification as Regulatory Infrastructure

The third theme moves from analysis to assurance. Digital evidence achieves lasting value only when regulatory systems formally accept it. The technical report by Omrani et al. (2026), *Digital Technologies as Regulatory Enablers in Off-Site Construction*, confronts this problem in the Australian context. Industrialised construction shifts fabrication into factories. Stage-based statutory inspection, designed for sequential on-site work, cannot verify elements concealed during manufacturing. The study examines two responses. The first is that image recognition systems capture, analyse, and archive progressive installation stages, turning inspection from an episodic event into continuous verification. The second is that digital chain-of-custody frameworks assign persistent identities to products, linking certification, transport, and installation into a single auditable record.

The central finding reaches beyond construction processes and production. While technical capability already exists, regulatory recognition does not. Image recognition and traceability records currently lack formal evidentiary status within statutory compliance pathways. Without harmonised standards, clear data governance, and third-party certification models, these systems remain efficiency tools rather than compliance infrastructure. The study therefore calls for regulatory reform that treats digital verification as a legitimate foundation of building assurance, advancing SDG 9 and SDG 16. A growing research base supports this direction. Integrated digital twins can track construction resources predictively (Elghaish et al., 2025). Blockchain-enabled twins extend verifiable records into commissioning and handover (Adu-Amankwa & Rahimian, 2025). Reviews of sensing technologies for equipment operation show similar potential for site safety (Soltanmohammadlou et al., 2024).

The position adopted in this study is consistent with arguments made in earlier issues of ABC2. The editorial for issue 2025-02 concluded that digital twins, artificial intelligence, and data analytics realise their potential only when regulatory evolution, organisational learning, and professional competence advance alongside them (Rahimian & Salama, 2025). What that editorial framed as a general condition, Omrani et al. (2026) now document as a specific gap with a specific remedy. Harmonised standards,

clear data governance, and recognised third-party certification are the missing pieces. Naming them precisely is the first step toward supplying them.

This institutional argument echoes across this whole issue of ABC2. Younan et al. (2026) find that resilience data fails to reach neighbourhood decisions because metropolitan institutions cannot absorb it. Najafi (2026) shows that city twins already recommend interventions and demands explainability and human oversight in return. Omrani et al. (2026) demonstrate the same gap inside the factory. The pattern is consistent where digital transformation stalls at the point where technology meets institutions, and research that addresses this meeting point delivers the greatest practical value.

4 Moving Forward: Research Pathways and ABC2 Commitment

This issue of ABC2 (2026-04) reaffirms the commitment of the journal to scholarship that connects technical innovation with equity, governance, and institutional change. The five contributions move from satellite evidence to statistical prioritisation, from single photographs to metropolitan twins, and from factory cameras to regulatory reform. Each treats digital capability as a means, while the ends remain resilient communities, protected heritage, honest representation, and accountable institutions.

Viewed against the journal's brief history, this issue also marks a maturing of its editorial project. Earlier issues established disciplinary breadth, examined the convergence of human and technological factors, and traced sustainability into situated practice (Rahimian & Salama, 2025; Rahimian & Salama, 2026; Salama & Rahimian, 2026). The present issue adds a further layer to that project. It argues that the digital evidence now flowing through architecture, building, construction, and cities must be diagnostic in purpose, honest in representation, and verifiable in institutional terms. That standard is demanding, yet it is the standard that public trust requires.

Future research should press further along these pathways. Urban diagnostics need finer temporal and spatial resolution, and stronger links to health and demographic data. Digital representation needs shared standards for declaring accuracy, originality and situatedness, and fitness for purpose. Regulatory scholarship needs to specify how digital records gain evidentiary status across jurisdictions. Above all, the field needs work that keeps people at the centre of digital systems. Education carries part of that responsibility. Built environment curricula must prepare graduates to question digital tools as confidently as they operate them (Burton & Salama, 2023). The journal invites contributions that further take up these questions with rigour, honesty, and ambition. The cities we build next will depend on the evidence we trust today.

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