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Drone Technology in High-Rise Building Construction Monitoring: A Conceptual Review with Reference to Bangladesh's Real Estate Sector

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ABSTRACT

High-rise residential and mixed-use construction has become the dominant urban development typology in rapidly densifying South Asian cities, and Bangladesh is no exception, with land scarcity in Dhaka pushing developers toward taller, more complex structures on constrained footprints. Monitoring the progress, safety, and quality of such projects using conventional ground-based methods is increasingly difficult given vertical scale, multiple concurrent work fronts, and restricted site access. This paper presents a conceptual review of unmanned aerial vehicle (UAV or drone) applications in high-rise construction monitoring, synthesising the academic and industry literature on photogrammetry, Building Information Modelling (BIM) integration, safety surveillance, and progress tracking. The review is anchored by an illustrative case drawn from an ongoing high-rise residential development in Dhaka, where periodic aerial documentation has been used informally to support progress communication. Drawing on this practitioner vantage point together with the literature, the paper proposes a conceptual framework for structured drone-integrated monitoring across the high-rise project lifecycle and discusses the regulatory, economic, and organizational barriers that condition adoption in the Bangladesh context. The paper concludes by identifying priority directions for empirical research, including quantification of accuracy and time savings under local site conditions.

INTRODUCTION

Vertical growth has become the default response to land scarcity in large South Asian cities. In Dhaka, the scarcity of buildable land and rising plot prices have pushed residential and commercial developers toward taller structures on comparatively small footprints, a pattern widely noted in recent assessments of the Bangladesh real estate sector (Intech Properties, 2025; Kopotakkho Homes, 2025). This densification has occurred alongside persistent concerns about planning discipline, code compliance, and the absence of consistent third-party monitoring of construction quality on many sites (bti, 2018).

High-rise construction magnifies the classic monitoring problem of the industry: schedules, safety conditions, and quality benchmarks must be tracked across dozens of simultaneous work fronts distributed vertically over ten, twenty, or more stories, often within congested urban plots with minimal peripheral access. Conventional monitoring, built on manual walkthroughs, static photography, and periodic surveying, struggles to keep pace with this complexity; it is time-consuming, exposes personnel to fall and struck-by hazards at height, and produces documentation that is difficult to compare consistently over time (Ham *et al.*, cited in IJRASET review; RoboticsTomorrow, 2026).

This paper addresses this monitoring challenge conceptually rather than empirically. It synthesizes the international literature on drone applications in construction monitoring and situates it against the operating realities of high-rise construction in Bangladesh, including its regulatory environment for UAV operations and its prevailing project management practices. The review is illustrated with a case vignette from an ongoing high-rise residential project in Dhaka, where periodic aerial photography has already been used, on an ad-hoc basis, to document progress and communicate milestones to stakeholders. The paper's contribution is a conceptual framework that structures drone use across the high-rise project lifecycle and a discussion of the barriers that would need to be addressed to move from ad-hoc aerial photography toward systematic drone-integrated monitoring in the local market.

LITERATURE REVIEW

Unmanned aerial vehicles equipped with high-resolution cameras, and increasingly with LiDAR and thermal sensors, have emerged over the past decade as a practical response to the construction monitoring problem outlined above. A substantial body of work has documented drone-based visual monitoring of civil infrastructure and buildings, spanning computer-vision methods for

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progress recognition, drone-to-BIM data pipelines, and safety-focused aerial surveillance (Lin, Han, Golparvar-Fard, cited in IJRASET review; Freeman *et al.*, cited in AIoT review). Yet most of this literature originates from, or is validated in, developed-country contexts with mature regulatory regimes, established drone-service markets, and BIM-mature construction firms. Empirical and conceptual work specific to South Asian, and particularly Bangladeshi, high-rise construction remains comparatively thin.

High-Rise Construction and the Monitoring Challenge in Bangladesh

Bangladesh's real estate sector has grown from a modest base in the 1970s into a major contributor to national GDP and employment, with the Real Estate and Housing Association of Bangladesh (REHAB), established in 1991, playing a central coordinating role in the sector's professionalization (RBS Property, 2024). Urban land scarcity, particularly in Dhaka and, to a lesser extent, Chattogram, has been a persistent driver of the shift toward high-rise residential and mixed-use typologies (Intech Properties, 2025; Dhaka Tribune, 2023).

This growth has occurred against a backdrop of documented planning and monitoring weaknesses. Several industry commentaries note that high-rise buildings in Dhaka are frequently constructed on narrow plots with minimal setback, and that regulatory compliance with the Bangladesh National Building Code and the Detailed Area Plan is unevenly monitored across projects (bti, 2018; Ceramic Bangladesh Magazine, 2025). At the same time, rising construction costs, land scarcity, and regulatory approval delays are widely cited as sector-wide constraints (Emerging Real Estate Trends, 2025). Within this environment, individual developers and project management teams bear a disproportionate burden for maintaining schedule, safety, and quality assurance without extensive external oversight infrastructure to rely on.

For a project management team running a multi-tower high-rise development, this translates into a practical monitoring problem: verifying that structural progress on each tower and each floor matches the planned schedule, that safety conditions at height are being maintained, and that stakeholders, including ownership, financiers, and prospective buyers, receive credible, current visual evidence of progress. Traditional monitoring approaches, ground-level photography, periodic manual surveys, and site walkthroughs, remain necessary but are structurally limited in their ability to capture whole-site, whole-height context in a single consistent dataset.

Drone and UAV Technology: A Brief Technical Overview

Construction-grade drones range from lightweight quadcopters carrying standard RGB cameras to survey-grade platforms equipped with real-time kinematic (RTK) or post-processed kinematic (PPK) GPS modules, LiDAR scanners, and thermal sensors. Enterprise platforms such as the DJI Mavic 3 Enterprise and Matrice series, paired with dedicated photogrammetric sensors, are commonly cited in the industry literature as suited to routine site monitoring and mapping (gnss.ae, 2025). RTK/PPK-equipped survey drones are reported to achieve horizontal and vertical accuracies in the range of two to three centimeters, a level considered adequate for structural layout verification, earthwork quantification, and construction survey work (GeoBuilderBD, 2026).

The core technical process underlying most drone-based monitoring is photogrammetry: overlapping aerial images are processed to generate two-dimensional orthomosaics and three-dimensional point clouds or textured meshes that represent the as-built condition of a site at the time of capture (DroneDeploy, 2025; Earthmappers, 2026). Where higher measurement fidelity is required, particularly through vegetation or in geometrically complex areas, LiDAR-based capture is used, sometimes fused with photogrammetric data in hybrid workflows (MDPI Buildings, 2025). Quality assurance of these outputs typically involves checking geospatial accuracy and internal consistency against ground control points before the data is used for measurement or comparison purposes.

The practical value of drone-derived 3D data is realized most fully when it is integrated with Building Information Modelling. As-built point clouds or reality meshes can be imported into BIM authoring and coordination platforms to support clash detection and as-built-versus-as-planned comparison (DroneDeploy, 2025; Castle Surveys, 2026). When linked to a project's construction schedule, this comparison becomes four-dimensional (4D), allowing project teams to visualize not just geometric deviation but also schedule variance at the element level. Several authors have further argued that combining photogrammetric point clouds with 4D BIM can support automated safety monitoring, for instance by cross-referencing visible personal protective equipment against zones flagged as active or hazardous in the schedule (MDPI Applied Sciences, 2021).

Applications of Drones in High-Rise Construction Monitoring

The most widely reported application of drones in construction is progress monitoring: capturing consistent, geo-referenced imagery at regular intervals, typically daily, weekly, or monthly, and comparing successive datasets against the planned schedule and design intent (RoboticsTomorrow, 2026; Eagleview, 2025). For high-rise buildings specifically, an aerial vantage point offers something ground-level photography cannot: a single frame that captures the relative progress of multiple towers, multiple floors, and the surrounding site logistics simultaneously. This is of direct value where, as is typical in multi-tower developments, different blocks progress through excavation, substructure, and superstructure stages concurrently.

High-rise construction carries elevated risk from falls, falling objects, and complex crane and hoist operations. The literature identifies drone-based visual monitoring as a tool for observing PPE compliance, edge protection, and material staging at height without requiring personnel to physically access every elevated work front for inspection purposes (MDPI Applied Sciences, 2021). While fully automated safety-detection systems using computer vision remain an active research area rather than a mature commercial product in most markets, the underlying image capture capability is already operationally accessible.

Photogrammetric and LiDAR-based point clouds allow project teams to verify structural geometry, such as floor slab levels, column alignment, and building envelope progress, against design models, supporting earlier detection of deviations before they compound through subsequent construction stages (MDPI Buildings, 2025). This is particularly relevant to superstructure and facade works, where cumulative small deviations across many floors can become costly to remediate late in a project.

Beyond the building itself, drones support site-wide logistics: volumetric calculation of excavation and stockpiled material, tracking of laydown areas, and monitoring of access routes and congestion, all of which are reported to be faster and less labor-intensive than equivalent ground survey methods (theaecassociates, 2025; GeoBuilderBD, 2026).

Aerial imagery and derived orthomosaics provide an accessible, intuitive format for communicating progress to stakeholders who lack technical training to interpret schedules or engineering drawings, including ownership, financiers, and prospective buyers. Industry sources describe this as a shift toward a shared, digital-twin-like reference point that reduces the ambiguity and disputes that arise from inconsistent site reporting (RoboticsTomorrow, 2026).

Barriers to Drone Adoption in Construction

A consistent finding across the international literature is that drone adoption in construction lags behind its demonstrated technical value, and that the barriers are only partly technical. Recent studies using structural equation modelling and interpretive structural modelling in Saudi Arabia and the Indian subcontinent identify four recurring barrier categories: regulatory complexity, economic constraints, technical or operational limitations, and public perception or organizational readiness issues (Emerald/World Journal of Engineering, 2025; Scientific Reports, 2025). A related stream of research focused specifically on developing-country contexts, including South Africa and India, similarly identifies economic, operational, and social-legal barriers, while proposing interventions such as clearer government policy, training and licensing pathways, and dedicated budgeting for drone operations within project costs (Aiyetan and Das, cited in Tandfonline, 2022).

In Bangladesh, commercial drone operations, which would include systematic construction-site monitoring, fall under the jurisdiction of the Civil Aviation Authority of Bangladesh (CAAB). Current guidance indicates that any drone used for filming, photography, or data collection, or exceeding roughly 248 grams in weight, must be registered with CAAB, and that commercial use requires a specific flight permit, with applications reportedly needing to be submitted well in advance of the intended flight (drone-laws.com, 2026; UAV Coach, 2022). Liability insurance is described as mandatory for commercial operations, and pilots operating certain drone categories require a Remote Pilot Certificate (drone-laws.com, 2026). For a construction project team, this means that routine, scheduled drone monitoring cannot simply be adopted ad-hoc; it requires deliberate planning around registration, permitting lead times, and pilot certification, distinct from the informal, occasional photography illustrated in Section 4.1.

Cost remains a frequently cited barrier, particularly for firms operating on tight project margins, whether the cost of survey-grade equipment and RTK/PPK infrastructure, of contracting third-party drone survey providers, or of the software licenses required to process photogrammetric data and integrate it with BIM (Academia.edu survey, 2025). In the Bangladesh construction sector, where BIM adoption itself remains uneven across firms, the marginal value of drone-BIM integration may not be immediately apparent to project sponsors unfamiliar with digital project controls, reinforcing a broader pattern in which developing-market drone adoption trails developed markets despite comparable or greater underlying need (Discover Robotics, 2025).

Operational limitations, including battery endurance, weather sensitivity, obstacle-dense urban airspace around adjacent buildings, and the technical skill required to process and interpret photogrammetric outputs, are commonly cited constraints (MDPI Drones and Autonomous Vehicles, 2023). In a market where formally trained UAV pilots and photogrammetry specialists are not yet widely embedded within construction project teams, sustained drone-integrated monitoring is more likely to depend on third-party survey providers in the near term than on in-house capability.

MATERIALS AND METHODS

This paper adopts a conceptual review methodology rather than a systematic empirical study, appropriate to its aim of synthesising a fragmented evidence base and proposing a practice-oriented framework for an under-researched local context. The review draws on a purposive synthesis of two literature streams: (i) peer-reviewed academic sources addressing drone-based photogrammetry, BIM integration, and safety monitoring in construction (e.g., published in Applied Sciences, Buildings, Drones, World Journal of Engineering, and Scientific Reports), and (ii) industry and grey literature specific to the Bangladesh real estate and construction sector and its UAV regulatory environment, reflecting the comparative scarcity of peer-reviewed, Bangladesh-specific empirical studies on this topic. Sources were identified through targeted searches of academic databases and industry publications and selected for relevance to high-rise construction monitoring, drone/UAV applications, BIM integration, and adoption barriers in developing-country contexts.

The literature synthesis presented in Section 2 was used to (a) characterise the current state of drone-based construction monitoring practice and technology internationally, and (b) identify barrier categories relevant to adoption in a developing-country, and specifically Bangladeshi, context. These findings were then used inductively to develop the three-tier conceptual framework presented in Section 4.2, intended to structure the transition from informal to systematic drone-integrated monitoring on high-rise projects.

The literature synthesis and proposed framework are illustrated, rather than empirically validated, through a single case vignette drawn from an ongoing high-rise residential project in Dhaka to which the author has direct practitioner access as part of his project management role. Aerial photographic documentation captured during routine site monitoring (June 2026) is used descriptively in Section 4.1 to ground the conceptual applications discussed in the review against an observed local example. This case-illustration approach is appropriate to the conceptual, hypothesis-generating aim of the paper but does not constitute empirical validation; quantitative validation of the proposed framework under local site and regulatory conditions is identified in Section 4.3 and the Conclusion as a necessary direction for future research.

RESULTS AND DISCUSSION

Illustrative Case: Aerial Documentation on a Dhaka High-Rise Project

The applications discussed in Section 2 can be illustrated with reference to an ongoing multi-tower high-rise residential development in Dhaka, where periodic drone photography has been used informally to document construction progress. Figure 1 shows a top-down aerial view capturing several towers at varying stages of superstructure construction, a tower crane and mobile crane in active use, and the surrounding site logistics, including material laydown, batching arrangements, and the boundary hoarding separating the site from the adjacent public road.

Even at this informal, non-systematized level of use, the image illustrates several of the conceptual applications reviewed above in a single frame: relative progress comparison across towers without requiring separate ground visits to each block; visibility of crane operating envelopes and their proximity to completed and adjacent structures, relevant to safety planning; and a stakeholder-legible record of the type increasingly expected by ownership and financing partners. What is absent, and what distinguishes ad-hoc aerial photography from the drone-integrated monitoring described in the literature, is systematic capture at fixed intervals, georeferencing and processing into comparable orthomosaics or point clouds, and linkage to the project schedule or BIM model for quantified as-built-versus-as-planned analysis. The gap between the two is the practical starting point for the conceptual framework proposed below.

Figure 1: Top-down drone view of a multi-tower high-rise residential project under construction in Dhaka, illustrating simultaneous superstructure progress across towers, active tower-crane operation, and site logistics. Image captured June 2026.

A Conceptual Framework for Drone-Integrated Monitoring on High-Rise Projects

Building on the applications and barriers reviewed in Section 2, this paper proposes a three-tier conceptual framework for moving from informal aerial photography toward structured drone-integrated monitoring on high-rise projects in the Bangladesh context. The framework is deliberately staged to reflect the economic and capability constraints discussed in Section 2.4, rather than assuming immediate access to full BIM-integrated workflows.

At the baseline tier (Tier 1 — Documentary Capture), drone flights are scheduled at fixed intervals, for example monthly, and used to produce a consistent photographic and orthomosaic record of the site, without formal BIM linkage. This tier requires the least investment and directly extends the type of use already illustrated in Section 4.1.

At the intermediate tier (Tier 2 — Quantified Progress and Safety Tracking), captured imagery is processed into georeferenced orthomosaics and, where justified, point clouds, enabling quantified comparison of progress against the planned schedule and visual auditing of safety conditions at height, edge protection, and material staging, across capture cycles.

At the most advanced tier (Tier 3 — BIM-Integrated As-Built Verification), drone-derived point clouds and orthomosaics are imported into the project BIM environment for element-level as-built-versus-as-planned comparison, supporting 4D schedule verification and early clash or deviation detection, consistent with the workflows described in the international literature (Castle Surveys, 2026; MDPI Buildings, 2025). This tier presumes an existing BIM-enabled project delivery process and is realistically a medium-term objective for most Bangladesh developers rather than an immediate starting point.

Progression through the tiers is not intended as a rigid sequence but as a practical maturity model: a project team can adopt Tier 1 immediately at low cost, while treating Tiers 2 and 3 as capability investments to be phased in as project scale, financing partner requirements, or organizational digital maturity justify the additional cost and coordination overhead.

Discussion and Directions for Future Research

This review has been deliberately conceptual: it synthesizes international evidence on drone applications and adoption barriers and situates that evidence against the documented realities of Bangladesh's high-rise construction sector and its UAV regulatory framework, illustrated with a single practitioner case vignette rather than a systematic empirical dataset. This is both the paper's contribution and its principal limitation. Three research directions follow directly from this limitation.

First, there is a clear need for empirical, project-level studies that quantify the time and cost differential between drone-based and conventional progress monitoring on Bangladeshi high-rise sites, extending the kind of survey-based accuracy and efficiency claims reported in other markets (GeoBuilderBD, 2026) into a locally validated evidence base. Second, research is needed on the specific interaction between CAAB's permitting timelines and the operational tempo of construction projects, since a permitting process requiring substantial advance notice, as currently described in public guidance, may be poorly matched to the responsive, frequent capture cadence that progress monitoring ideally requires. Third, given the uneven BIM maturity across Bangladeshi developers noted in Section 2.4, research into lightweight, non-BIM-dependent drone monitoring workflows, corresponding to Tier 1 and Tier 2 of the framework proposed above, may have more immediate practical relevance to the sector than research premised on full BIM-integrated Tier 3 adoption.

For practitioners, the framework proposed in Section 4.2 offers an actionable entry point: formalizing existing informal drone use into a Tier 1 documentary capture programme is achievable within current organizational and regulatory constraints, and provides the operational foundation, consistent site imagery, established flight and permitting routines, on which Tier 2 and Tier 3 capability can later be built.

CONCLUSION

Drone technology offers a well-evidenced set of applications for high-rise construction monitoring, spanning progress tracking, safety surveillance, quality documentation, and stakeholder communication, and the underlying photogrammetric and BIM-integration methods are mature in the international literature. Their application to Bangladesh's high-rise residential sector, however, remains largely informal and under-researched, constrained by regulatory permitting requirements, cost, and uneven digital project-management maturity rather than by any lack of demonstrated value. Using an illustrative case from an ongoing Dhaka high-rise project, this paper has argued that the practical path forward for most Bangladeshi developers lies not in immediate adoption of fully BIM-integrated drone workflows, but in a staged progression, beginning with formalized documentary capture and advancing toward quantified and BIM-integrated monitoring as organizational capability and project scale justify the investment. Empirical validation of this framework, and of the time, cost, and safety benefits it implies under local regulatory and site conditions, is the necessary next step.

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