# Implementation of Drone Technology in the Kenyan Construction Industry

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## Abstract

The world is constantly evolving, creating a need for more efficient, safe and timely technologies. The increase in the number of construction-related injuries and fatalities in Kenya prompts the construction industry to look into more efficient and safe technologies for conducting time-consuming activities such as survey, mapping and quality assurance and control. High-rise structures, for instance, require regular inspection which can be costly in terms of the safety of the workers and time.

This paper aims to replace visual inspection of high-rise buildings with the use of basic drones to ensure the safety of the workers and efficient data collection. This will be done using Unmanned Aerial Vehicles (UAV) equipped with DroneDeploy software to collect real-time construction data. The data collected will then be used to generate 2D plans and 3D models of the building that can then be shared with the involved stakeholders for analysis and inspection.

The construction industry is rapidly booming and adapting drone technology prospects manifold growth. The use of drone technology in construction shares countless advantages. If implemented, this would be a stepping stone for the construction industry as it is still lagging behind when it comes to adopting new technologies.

**Keywords:** Drone technology, Unmanned Aerial Vehicles (UAV), DroneDeploy Software, REVIT, 3D maps and models

## 1. Introduction

### 1.1 Overview of the Research Topic

The Kenyan construction industry contributes to 5.5% of the country's GDP and spends over Ksh. 3.2 billion in annual wages of over a million workers. Since it deals with millions of people, its negative contributions, such as risks of accidents, cannot be left unmentioned. Globally, the construction industry contributes to roughly 60,000 fatal accidents annually. In Kenya, the construction industry contributed to 237 fatal injuries between 2014 and 2018, with Nairobi recording over a quarter of this number. These numbers are on the rise and are contributed to by substandard occupational safety practices and neglect (Makori et al., 2018).

Traditional remedies such as maintenance of construction equipment to the standard of the contracts, regular and quality inspection projects; and auditing of the contractors and skilled laborers have proven to be only sufficient to an extent when correctly implemented, yet time-consuming (Makori et al., 2018). Regular inspection of high-rise buildings with scaffolding for access has also put more workers and professionals at the risk of falling and losing their lives. There is, thus, a need for a more innovative and safe method of conducting quality assurance and control inspections such as the use of drones, otherwise referred to as Unmanned Aerial Vehicles (UAVs). These are small aerial vehicles without pilots on board and controlled by ground-based controllers, either remotely or autonomously, through communication systems.

The proposed use of UAVs in the construction industry has countless benefits such as timely and secure inspections of structures of great heights by generating real-time videos, images, and models for façade analysis of structures and quality assurance and control determination in more details than can be achieved on-site. This will immensely save the country on various construction-related costs (Ly, 2018).


*Figure 1.1: Benefits of using UAVs in construction (Ayemba, 2018)*

## 1.2 Problem statement

The increasing numbers of reported cases of construction-related injuries and fatalities in Kenya, especially in regions such as Kasarani and Kibera in Nairobi, have been quite alarming. The methods and policies implemented by the government as well as quality assurance bodies such as the National Construction Authority, could be improved by the use of drone technology. As such, there is a need for the use of revolutionary technologies to ensure workers' and professionals' safety and improve the timeliness and cost of construction activities.

## 1.3 Research Objectives

To use technological innovations to generate an efficient, cost-effective and safe construction environment by doing away with human inspection of high-rise structures.

## 1.4 Literature Review

As an innovation of real-time monitoring technology, drones have numerous applications in the various phases of civil engineering projects by capturing images and videos of different project elevations as many as possible. UAVs have been employed in multiple transportation sectors such as traffic controls and surveying, analysis of accidents, and monitoring of repair and construction activities. Developed countries such as the United States of America have been using drones for construction site inspections to ensure the workers' safety. African countries such as Malawi, South Africa and Tanzania have also embraced drones in construction. Contrary to human assessment, UAVs can be flown over vast areas to collect large amounts of data.

Applications of UAVs in construction monitoring and quality control includes; -

i. **Project Progress Process**

One of the critical tasks in a construction project is progress monitoring. The assessment of progress provides an opportunity to recognize the as-built project conditions and identify the existing disparities between the as-built and the as-constructed/as-planned progress. Consequently, the process assists in determining appropriate corrective measures to be implemented. The inspection and monitoring of site progress is essential as it provides a means for the assessment of site conditions and plays a crucial role in ensuring quality and timely delivery of projects within the given budget. Due to its importance, it is one of the most time-consuming construction activities due to the existing interdependency and convolution of activities.

UAVs have proven to be the most useful technology in solving this puzzle. The implementation of drones in the construction industry for project monitoring purposes creates a means of effectively controlling the site. The Associated General Contractors of America (AGC) have attested that with UAVs' use, the progress of progress can be documented and these visual records used to solve arising disputes between the contractors and the engineers or clients. These aerial vehicles can cover large areas while collecting data in the form of real-time images and videos. They collect data from all locations and angles of the construction site. This enables a straightforward relation between the pre-construction and construction phases (Kopsida, 2015).

ii. **Damage Assessment**

For a rapid response, rescue and recovery planning for post disasters such as earthquakes and floods, quick detection of the damages caused in buildings or on-going construction sites is essential. Remote sensing, in light of the advancement of technology, is a vital tool for damage assessment. Image-based assessments cover vast areas and are easily understood during the evaluation process, provided skilled surveyors study them. Damages in construction are very significant and demand a lot of attention. Countries such as the United States have been using drones to monitor construction projects with the aim of early detection of damages. Since drones provide high-resolution images from all angles, they become handy in efficiently providing engineers with accurate information on the onset of damages (Fernandez et al.,2015).

iii. **Safety assurance**

Globally, the construction industry ranks first in the list of most dangerous working environments. This makes safety one of the most significant concerns in construction sites. There are high-risk, unavoidable and hazardous worker interactions in the areas, creating a need for safety measures to ensure the mitigation of injuries or fatalities. These accidents and deaths can be prevented by adopting structured safety inception at the beginning of the projects and as they progress. Workers' safety can be drastically improved by eliminating high-elevation human monitoring and inspection, which is traditionally done using mechanical lifts and scaffolding.

Various technologies can be used to eliminate risky construction situations. These technologies include the Radio Frequency Identification (RFID), Ultra-wide Band (UWB), BIM applications, Wireless Networks (WN), and, recently, the use of UAVs. UAVs have been essential in collecting real-time data on blind spot areas, especially in high elevation, from different angles. They have become instrumental in providing warnings on perilous spots in large construction sites in all phases, from preparation to completion. Since they hover around the construction site, they can provide data on the location of moving equipment, blind spots, dangerous materials, and personnel to ensure timely issuing of warnings to prevent the occurrence of accidents. The UAVs also assist in the rapid identification of accident scenes and the location of the injured victims. Thus, this technology has the perspective of helping the contractors and project managers ensure the safety of all the stakeholders and minimize the occurrence of construction-related accidents (Skibniewski, 2014).

## 2. METHODOLOGY

Drones come in different sizes ranging from small ones to big ones spanning over 60 meters. They have different flight distances. Surveying and monitoring of progress in civil engineering projects require small drones. The drones necessary for civil infrastructure- related missions have a flight altitude of not more than 120 meters, a height sufficient for activities such as inspection and surveying of high-rise structures. A typical commercial drone can fly for 55 minutes without charging. UAVs can be classified as fixed-wing UAVs (advanced in longer-range coverage and flight endurance) and rotary-wings UAVs (having short take-off and landing times and capable of hovering). The rotary-wings UAVs are most suitable for infrastructure monitoring.

To effectively apply drones in the construction industry, they need to be incorporated with a detecting system. The most common techniques used are high-resolution cameras, useful in visual monitoring sites and infrastructure conditions. Thermal cameras come in handy in regions where the visual field is crippled or in inaccessible areas. Impulse thermography is useful in detecting the presence of voids in concrete members. It is capable of producing accurate information on structural degradation. RADAR (Radio Detection and Ranging), LiDAR (Light Detection and Ranging), X-rays and metal detection can also be incorporated in drone technology for mapping and inspection (Fan and Saadeghvaziri, 2019).

Construction activities can be continuously monitored using drones. At critical phases of the construction, a software-equipped UAV is flown, by a skilled ground-based operator, at least four times in predefined routes to capture data at various angles and distances. In the initial phases of the construction project, a camera and sensor-equipped drone is flown at the height of 30 meters above the structure with its camera/sensor at an angle of 0 degrees. As the construction progresses, sets of drone flights are arranged. For a high-rise building under construction, the first flight involves flying the drone at the height of 20metres above the building height with its camera at an 80-degree angle. The third data set is captured with the drone flown at the height of 20-30 meters above the specific areas of interest with the camera at an angle of 45 degrees. Finally, the UAV is flown at the height of 20-30 meters, with the camera tilted at an angle of 30 degrees. It is important to note that the flight distances and camera angles can be customized depending on the intended study/activity or data to be captured. The drones can also be flown inside the buildings and used to capture up-close and detailed data (Anwar et al., 2019).

Once the aerial photography phase is over, the collected images and videos are compiled using basic software known as DroneDeploy and reconstructed into 3D models. These models are produced through semi-automated or manual methods. Manual methods generate 3D geometrical models, which are used together with videos for monitoring of progress. The 3D models are exported in .obj format, imported and analyzed by a software known as REVIT. Here, the models are overlaid with as-designed models to assess the building (Ham et al., 2016). For the detection of damages and cracks in concrete structures, algorithms are utilized. Videos obtained from a UAV flight can also detect cracks with up to 91.9% sensitivity and 97.7% specificity. Texture and color algorithms, currently used in other fields, can also be used in construction projects to detect corrosion and deformation in structural members. The generated models from different construction phases can also be overlayed to monitor progress and identify any damage or impending danger (Fan and Saadeghvaziri, 2019).

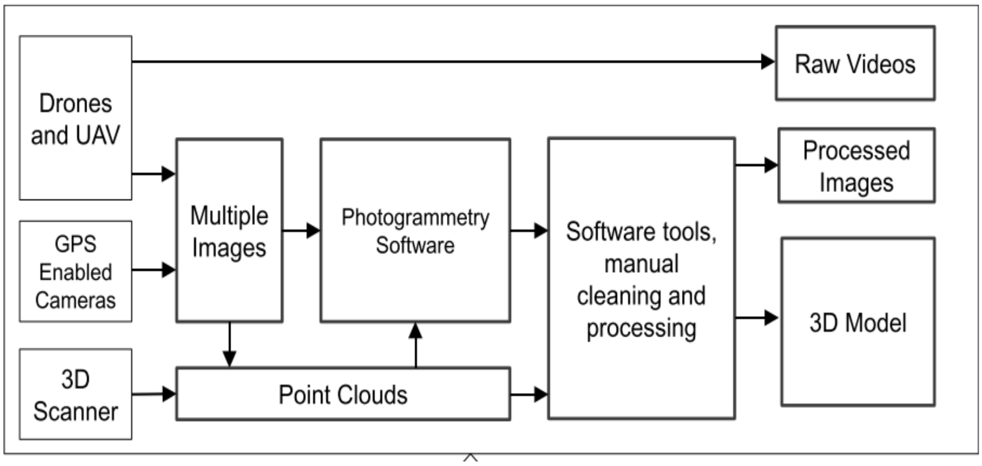


*Figure 2.1: The general process of using drones in construction (Fan and Saadeghvaziri, 2019).*

## 3. RESULTS

The traditional construction monitoring approaches have proven to be relatively rigid and give no room for accurate progress monitoring and comparison. On the other hand, the use of UAVs provides sequential real-time data collected using high-resolution cameras and sensors. The data collected can then be applied in the following regions:

1. 3D scanning of the Construction site: This helps determine the location of various elements of the construction site as well as recording progress.
2. Progress assessment: Aerial photography using UAVs is an important tool in surveying as it assists in coming up with 3D maps of the site. These maps can be generated for the different construction phases and stored for thorough assessment of the work progress. Overlaying of 3D maps and models in REVIT enables the detection of delays in the construction schedule.
3. Measurements of volumes: using the generated 2D and 3D maps, volumes of large areas (a task that could be cumbersome when done manually) can be accurately generated in minutes.
4. Inspection of the building under construction: The involved stakeholders can study the generated maps of the building and videos at the comfort of their offices. This gives them more time to thoroughly assess the project at the moment and in the future. It also reduces the risk of climbing very tall structures for monitoring (Anwar et al.).

## 4. DISCUSSION

As the world continues to embrace technological advances, the Kenyan construction industry needs to embrace technology to eliminate risky situations. Using UAVs for quality assurance and control in place of human inspection should be one of such revolutions.

Use of UAVs Vs. Human inspection of High-rise buildings.

- Using UAVs is a safer-methods as it eliminates the dangers such as falling or getting involved in construction-related fatal accidents, saving on the cost of insurance of construction workers and professionals. They can also be used to access hazardous areas.
- UAVs can collect highly detailed and in-depth data free from bias at angles and elevations that humans cannot.
- UAVs for inspection are time-saving as they have a short deployment time and only take 15 to 20 minutes to inspect a building completely.
- Drones are very flexible in terms of size, purpose, and the types of data they can collect. Some drones are equipped with cameras for videos and images, while others have thermal sensors for thermal images and analysis (Loveless, 2017).

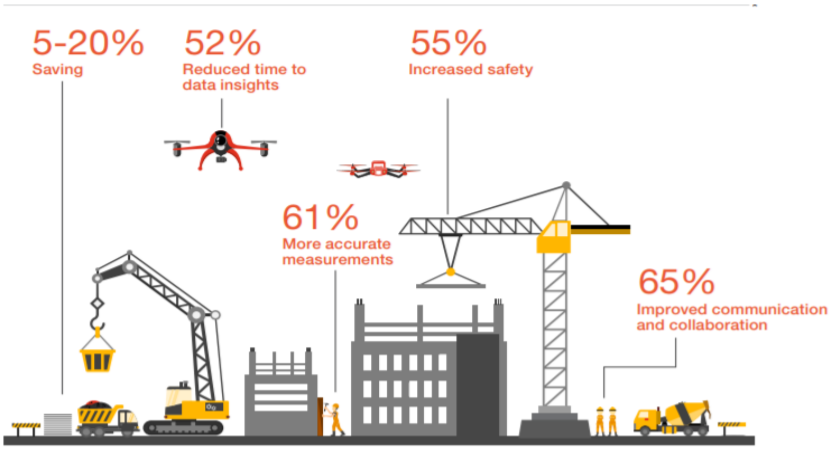


*Figure 3.1: Benefits of using UAV in construction (Ayemba, 2018)*

## 5. CONCLUSION

This paper endorses the adoption of Unmanned Aerial Vehicles in the construction industry to inspect high-rise buildings to eliminate the risks associated with human inspection. This technology includes taking real-time high-resolution images and 4K videos using UAVs flown at different angles and elevations, compiling and transforming these images into 3D maps and models for analysis and studies by the responsible personnel.

UAVs can be used for several tasks on a construction site due to their flexibility. It is a disruptive technology prospected to reform the ways land surveys and monitoring of construction sites are conducted. The implementation of drone technology in the rapidly-booming Kenyan construction industry would be a stepping stone for the sector as it has a long way to embrace the advancing technologies.

## Reference

Anwar, N., Izhar, M. A. And Najam, F. A "Construction Monitoring And Reporting Using Drones And Unmanned Aerial Vehicle (UAVs)". pp. 3-6. (2019).

Ayemba, D. (2018). *Utilizing Drone Technology in Construction*. Retrieved from Construction Review

Fan, Jin, and Ala Saadeghvaziri. "Application Of Drones In Infrastructure: Challenges And Opportunities", pp. 2-3.(2019).

Ham, Youngjib et al. "Visual Monitoring Of Civil Infrastructure Systems Via Camera-Equipped Unmanned Aerial Vehicles (UAVs): A Review Of Related Works". Visualization In Engineering, vol 4, no. 1, (2016).

Kopsida M, Brilakis I, Vela PA. A review of automated construction progress monitoring and inspection methods. InProc. of the 32nd CIB W78 Conference. pp. 421-431. (2015)

Fernandez Galarreta J, Kerle N, Gerke M. UAV-based urban structural damage assessment using object-based image analysis and semantic reasoning. Natural hazards and earth system sciences. (2015).

Loveless, Caroline. "Drones In Construction". SSRN Electronic Journal, pp. 2-3. (2017)

Makori, G.O, Edward, G.M, and John Bosco Njoroge. "Evaluation of Factors that Contribute to Occurrence of Accidents at Construction Sites in Nairobi County". *Scientific Research Journal*, Vi, No. Viii, (2018)

Ly, Lisa. "Benefits of Using Drones for Construction Projects," USCAD." (2018).

Skibniewski, Miroslaw. "Research Trends In Information Technology Applications In Construction Safety Engineering And Management". Frontiers Of Engineering Management, vol 1, no. 3, 2014, p. 246.