Evaluating the potential of UAV technology to enhance the realization of the UN's Sustainable Development Goals and Fundamental Geospatial Themes: Evidence from SASDI and DLRRD's drone initiatives

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SUMMARY

Geospatial information is increasingly recognized as essential infrastructure for evidence-based governance and monitoring progress toward the United Nations Sustainable Development Goals (SDGs). This paper evaluates the contribution of Unmanned Aerial Vehicle (UAV) technology to enhancing the availability, accuracy, and usability of geospatial data in support of SDG implementation, drawing on evidence from South Africa's Spatial Data Infrastructure (SASDI) and the Department of Land Reform and Rural Development's (DLRRD) National Drone Programme.

The study situates UAV deployment within national and international geospatial governance frameworks, including the alignment between SASDI Themes and the UN Fundamental Geospatial Data Themes. Despite institutional advances through mechanisms such as the Committee for Spatial Information, persistent gaps remain in data resolution, timeliness, and operational usability. UAV technology addresses these limitations by enabling rapid acquisition of high-resolution, context-specific geospatial datasets.

Three case studies demonstrate the applied value of UAV-enabled geospatial intelligence. In Ladysmith, UAV-derived elevation models and orthomosaic are informing flood risk analysis and infrastructure planning, contributing to climate resilience and sustainable urban development (SDGs 11 and 13). In Sikiti, UAV deployment supported real-time disaster response through improved situational awareness and search-and-rescue operations contributing to reducing disaster impact (SDG 11.5). In Grabouw, UAV deployment supports GeoAI driven urban sprawl monitoring contributing to sustainable cities (SDG 11). These findings highlight UAVs' capacity to strengthen the practical implementation of Fundamental Geospatial Data Themes, particularly for elevation, land use, buildings and settlements and built environment monitoring.

While UAV-derived data are not yet suitable for national-scale base data coverage, they offer substantial value for localized interventions and disaggregated SDG monitoring. The paper concludes that formal integration of UAV products into national geospatial frameworks—through standardized technical specifications and governance mechanisms—is necessary to fully realize their potential.

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1. Introduction

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) characterizes geospatial information as a "digital currency" essential for evidence-based planning and decision-making (UN-GGIM, 2018). Geospatial information is increasingly recognized as a critical resource for monitoring progress toward the United Nations Sustainable Development Goals (SDGs), particularly through the use of Fundamental Geospatial Datasets.

This paper examines the potential of Unmanned Aerial Vehicle (UAV) technology to accelerate and strengthen efforts toward achieving the SDGs, with a specific focus on its role in enhancing the availability, accuracy, and implementation of Fundamental Geospatial Data. The study draws on the case of the South African Department of Land Reform and Rural Development's (DLRRD) national drone programme to illustrate the application of UAV technology in supporting sustainable development initiatives.

2. Background and Context

The Inter-Agency and Expert Group on the SDG Indicators (IAEG-SDGs) concluded that geospatial information and Earth Observation (EO) supported by partnership with key stakeholders can provide *"new and consistent data sources and methodologies to integrate multiple "location-based" variables to support and inform official statistics and indicators for the SDGs"*[UN Statistics, 2025]. Consequently, the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) published a list of Global Fundamental Geospatial Data Theme which serves as the foundational data for SDGs [UN-GGIM, 2019).

South Africa's Spatial Data Infrastructure Acts established the South African Spatial Data Infrastructure (SASDI) as "*the national technical, institutional and policy framework to facilitate the capture, management, maintenance, integration, distribution and use of geospatial information"* [South Africa, 2003]. The SASDI identified [1]ten prioritized base data set themes (referred to as SASDI Themes) as the key geospatial information required to advance local and national priorities. Comparatively, 68% of the SADI Themes are aligned with the

[1] 10 Prioritized SASDI Themes includes: Administrative Boundaries, Cadastre, Conservation, Geodesy, Hydrology, Imagery, Land Cover, Land Use, Social Statistics, and Transport, see "http://www.sasdi.gov.za/sites/SASDI/Acts%20Policies%20and%20Procedures/List%20of%20appointed%20base%20data%20set%20custodians%20-%2030%20November%202020.pdf"

United Nations (UN) Fundamental Geospatial Data Themes with the exception of themes: Addresses, Buildings and Settlements, Elevation and Depth, Geographical Names, Geology and Soils, and Physical Infrastructure.

The Committee for Spatial Information (CSI) established in terms of section 5 of the SDI Act to oversee the implementation of SASDI has resolved to align SASDI Themes with that of the UN to improve the country's data readiness for sustainable development goals (SDGs) reporting. The assessment of alignment of the themes showed: Differences in naming conventions (e.g. Administrative Boundaries and Functional Areas); certain UN Themes not prioritized; and Land Cover and Land Use separated in SASDI Themes and combined in the UN Themes. The CSI therefore prepared an alignment plan guided by the following principles:

- Where SASDI Theme aligns with UN Themes, the CSI resolved to prioritize the naming convention of SASDI Themes, (e.g. Cadastre instead of Land Parcels). The implementation documentation will demonstrate linkages.
- Where there is non-alignment, the country will adopt the UN Themes *"as is"* and develop a prioritization plan advised by the national priorities.

3. Use of UAV to support national planning

The National Drone Program of the Department was introduced in 2022 to provide mechanism for ad-hoc data collection to support various mandates of the department inclusive of land reform, spatial planning and land use management, rural development, agriculture and land administration. The program was extended beyond the mandate of the Department and provides support for other government entities such as Boarder Management Authority, National Disaster Risk Centre, etc. To date, the Program has provided support to various initiatives such as those used in the case examples below.

National Drone Program at a glance

The image below shows the national footprint of the program which includes:

- A Total of 50 certified pilots in each province within South Africa.
- Procurement of infrastructures inclusive of drones (Fixed-Wing and Multi-Rotor), vehicles and storage facilities in accordance with the prescribed standards by the South African Civil Aviation Authority (SACAA).
- Processing licenses obtained through the extension of the enterprise license agreement between the Department and ESRI South Africa. This include the use of story maps to publish details of the program, see "DLRRD National Drone Programme"

In line with South African Civil Aviation Authority (SACAA) regulatory requirements, the Department of Land Reform and Rural Development (DLRRD) successfully obtained an Unmanned Aircraft Systems Operator Certificate (UASOC) in 2025, thereby enabling the

Department to operate Unmanned Aerial Vehicles (UAVs) independently for official surveying, monitoring, and geospatial data acquisition purposes.

Through the program, the Department is able to capture high resolution imagery (RGB, multispectral, panchromatic and Obliques at 1.29cm Ground Sampling Distance (GSD) resolution or lower) and LiDAR data. This also enable the department to create by-products (such as digital elevation models, 5cm contours, etc.) and create products such as a digital twin model which was created for Victoria West town in the Northern Cape province, see Victoria West Digital Twin.

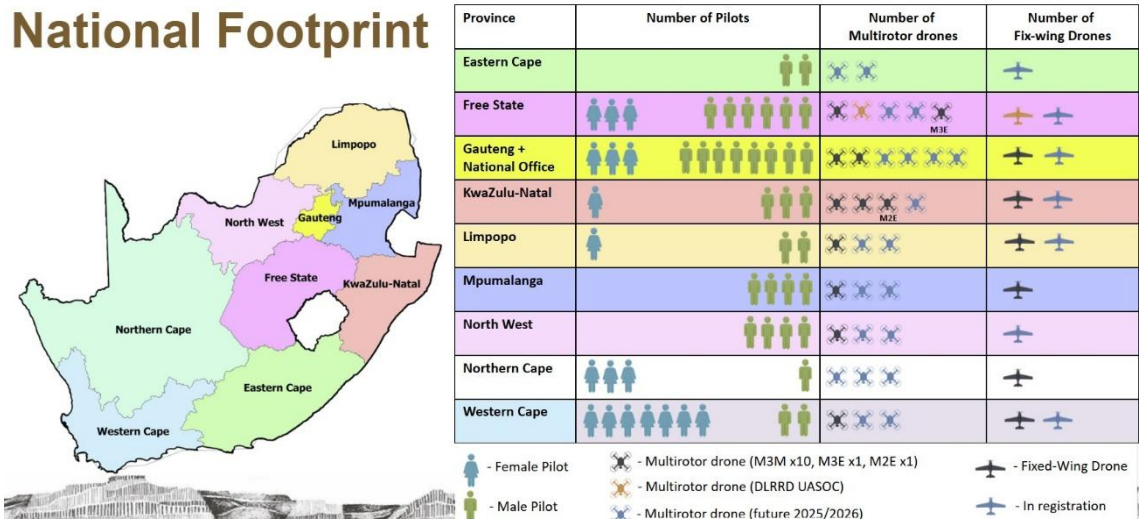

Figure 1: National Drone Program Footprint (DLRRD, 2025)

4. Implementation

Case: Ladysmith/Mnambithi Flood Mitigation and Spatial Intelligence (SDG 11 and 13)

Ladysmith, situated along the Klipriver, has faced devastating floods since the 1940s. Following the January 2023 disaster which claimed 24 lives, the DLRRD was tasked with providing high-resolution elevation data to support long-term engineering interventions.

Aerial Survey: Over six days, the team deployed the Trinity F90+ with an Oblique RGB payload (at 760ft) for the longitudinal river profile and the Mavic 3 Multispectral (at 364ft) for redundancy and spectral analysis at the city centre.

Methodology: The river was subdivided into three longitudinal corridors (8km long x 400m wide). Ground Control Points (GCPs) were established by DLRRD surveyors to ensure survey-grade accuracy.

Analytical Output: The resulting 2.87cm GSD orthomosaic and 5-meter contours (processed in Site Scan) allowed for sophisticated surface catchment water and flooding flow simulations

with ongoing bathymetric studies to compliment the profiling in order to understand factors that may be contributing to the issues of flooding in the area.

This data is currently being used to evaluate the feasibility of raising the N11 road, dredging the riverbed, and even the potential relocation of the CBD. The multispectral data from the DJI further assists in identifying anthropogenic factors in the catchment that contribute to siltation.

Case: Sikiti Informal Settlement: Rapid Disaster Response (SDG 11.5)

In June 2025, during a declared flood disaster in the Eastern Cape, the DLRRD deployed DJI drones to the Sikiti settlement.

Real-Time Intelligence: Drones revealed damaged infrastructure and inaccessible roads that were invisible from the ground.

Search and Rescue: As waters subsided, the aerial perspective helped locate stranded and displaced individuals, directly supporting humanitarian efforts in a high-risk environment.

Case: Grabouw: Urban Resilience and GeoAI Efficiency (SDG 11)

The Theewaterskloof Municipality faced a critical challenge in monitoring urban sprawl and informal settlement growth Grabouw. Accurate structure counts are the "digital currency" required for service delivery and disaster risk planning, the team deployed the Trinity F90+ with an Oblique RGB payload.

Real-Time Intelligence: DLRRD captured high-resolution imagery at varying altitudes, yielding resolutions from 50cm down to 3cm. The core innovation lay in the transition from manual labor to GeoAI. A manual digitization effort initially identified approximately 12,400 structures. However, by applying the "Classify Pixels Using Deep Learning" tool in ArcGIS Pro and utilizing a High-Resolution Land Cover Classification (.dlpk) model, the team identified 15,800 structures.

Analytical Output: GeoAI workflow unlocked these insights in under 10 minutes post-processing. This 27% increase in detected structures revealed the true extent of urban sprawl, providing a precise evidence base for municipal intervention and proving that UAV-derived GeoAI is essential for real-time urban resilience.

5. Conclusion and Recommendations

Using the case studies, it is evident that the use of UAVs for ad-hoc data collection provides an opportunity to improve disaster rescue and response efforts, and localized planning and policymaking.

Traditional satellite imagery often lacks the granularity required for urban planning in complex environments like Sikiti or Grabouw. By providing sub-decimeter imagery, the DLRRD effectively "minting" new data for the Fundamental Geospatial Themes and fulfilling the Data Pathway objective of providing integrated, "fit-for-purpose" information. In the case studies presented UAV technology is the primary driver for enhancing the resolution of Elevation and Depth as seen in the Ladysmith 5-meter contour generation.

Can UAV drone data contribute to Base Data Set Themes?

SASDI identified a list of [2]criterion to distinguish base data sets from non-base. A key criterion is that the data set must have complete coverage of the area of interest preferably national. In case of UAV data, this would mean that the high-resolution imagery and by-products should be at national level. This requirement is not yet feasible as the technology is suited for small areas. The technology, however, provides an opportunity for local scale interventions and disaggregate measurement of the SDGs as demonstrated by the cases included in this paper.

To integrate high-resolution products into national Geospatial Themes captured by these technologies, the country would need to develop standards, prescriptions or procedures for consistent capture and processing.

The evidence presented through the DLRRD drone programme demonstrates that Unmanned Aerial Vehicle (UAV) technology is no longer an experimental luxury but a foundational requirement for modern land administration and sustainable development. By bridging the gap between high-level policy (SDGs and SASDI) and on-the-ground implementation, UAVs provide the "digital currency" necessary for a resilient South Africa.

[2] SASDI criterion for identification of base data set includes:

- Aim at complete coverage of the area of interest (Compulsory);
- A diversity of users from different sectors derive significant benefit from their use (Compulsory);
- Have sufficient detail and accuracy for widespread use; (Compulsory);
- A source for accurate referencing other datasets or for displaying the results of the analysis; (Conditional: relevant for the kind of dataset;
- The dataset is produced as a result of the core mandate of the custodian (Conditional); and
- Cannot be substituted easily or generally; (Compulsory)

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BIOGRAPHICAL NOTES

Both authors are geospatial professional specializing in the integration of Unmanned Aerial Vehicle (UAV) technology with the South African Spatial Data Infrastructure (SASDI). Their work focuses on the application of high-resolution, standards-compliant geospatial data to support land reform, land administration, and sustainable urban and rural development within the public sector and contributing to evidence-based planning, improved spatial governance, and the advancement of innovative geospatial practices in support of sustainable development objectives..

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