

# From Digital Speed to Accountable Evidence: GIS, AI and Lightweight Digital Twins in National Infrastructure Planning

## 1. Introduction: From Digital Speed to Accountable Planning

National infrastructure planning involves complex decisions about route selection, environmental impact, community disruption, carbon targets, delivery risk and public legitimacy. This essay responds to the question of how digital tools such as GIS and AI can improve the **quality** and **efficiency** of national infrastructure delivery.

It argues that **quality and efficiency are not synonymous**. Digital tools can accelerate data processing and option comparison.

Although digital twins are framed as tools for engagement, their participatory effectiveness remains uneven (Luo et al., 2025).

Digital tools improve quality only when they make evidence transparent, assumptions contestable, outputs verifiable and trade-offs understandable.

The problem is not digitalisation itself, but the risk that digital outputs are treated as neutral evidence before their limits are tested. As De Jaeger and Swerts (2026) show, participation does not follow automatically from technology: digital divides and limits-by-design constrain inclusion. Highly polished images may discourage participation if provisional options appear too fixed (Nassauer, 2015).

The central task is to build an **accountable digital evidence chain**: treating digital outputs not as final answers, but as evidence that must be disclosed, audited, reviewed, ground-truthed and tested through community verification. The starting point is why digital speed alone is insufficient.

## 2. Why Digital Speed Alone Is Not Enough

Three risks arise when digital outputs are treated as self-evident evidence.

**First, black-box decision-making.** GIS and AI outputs such as a ‘preferred route’ appear objective, but their objectivity depends on hidden assumptions, datasets and weightings. In GeoAI,

explainability is a central concern because opaque models reduce trust in high-stakes contexts (Cheng, 2025).

**Second, data bias and missing local knowledge.** Informal routes, perceived safety, seasonal flooding and place attachment shape community experience but rarely appear in standardised datasets. AI outputs can be ‘nationally representative’ yet locally misaligned (Bollen, Higton and Sands, 2025). A model prioritising cost may undervalue community wellbeing.

**Third, visual determinism.** Photorealistic renders can engage stakeholders, but their realism may bias civic participation (Nassauer, 2015). When a provisional route is shown with cinematic clarity, communities **may** assume the decision has already been made, weakening public confidence.

Efficiency without accountability introduces new risks. The next section shows how digital tools can be used as accountable decision-support systems.

### **3. Deploying Digital Tools Across the Infrastructure Lifecycle**

This section uses an **onshore cable route connecting an offshore wind farm to the grid** as an illustrative case, combining route selection, ecology, land use, construction disruption and community impact.

**GIS for early route screening.** GIS can integrate ecology, flood risk, settlements, infrastructure corridors and social vulnerability. Its value is organising spatial evidence into a comparable structure. However, this comparison is not neutral: the choice of layers and thresholds determines which impacts become visible.

**AI for option appraisal.** AI compares route options by testing weightings across cost, carbon, ecology, community disruption and delivery risk. Yet AI should not define the ‘best’ option without transparent criteria. Optimisation embeds priorities; AI structures complexity but does not replace planning judgement.

**Digital twins for scenario visualisation.** Digital twins can translate proposals into discussable scenarios, showing construction access, land-take, noise, landscape change and mitigation across options. Their purpose is not to present a polished final image, but to make alternatives and trade-offs easier to compare.

Used in this way, GIS, AI and digital twins support accountable decision-making. However, these outputs become accountable evidence only when systematically verified.

## 4. Ground-Truthing the Digital Evidence Chain

This section proposes a **digital evidence chain**: a four-step protocol to ground-truth outputs before they are relied on in key decisions.

**First, data disclosure.** Every output must state data provenance: source, scale, resolution, gaps, uncertainty and whether evidence is national, regional or site-specific. Without disclosure, users cannot judge fitness for the specific decision. For digital twins, disclosure should clarify what is measured, modelled and illustrative.

**Second, assumption and weighting audit.** Models rely on weightings for cost, carbon, ecology, community disruption, delivery speed and land acquisition risk. These embed priorities. An audit must record what weights were used, who set them, and whether the preferred option changes under alternative weightings. The key question is what values have been built into the recommendation.

**Third, professional review.** Digital outputs require cross-disciplinary and, where appropriate, independent review by planners, engineers, environmental and consenting specialists. Human-in-the-loop review is a planning requirement, not an optional add-on.

**Fourth, site-based verification.** Fieldwork can reveal mature trees, access problems, unrecorded ecology or heritage constraints that GIS misses. Site visits identify observable conditions but cannot fully explain how disruption or place value is experienced by communities.

These four steps form the technical core of a digital evidence chain. The chain should be iterative: when verification reveals weaknesses, models should be revised and the reasons recorded. Yet accountable evidence also requires testing against local experience, which turns the argument to public-facing lightweight twins.

## **5. Lightweight Digital Twins for Public Understanding and Traceable Co-Creation**

This section argues for **lightweight public-facing twins**: not full engineering replicas, but explanatory layers that make trade-offs interpretable, comparable and traceable.

**Lightweight, not polished.** Unlike photorealistic models, a lightweight twin avoids over-realism. It uses simplified scenes, maps, scenario cards and trade-off tables. It makes clear what is measured, modelled and uncertain. McRae's idea of visual "irresolution" is useful: less seamless images may keep options open for deliberation rather than passive acceptance (McRae, 2026).

**Scenario cards for visible trade-offs.** For the cable route, a twin could present three scenarios side by side: one route might be cheaper but more disruptive; another might reduce ecological impact but take longer; a third might lower visual impact but increase land risk. This shows that planning involves trade-offs, not a simple yes/no. Some constraints, such as irreplaceable habitats, may rule out options altogether rather than merely lowering their score.

### **Community verification as part of the evidence**

**chain.** Communities know which paths are used, how disruption affects daily life, and which mitigation measures seem unrealistic.

Community engagement should become part of evidence verification, not a late-stage response. This does not mean communities replace professional or regulatory judgement; they contribute situated knowledge that tests assumptions and improves credibility.

**Traceable co-creation.** When residents flag an overlooked condition, the platform can record that input, allow indicators to be updated, and show how feedback influenced revisions. Where feedback is not incorporated, the reasons must be recorded. This shifts participation from one-way feedback to traceable co-creation.

A public-facing twin should look less like a final image and more like an open decision space. Such tools should support, not replace, facilitated discussion, site meetings and non-digital engagement – a safeguard to which the next section returns.

## **6. Limits and Safeguards: Digital Exclusion and False Legitimacy**

Even well-designed lightweight twins are not automatically inclusive or legitimate. Three safeguards are necessary.

**First, digital exclusion.** Residents facing unstable internet, low digital confidence, time constraints, language barriers or distrust of planning systems may be marginalised. Digital platforms should supplement, not replace, face-to-face meetings and paper-based materials.

**Second, cognitive load.** If a twin shows too many layers or options, non-expert users may become confused. Plain language, guided explanation, layered information and facilitated workshops are essential.

**Third, false legitimacy.** The issue is not only whether people can comment, but whether their input can alter assumptions, options or mitigation measures. A digital tool becomes meaningful only when it records what changed, what did not change, and why.

These safeguards do not undermine digital tools; they make them more likely to earn public trust.

## **7. Conclusion: Towards Accountable Digital Infrastructure Planning**

This essay has argued that digital tools can improve both the quality and efficiency of national infrastructure delivery, but only

as accountable decision-support systems, not black-box substitutes for judgement. Three recommendations follow.

First, use digital tools as decision-support, not decision-replacement. GIS, AI and digital twins should organise evidence, compare options and communicate uncertainty, but they cannot replace professional, regulatory or public deliberation.

Second, require a verification record for every major digital output. Data sources, assumptions, weightings, professional review and site inspection must be disclosed and audited. Outputs become accountable evidence only when their limits are visible.

Third, create a public-facing explanation layer for infrastructure projects. Lightweight twins with scenario cards, traceable feedback and clear records of what changed, what did not change, and why should become standard practice.

The future of digital infrastructure planning should not be judged only by speed, but by whether decisions become more transparent, accountable and trusted.

## **References**

Bollen, P., Higton, J. and Sands, M. (2025) 'Nationally representative, locally misaligned: The biases of generative artificial intelligence in neighborhood perception', *Political Analysis*, pp. 1–9. doi: 10.1017/pan.2025.10022.

Cheng, X. (2025) 'Explainable AI applications in GIS', in Wilson, J.P. (ed.) *The Geographic Information Science & Technology Body of Knowledge*, 2025(2). doi: 10.22224/gistbok/2025.2.1.

De Jaeger, A. and Swerts, T. (2026) 'Right to the digital Twin City? Citizen participation and limits-by-design in Rotterdam's urban digital twin', *Cities*, 168, 106498. doi: 10.1016/j.cities.2025.106498.

Luo, J., Liu, P., Kong, X., Shen, J., Wu, Q. and Xu, D. (2025) 'Urban digital twins for citizen-centric planning: A systematic review of built environment perception and public participation', *International Journal of Applied Earth Observation and Geoinformation*, 143, 104746. doi: 10.1016/j.jag.2025.104746.

McRae, E. (2026) 'Visualising the urban imaginary: Failure and irresolution in an urban digital twin', *Transactions of the Institute of British Geographers*, early view, e70060. doi: 10.1111/tran.70060.

Nassauer, J.I. (2015) 'Commentary: Visualization verisimilitude and civic participation', *Landscape and Urban Planning*, 142, pp. 170–172. doi: 10.1016/j.landurbplan.2015.07.013.

## **AI Use Declaration**

AI-based tools were used only for language refinement, structural checking and proofreading support. The argument, case framing, source selection, source verification and final writing decisions are my own. All cited sources have been manually checked.

**Word count: approximately 1406 words, excluding references and AI Use Declaration.**