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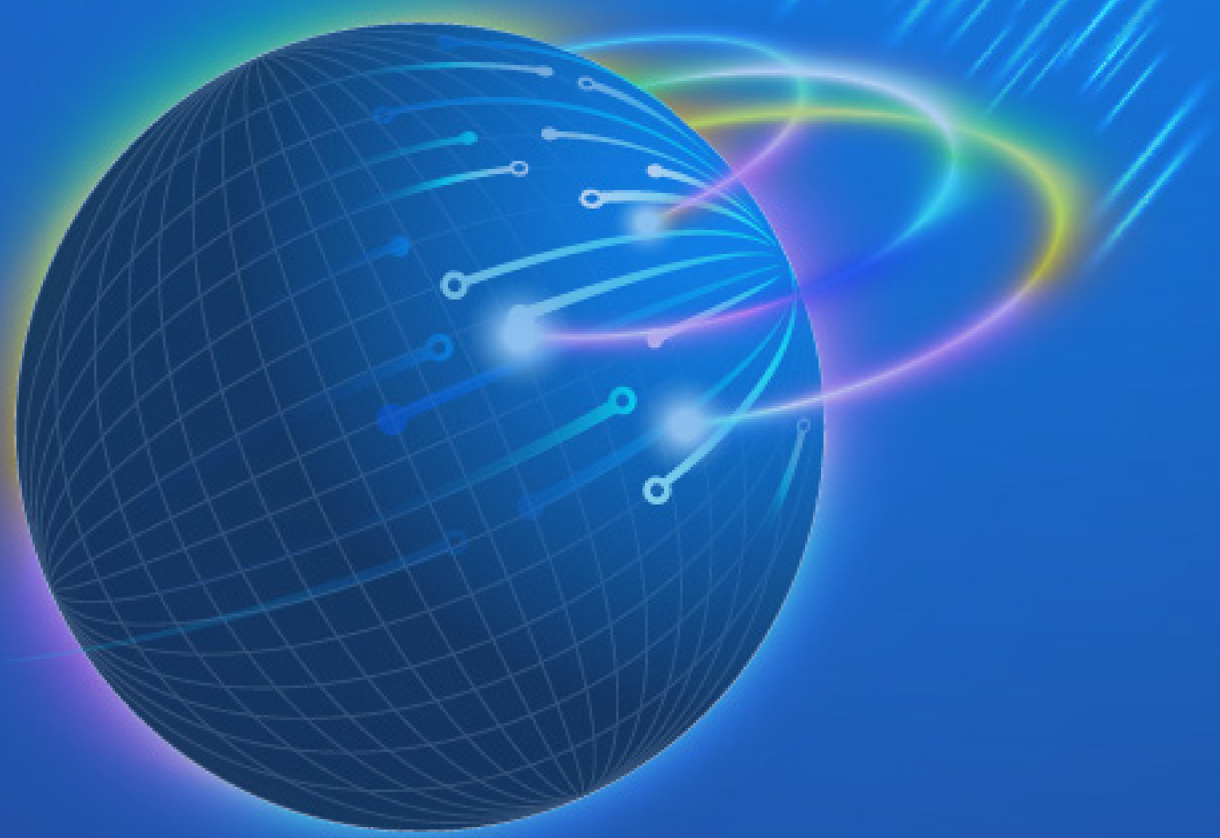

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Adaptation of Drone Technology in the Bangladesh Construction Industry: Opportunities, Barriers, and a Framework for Implementation

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ABSTRACT

Drone technology - formally, unmanned aerial vehicles (UAVs) - is reshaping how construction projects are surveyed, monitored, and kept safe, with applications now ranging from rapid topographic mapping to real-time progress tracking and remote site inspection. Bangladesh's construction industry, however, has been slow to follow this trend: drone use here remains patchy, concentrated on a small number of flagship infrastructure projects rather than embedded in routine practice. This review examines why, set against the backdrop of Bangladesh's rapid infrastructure expansion - most visibly the Padma Multipurpose Bridge and the Dhaka Mass Transit (Metro Rail) network. Using the Technology–Organization–Environment (TOE) framework, it maps five categories of opportunity and six interlinked barriers to adoption, then proposes a five-phase implementation pathway: building awareness and capacity, easing regulatory constraints, piloting integration on live projects, converging drone data with Building Information Modeling (BIM) and Geographic Information Systems (GIS), and finally embedding the technology through institutional policy. The paper closes by outlining the empirical research needed to test and refine this framework.

INTRODUCTION

Construction is going digital fast, and unmanned aerial vehicles have been part of that shift: once a novelty used mainly for aerial photos, drones are now a standard tool in how projects get delivered. The global construction-drone market is estimated at roughly USD 5.5–6.5 billion in the mid-2020s, and industry analysts expect double-digit growth to continue as firms look for faster site data capture, better safety monitoring, and less reliance on manual surveying (Allied Market Research, 2023; Straits Research, 2026). Academic work has kept pace with this commercial growth, documenting UAV-based photogrammetry, LiDAR-enabled remote sensing, and how these feed into digital twins and Building Information Modelling (BIM) across a project's lifecycle (Guan *et al.*, 2022; Javaid *et al.*, 2022; Mohsan *et al.*, 2023). That growth is not evenly spread, though. In India, for instance, only around 30 percent of construction firms use drones, against roughly 60 percent in developed markets (Sivaraman & Judson, 2025), and systematic reviews of UAV-based site digitalisation point to economic, technical, regulatory, and organisational barriers that bite hardest outside high-income economies (Onososen *et al.*, 2023). Bangladesh is a useful case in point. Construction contributes an estimated 8 percent of the country's GDP and employs more than 3.5 million people (The Business Standard, 2024), and the sector is in the middle of an infrastructure build-out on a scale it has not seen before - the Padma Multipurpose Bridge, the Dhaka Mass Transit (Metro Rail) network, the Karnaphuli River Tunnel, and the Dhaka–Chattogram Elevated Expressway among them (South Asia Monitor, 2022; WinTK, 2026). Digital-technology uptake has not kept pace with this expansion: fewer than 10 percent of Bangladeshi construction projects reportedly use BIM, against 71–73 percent in the United States and the United Kingdom, and fewer than 10 percent of the country's engineers are reported to be trained in BIM or AI-adjacent tools (The Business Standard, 2024).

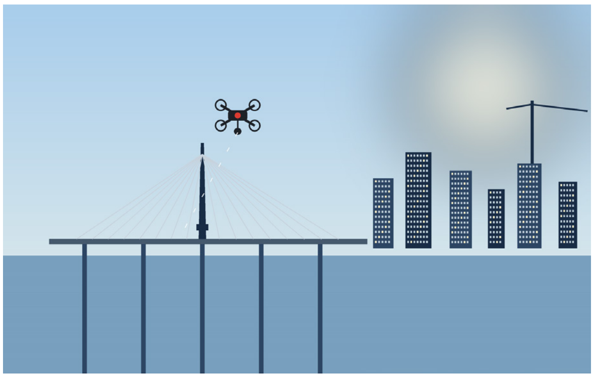

Figure 1: Conceptual illustration of UAV-based aerial survey and progress monitoring on a bridge and mega-project construction corridor (original conceptual graphic).

Drone footage from flagship projects such as the Padma Bridge and the Metro Rail is now a familiar sight (Golden Info Systems, 2025), yet no study has looked specifically at the opportunities, barriers, and implementation pathway for drone technology across Bangladesh's construction industry as a whole - separately from the wider BIM-adoption literature it usually gets folded into. This review sets out to close that gap, with three objectives: first,

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to identify the opportunities drone technology offers a construction sector defined by land scarcity, mega-projects, and disaster exposure; second, to examine the regulatory, financial, technical, organisational, and environmental barriers currently holding adoption back; and third, to propose a phased, conceptual framework for implementation, built on the Technology–Organization–Environment (TOE) perspective used in comparable studies elsewhere (Sivaraman & Judson, 2025).

LITERATURE REVIEW

The technical case for construction-sector drone use is well established by now, and the literature backing it up keeps growing. Guan *et al.* (2022) review UAV-based remote sensing across construction and civil-engineering settings, covering photogrammetric surveying, structural inspection, and progress monitoring. Javaid *et al.* (2022) place these capabilities within the broader Industry 4.0 shift in manufacturing and infrastructure, and Mohsan *et al.* (2023) work through UAV platforms, payloads, and operational limits in detail, including the security and airspace-management questions that resurface later in the barriers literature. The market data tells a similar story: Allied Market Research (2023) and Straits Research (2026) both expect double-digit growth in the global construction-drone market to continue into the early 2030s, pushed by demand for faster data capture and less reliance on manual surveying. More recently, Zhong *et al.* (2025) pulled together the evidence on UAV-enabled safety improvements specifically, and site-safety monitoring comes out as one of the most consistently reported use cases in the global literature. Taken as a whole, this body of work treats UAV technology as mature and commercially significant for construction - the open question is not whether it works, but why its uptake varies so much by region.

A smaller strand of research asks why that technical maturity has not turned into even adoption worldwide. Onososen *et al.* (2023) point to economic, technical, regulatory, and organisational barriers as the main obstacles to UAV-based site digitalisation outside high-income economies - a finding Aiyetan and Das (2023) echo in their review of drone-adoption barriers across developing-country construction sectors. The Technology–Organization–Environment (TOE) framework shows up repeatedly in this literature as the analytical lens of choice; Sivaraman and Judson (2025) apply it directly to the Indian construction industry, and their paper is the closest published analogue to this one, and the main theoretical template this review follows. Boutros *et al.* (2026), in a more recent study, find that managerial perceptions of usefulness and organisational readiness are decisive predictors of technology adoption across developing-country construction firms, which lines up with the organisational leg of the TOE framework used here. Closer to home, Sossah *et al.* (2025) examine autonomous drone adoption for construction progress monitoring in Ghana - another land- and resource-constrained economy — and report technical, financial, and regulatory constraints strikingly similar to those identified for Bangladesh in this review. On Bangladesh specifically, though, the directly relevant literature thins out fast and mostly circles the adjacent question of BIM rather than UAVs: Rakib *et al.* (2018) document a persistent gap between awareness and actual proficiency among Bangladeshi construction professionals, which they attribute to limited training infrastructure and software access - a pattern this review returns to later in relation to drones. Put together, this literature makes two things clear: construction UAV adoption has real global momentum, and no study has yet looked at drone technology adoption in Bangladesh's construction industry specifically. That is the gap this review addresses.

MATERIALS AND METHODS

This paper uses a narrative review methodology. That approach fits the material: the literature on UAV engineering, construction management, and technology-adoption theory is fragmented and spans several disciplines, and the goal here is to build a conceptual framework rather than test statistical hypotheses (Onososen *et al.*, 2023; Sivaraman & Judson, 2025). Sources were located through structured searches of academic databases and industry publications, combining the terms "drone," "UAV," "construction," "Bangladesh," "BIM adoption," and "Technology-Organization-Environment." A source was included if it covered at least one of four areas: UAV or drone applications in construction globally; digital-technology adoption barriers in developing-country construction industries; the regulatory environment for UAV operation in Bangladesh; or Bangladesh's construction industry context and mega-infrastructure programme. Reference-list snowballing turned up further sources, including Sivaraman and Judson's (2025) TOE-based study of drone adoption in the Indian construction industry, which shaped the theoretical structure used here. No survey, interview, or statistical data were collected specifically for this paper — it is a conceptual and narrative synthesis, not a primary empirical study. The opportunity and barrier categories in the Results and Discussion section come from qualitative thematic synthesis of the sources reviewed, and the emphasis and frequency figures shown later (Figures 3 and 4) summarise how much attention each theme received across the literature assembled for this review; they are not primary survey results. The five-phase implementation framework (Figure 6; Table 1) was built the same way, conceptually, from the opportunities, barriers, and TOE perspective identified above, following the approach of comparable conceptual-framework papers in the drone-adoption literature (Sivaraman & Judson, 2025).

RESULTS AND DISCUSSION

The Bangladesh Construction Industry Context

Bangladesh's construction industry has grown quickly over the past decade, pushed along by urbanisation, rising middle-class demand for housing, and a heavy pipeline of state-led mega-projects. The Padma Multipurpose Bridge - a 6.15-kilometre road-and-rail crossing over the Padma River - opened to traffic in 2022 after nearly a decade of construction (SMEC, 2026; Railway Technology, 2023). MRT Line-6, the Dhaka Mass Transit Company's 20.1-kilometre elevated metro line, was built to Japanese engineering standards with JICA financing and has been fully operational since November 2023, now carrying several hundred thousand passengers a day (WinTK, 2026). Figure 2 maps this concentration of large, geographically spread, schedule-critical projects - exactly the conditions in which a technology that speeds up data capture and cuts manual survey time, like a UAV, has the most to offer.

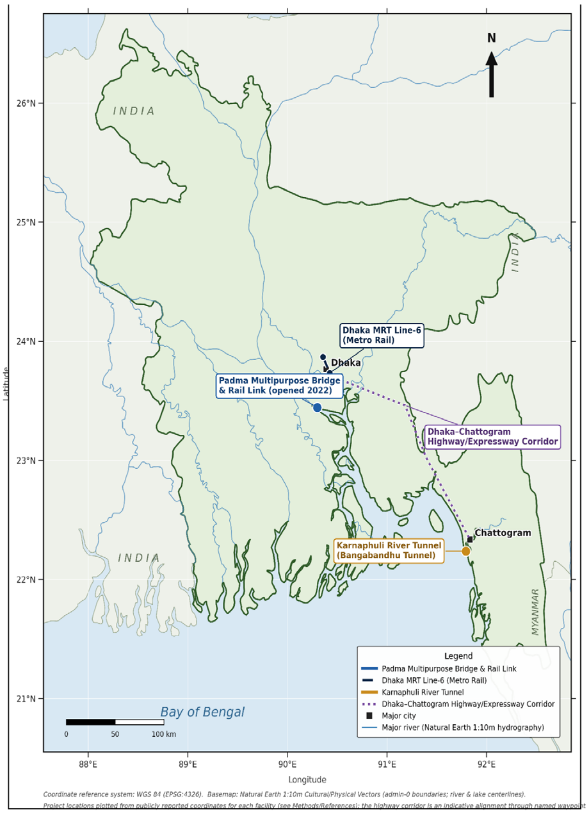

Figure 2: Study area map of Bangladesh showing the locations of key mega-infrastructure projects referenced in this review, plotted on a Natural Earth 1:10m-resolution GIS basemap (administrative boundary and river hydrography layers) using publicly reported project coordinates (see Methods and References).

This infrastructure boom has not been matched by digital-technology adoption, though. In an early empirical study, Rakib *et al.* (2018) found that most of the professionals and students they surveyed knew what BIM was, but actual proficiency and day-to-day use lagged well behind that awareness - a gap they trace to limited training infrastructure and software access. Drone technology sits differently in this picture. BIM demands significant software investment, data standardisation, and organisation-wide process change; basic UAV-based aerial photography and mapping asks for much less capital and a shorter learning curve, which could make it a more realistic first step into the country's wider digital-transformation push.

Opportunities for Drone Adoption

Five categories of opportunity stand out as particularly relevant to Bangladesh, shaped by the country's land constraints, its mega-project pipeline, monsoon exposure, and its reliance on external development financing (Figure 3).

- Land surveying and topographic mapping: Bangladesh's terrain - dense, low-lying, and often waterlogged - makes conventional ground-based surveying slow and labour-heavy. A UAV fitted for photogrammetry can cover large tracts of land far faster than a ground survey team (Guan *et al.*, 2022).
- Mega-project progress monitoring: Aerial documentation is already happening, informally, on flagship projects such as the Padma Bridge and the Metro Rail (Golden Info Systems, 2025). Building this into a structured progress-reporting workflow, rather than leaving it ad hoc, would give project owners and financiers better visibility into schedule status.
- Site safety and worker protection: Work at height - bridge-pier and viaduct construction, for example - puts workers at risk of falls and structural failure. A remote aerial inspection can do much of the routine visual checking without sending anyone up there in person (Mohsan *et al.*, 2023; Waqar *et al.*, 2023; Zhong *et al.*, 2025).
- Quality assurance and structural inspection: Imagery and point clouds captured by a UAV can be checked against the design model, catching deviations and defects earlier than a periodic manual inspection typically would (Onososen *et al.*, 2023).
- Stakeholder communication and accountability: Many of Bangladesh's biggest infrastructure projects run on multilateral or bilateral development financing - JICA's backing of the Metro Rail is one example (WinTK, 2026). Routine aerial documentation gives financiers and oversight bodies a more transparent, verifiable record of progress.

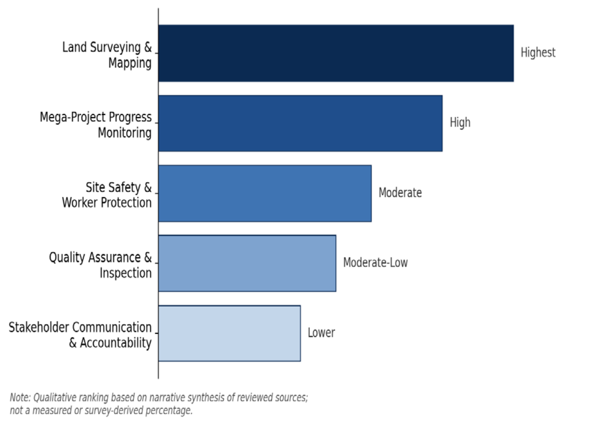

Figure 3: Relative emphasis of the five opportunity categories discussed in this review, derived from qualitative synthesis of the reviewed literature.

Barriers to Drone Adoption

These opportunities come up against a set of barriers that are interlinked and, at present, hard to get around. The financial one is the capital cost of professional-grade drones and LiDAR payloads - comparable developing markets report economic factors as the single most critical barrier to UAV-based site digitalisation, and Bangladesh looks no different (Onososen *et al.*, 2023; Aiyetan & Das, 2023; Sossah *et al.*, 2025). Skills and human capital are a second constraint, mirroring the BIM skill shortage already documented in the country (Rakib *et al.*, 2018). A third is organisational and cultural: small and medium contractors still largely run on traditional, paper-based project management, and that habit does not shift easily. A fourth concerns data security and privacy - heightened here by the state's evident caution toward unauthorised drone activity. And a fifth is environmental and operational, rooted in Bangladesh's monsoon climate and the GPS-signal degradation common in its dense urban areas.

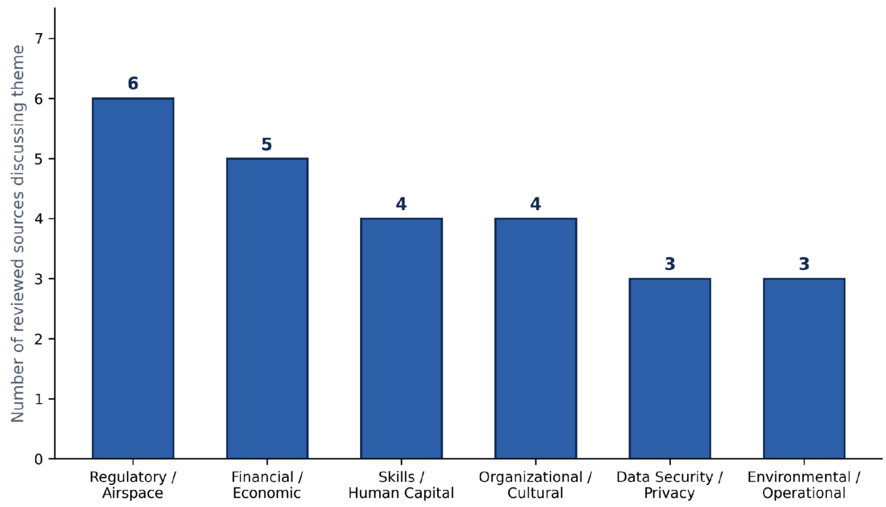

Figure 4: Frequency with which each barrier theme was discussed across the sources reviewed for this paper.

Theoretical Lens: The Technology–Organization–Environment Perspective

The Technology–Organization–Environment (TOE) framework explains innovation adoption as the product of three interacting forces: the technology's own characteristics, how ready the organisation is, and the external environment it operates in. It has already been used to explain drone adoption in other developing construction markets, including a recent TOE-based analysis of the Indian industry (Sivaraman & Judson, 2025; Boutros *et al.*, 2026). Figure 5 maps the Bangladesh case onto that same structure. The technological dimension covers drone capability, cost, and how easily it slots into existing survey and BIM workflows. The organisational dimension covers contractor and consultancy readiness, skills, and how mature their internal processes are. And the environmental dimension covers CAAB regulation, the wider digital-policy landscape, and Bangladesh's physical and institutional operating conditions.

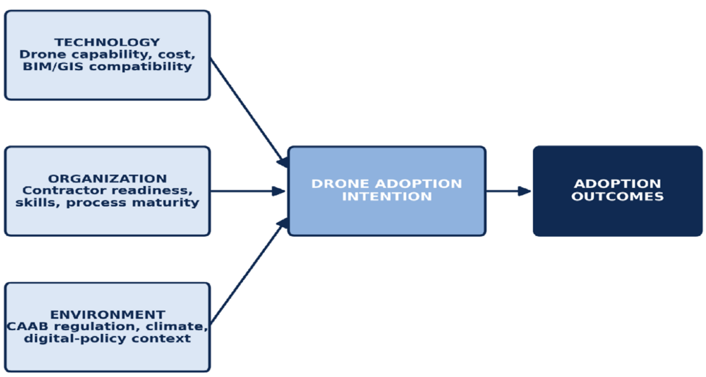

Figure 5: Conceptual path diagram of drone adoption in the Bangladesh construction industry, based on the Technology–Organization–Environment (TOE) framework. This is a hypothesised conceptual model, not a fitted statistical path model.

Proposed Framework for Implementation

Drawing on the opportunities, barriers, and TOE analysis above, this paper sets out a five-phase conceptual framework meant to guide a structured move toward mainstream drone use in Bangladesh's construction industry (Figure 6; Table 1).

Figure 6: Five-phase conceptual framework for drone technology implementation in the Bangladesh construction industry.

Table 1: Proposed five-phase implementation framework

Phase	Focus	Key Actions	Lead Actors	Time frame
Phase 1	Awareness & Capacity Building	Short courses and workshops on UAV operation, data processing, and photogrammetry; sensitization seminars for contractor associations; curriculum modules in civil engineering programs.	Universities (BUET and others), IEB, MIEB, contractor associations	0–12 months
Phase 2	Regulatory Facilitation & Standardization	Establish a streamlined permit category for registered construction-site UAV operations; publish standard operating procedures and safety checklists; align with existing CAAB circulars.	CAAB, RAJUK, LGED, Bangladesh Bridge Authority	6–18 months
Phase 3	Pilot Integration on Flagship Projects	Structured pilots on ongoing or upcoming mega-projects for survey, progress monitoring, and safety inspection; document lessons learned and cost-benefit outcomes.	Project owners, EPC/ consulting contractors, project management consultants	12–24 months
Phase 4	BIM–UAV–GIS Convergence	Integrate UAV-derived photogrammetric and point-cloud data with BIM models and municipal GIS platforms for as-built verification and asset management.	BIM consultants, IT/ GIS units, city and development authorities	18–36 months
Phase 5	Institutionalization & Policy Mandate	Incorporate UAV-based monitoring into public procurement guidelines and project reporting requirements; incentivize local drone assembly and service industries.	Ministry of Housing and Public Works, Planning Commission, development partners	36+ months

The five phases build on each other, but they are not meant to run strictly end-to-end. Figure 7 sketches an indicative timeline with deliberate overlap between adjacent phases: regulatory facilitation (Phase 2), for instance, starts while awareness-building (Phase 1) is still under way, and pilot integration (Phase 3) carries into the early part of the BIM–UAV–GIS convergence work in Phase 4.

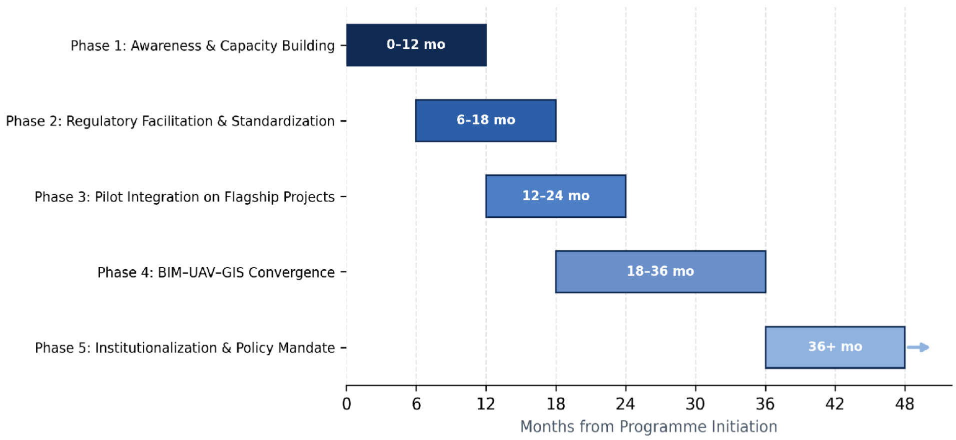

Figure 7: Indicative timeline of the five-phase implementation framework, showing planned overlap between adjacent phases.

One idea runs through all five phases: drone adoption works better framed as a complementary, comparatively low-cost entry point into Bangladesh's wider BIM and digital-construction agenda, not as a standalone initiative of its own (The Business Standard, 2024). That is why Phase 4 — integrating UAV outputs with BIM and GIS platforms — comes after pilot testing rather than at the start; BIM adoption itself is still at an early stage in Bangladesh, so building on top of it too soon would be getting ahead of the sector. Figure 8 shows what that convergence could look like: UAV-derived imagery and point clouds, BIM design and schedule data, and GIS spatial and land-record data folded into one integrated digital construction data ecosystem, instead of sitting in the separate technological silos most Bangladeshi projects currently use.

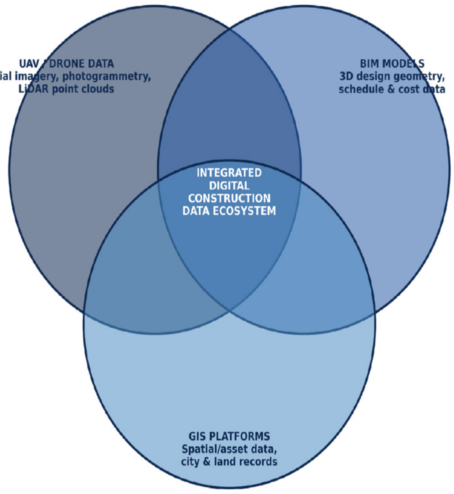

Figure 8: Conceptual diagram of UAV–BIM–GIS technology convergence proposed under Phase 4 of the implementation framework.

It is worth being explicit about what this paper is and is not. It is conceptual: the opportunities, barriers, and framework presented here come from a narrative synthesis of global and Bangladesh-specific literature, not from primary survey or interview data, and the framework's phases, actors, and timeframes should be read as a starting point for empirical refinement rather than a finished result. Quantitative outputs that need primary fieldwork — a fitted statistical adoption model with residual diagnostics, say, or a principal component analysis (PCA) score map of stakeholder survey responses — are deliberately left out here; producing them without actual survey or sensor data collected in Bangladesh would misrepresent this review as something it is not. Those remain priority outputs for the empirical follow-up study proposed in the Conclusion.

CONCLUSION

This paper has examined the opportunities and barriers around drone technology adoption in Bangladesh's construction industry, and proposed a five-phase conceptual framework for implementation grounded in the Technology–Organization–Environment perspective. Bangladesh's mega-project pipeline, land constraints, and monsoon-affected operating environment together make a plausible case for faster drone adoption. But regulatory lead times, financial and skill constraints, organisational resistance, data-security sensitivities, and environmental limitations add up to a substantial barrier of their own — one that mirrors, and in some ways compounds, the challenges the country already faces with BIM adoption.

Empirical validation of the proposed framework should be the priority for future research: structured surveys or interviews with contractors, consultants, and regulators, using TOE- or TAM-based instruments similar to those applied in comparable developing-country studies (Sivaraman & Judson, 2025); comparative cost-benefit case studies of UAV-based versus conventional surveying on a specific Bangladeshi mega-project; and policy research into whether a dedicated, fast-track permit category for registered construction-site UAV operations is workable. That follow-up study would also be the right place to build a fitted adoption model with proper diagnostic plots and a PCA-based score map of stakeholder perception data, once primary data collection in Bangladesh has actually been carried out.

Declaration of Generative AI Use

During the preparation of this manuscript, the author used an AI-based writing assistant to support language refinement and the structuring of draft text. All AI-assisted content was subsequently reviewed, fact-checked, and edited by the author, who takes full responsibility for the accuracy, originality, and intellectual content of this publication.

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