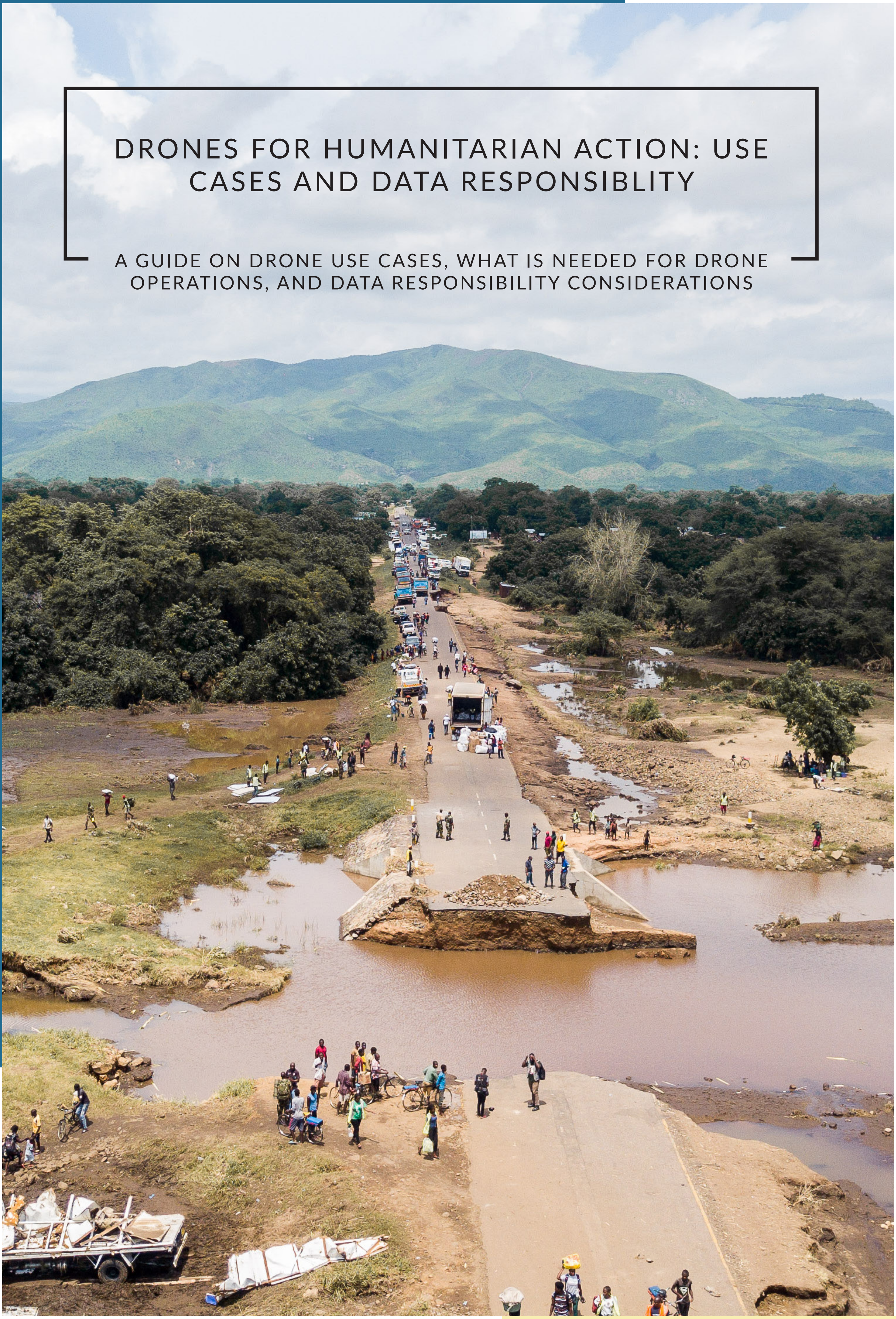
DRONES FOR HUMANITARIAN ACTION: USE CASES AND DATA RESPONSIBLITY

A GUIDE ON DRONE USE CASES, WHAT IS NEEDED FOR DRONE OPERATIONS, AND DATA RESPONSIBILITY CONSIDERATIONS



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INTRODUCTION

In recent years, the emergence of drones has revolutionized the way we approach challenges and opportunities in sustainable development. Drones, also known as Uncrewed Aerial Vehicles (UAVs) or Remotely Piloted Aircraft Systems (RPAS), have transcended their military origins to become versatile tools for a wide range of applications. From environmental monitoring and conservation efforts to infrastructure development and disaster response, drones have proven to be serviceable for promoting sustainable practices across the globe. As we strive to address pressing environmental issues and achieve the United Nations' Sustainable Development Goals (SDGs), the innovative use of drones is emerging as a promising tool.

One of the most significant contributions of drones to sustainable development lies in their ability to gather crucial data in a cost-effective manner. Drones can rapidly collect high-resolution imagery and elevation data with high precision. The technology is relatively affordable (compared to the planes required for traditional aerial surveys), and are therefore a key enabler to providing local decision-makers with the power to collect data where and when they need it. This data, in turn, aids decision-makers and policymakers in taking informed decisions about planning, resource management, and disaster risk reduction.

Malawi is at the forefront of using drones for sustainable development in Africa. In June 2017, the first UAV testing corridor was established with the aim of assessing the potential of UAVs to support humanitarian efforts. In 2020, the African Drone and Data Academy (ADDA) was launched to train youth in the region, equipping young Africans with the skills required to utilize drones and exploit the data they collect.

The purpose of this document is to provide an overview of drone use cases that have emerged from these activities in Malawi and how they support broader development issues, as well as to provide an introduction to the workflow and skills required. It is intended to serve as a brief introduction on what is needed to start a new project with drones as well as inspiration on what the data they provide can be used for. It should be noted that this report focuses on the use of drones for the collection of imagery, and does not consider their use for transport and delivery. Though the latter also has great potential for humanitarian purposes.

This document describes: the standard workflow for the use of drones, the skills required to successfully deploy drones, standard outputs from the drone imagery, successful drone use cases, and last but not least general data risk considerations and possible mitigation measures. For although drones have a great potential to support humanitarian efforts, their use and the use of their data also present risks. Responsible usage is crucial to protect vulnerable communities.

STANDARD WORKFLOW

PLANNING STAGE

01

- Defining project objectives, data requirements, and the area of interest - this is ideally done in collaboration with affected populations and includes the option to choose a non-drone based data collection and analysis approach if that approach is contextually sufficient or preferable.
- Selecting appropriate drone and camera equipment and software
- Identifying standard and specific skills needed to conduct the aerial mapping and image processing
- Obtaining necessary permissions and permits for flight operations
- Notifying local authorities and communities of drone flights, data that will be collected, intended purpose, and what will be shared and with whom
- Planning the flight mission, considering flight paths, altitudes, overlap, camera angle, light conditions, and area coverage to ensure the collected data is adequate for the intended purpose
- Conducting a Specific Operation Risk Assessment (SORA) is recommended to comprehensively address and mitigate the potential risks of the drone operation

DRONE OPERATIONS STAGE

02

- Confirming that the weather conditions are expected to be suitable for drone flights
- Conducting pre-flight checks to ensure the drone equipment are in working order, ensuring enough spare accessories to support smooth operation
- Flying the drone following the planned mission to capture imagery or video data
- Monitoring the flight for safety and be prepared to respond to any emergencies

DATA COLLECTION STAGE

03

- Once in flight, capturing aerial imagery or videos of the designated areas or features
- Multiple flights may be used to ensure complete coverage of the area of interest
- Ground Control Points (GCPs) or other appropriate tools may be used for precise georeferencing

DATA PROCESSING STAGE

04

- Transferring the collected data to a computer or a cloud facility for processing
- Ensure data is erased from the collection device and that data and outputs are adequately encrypted on the processing platform (see data management)
- Processing the imagery using specialized photogrammetry software to create and generate orthomosaic maps or any other aerial imagery output (see the dedicated section)
- Embedding GCPs (if needed) into the processing workflow and conducting quality control to verify the accuracy and clarity of the processed data

DATA ANALYSIS STAGE

05

- Analysing the processed data to extract relevant information and insights using various tools, including GIS analyses and machine learning
- Measuring distances and areas, identifying objects, detecting or clarifying objects/areas, or tracking changes over time based on project objectives
- Conducting any additional post-processing or editing as necessary
- See the “Standard Outputs” section for more information on data products that can be derived from drone imagery.

DATA DISSEMINATION STAGE

06

- Presenting the results of the data analysis in suitable formats such as maps, charts, or reports.
- Disseminating the data outputs to relevant stakeholders, clients, or teams involved in the project using accessible formats (such as geodata catalogues, web maps, etc.)

DATA MANAGEMENT AND SHARING STAGE

07

- Archiving the acquired data in a secure and organized manner to prevent data loss
- Creating redundant backups of the processed data to protect against hardware failures or accidents
- Maintaining a well-organized data storage system for easy retrieval and future reference
- Ensuring data accessibility for future use, analysis, or comparison with new data
- Making clear decisions on who should be able to access the data and take steps to protect the data from illicit access if needed.

STANDARD EQUIPMENT AND SOFTWARE

DRONE

- Drones used for mapping can be of various types: rotor-based (quadcopter, hexacopter, etc.), fixed-wing, or VTOL (Vertical Take-Off and Landing).
- Rotor-based drones are more flexible, capable of hovering and capturing detailed imagery of specific areas. Fixed-wing drones are better suited for larger area coverage and longer flight times, making them ideal for large-scale mapping projects. VTOL drones combine the characteristics of both rotor-based and fixed-wing drones.

PAYLOAD / CAMERA

- The payload or camera that is mounted on the drone determines the type of information that it can collect. Some drones have a fixed payload, but many enable the user to switch payloads between flights.
- Visual cameras (including the ones with a zoom function) capture standard RGB images, essential for creating orthomosaic maps and detailed visual inspection or search for missing people.
- Photogrammetric cameras are similar to visual cameras, but designed to take high quality images that can generate more precise orthomosaics.
- Thermal cameras capture infrared radiation, enabling the detection of heat signs/anomalies and temperature variations.
- Multispectral cameras capture data in multiple bands beyond visible light (e.g., near-infrared, red-edge), useful for agricultural and environmental applications like crop health monitoring and vegetation analysis.
- LIDAR (Light Detection and Ranging) sensors can provide accurate point cloud data and are often used for terrain modeling, vegetation analysis, and 3D mapping.

REMOTE CONTROL

- The remote control is used to pilot the drone and control its flight.
- Some controls have built-in screens for live video feed and basic data display, while others require an external device (e.g., smartphone or tablet) to view the live feed and telemetry data.

ACCESSORIES

- **Propellers**: Extra propellers are essential in case of damage or wear during flight operations.
- **Spare Batteries**: Additional batteries allow for extended flight times and more efficient data collection.
- **Charging**: Charging hubs and cases for batteries and equipment organization.
- **Digital Data Storage**: additional external drives and micro SD cards for storage of data.
- **Radio/Telemetry**: Data link systems for real-time communication between the drone and ground control.
- **Carrying cases**: to organize all the accessories and ensure the drone is protected from damage during transport.
- **Laptop**: depending on the type of drone utilized, sometimes a laptop is needed to adapt flight plans while in the field, download the data from the drone, or start processing.

GEOREFERENCING TOOLS

- Most drones are equipped with a GPS that can assign images coordinates to a precision within a few meters.
- Drones equipped with RTK (Real-Time Kinematic) and PPK (Post-Processed Kinematic) systems provide highly accurate positioning data for georeferencing drone imagery without the need for Ground Control Points (GCPs).
- GCPs (Ground Control Points) are physical markers placed on the ground which are visible in the drone imagery. Their coordinates on the ground are carefully measured and can later be marked in the drone imagery. They are used to improve the accuracy of drone imagery when RTK or PPK is not available or for validating the accuracy of georeferencing methods.

FLIGHT PLANNING AND CONTROL SOFTWARE/APP

- Flight planning software allows operators to design and simulate drone missions. It helps optimize flight paths, set altitude, overlap, and camera settings.
- Control apps provide real-time flight monitoring, telemetry data, and remote control features.
- Popular flight planning software and apps include DJI GS Pro, Pix4Dcapture, and senseFly eMotion.

PHOTOGRAMMETRY SOFTWARE FOR IMAGE PROCESSING

- Photogrammetry software processes the collected imagery to create orthomosaic maps, 3D models, point clouds and other outputs.
- Popular photogrammetric software include Pix4D, Agisoft Metashape, DroneDeploy, and OpenDroneMap (free).

GIS SOFTWARE FOR OUTPUT PROCESSING AND ANALYSIS

- GIS (Geographic Information System) software is used for in-depth analyses, data visualization, and integration with other spatial data.

STANDARD SKILLS

Various types of skills and knowledge are required for successful drone operations. Not all of these skills need to be present in a single person, they can also be spread amongst different members of the team.

DRONE OPERATIONS

Piloting Skills: Proficiency in flying the drone safely and effectively is fundamental. Drone operators should be familiar with basic flight maneuvers, take-offs, landings, and handling various flight scenarios.

Regulatory Knowledge: Understanding local drone regulations, airspace restrictions, and obtaining necessary permits and permissions is essential for compliant and legal operations.

Pre-flight Checks: The ability to conduct thorough pre-flight checks to ensure the drone, camera, and other equipment are in proper working condition before each flight.

Emergency Response: Being prepared to respond to unexpected situations, such as sudden weather changes, equipment malfunctions, or potential hazards during flight operations and handling stressful situations calmly.

DRONE MAPPING

Flight Planning: Skill in designing efficient flight plans using appropriate flight paths, altitudes, and overlaps to ensure complete and accurate coverage of the area of interest & sufficient quality of the outputs.

Georeferencing: Understanding various georeferencing techniques like RTK, PPK, or GCPs, and their application for achieving precise and reliable mapping results.

Data Collection Optimization: The ability to optimize data collection parameters like flight altitude, camera settings such as light conditions and camera angle, and flight speed to meet project objectives while maintaining data quality.

Mapping Data Interpretation: Interpreting the aerial imagery and data collected during the mapping process to identify potential issues, areas for improvement, and adapting flight plans accordingly.

Photogrammetry Knowledge: Understanding the principles of photogrammetry, which involves reconstructing 3D information from 2D images, and its application in generating accurate orthomosaics, 3D models, and point clouds.

Image Pre-processing: Skills in performing image pre-processing tasks such as image alignment, calibration, and removing distortions to prepare the data for photogrammetric processing.

Photogrammetry Software Proficiency: Ability to work with photogrammetry software to process raw imagery into useful mapping products like orthomosaics, Digital Elevation Models (DEMs), and point clouds.

Data Analysis and Interpretation: Analyzing and interpreting the processed data to extract relevant information, identify patterns, and make informed decisions based on the project objectives.

GIS skills: Enable the integration of the imagery collected by drones with other maps and spatial information.

IMAGE PROCESSING AND ANALYSIS

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STANDARD OUTPUTS

DIRECTLY FROM THE DRONE

- Photo and video

(characteristics of the photo and video depend on which sensor is used, usually RGB but can also be thermal, multispectral, or hyperspectral)

AFTER PHOTOGRAMMETRIC PROCESSING

- Point cloud
- 3D model
- Digital Surface Model (DSM)
- Orthomosaic

AFTER ADDITIONAL GIS / IMAGE PROCESSING

- Digital Terrain Model (DTM)
- Contour lines
- Land cover classification
- Vegetation indices
- Above Ground Biomass (AGB)
- Object detection
- Change detection

PHOTO AND VIDEO

Regular photos and videos offer a comprehensive view of the surroundings, capturing details that may not be easily observable from ground-level perspectives. Aerial imagery is an important tool for improving overall situational awareness in many sectors. The aerial photos and videos as documentation can be valuable for historical records, detection of missing people, environmental monitoring, change detection, disaster damage assessments, and progress monitoring.

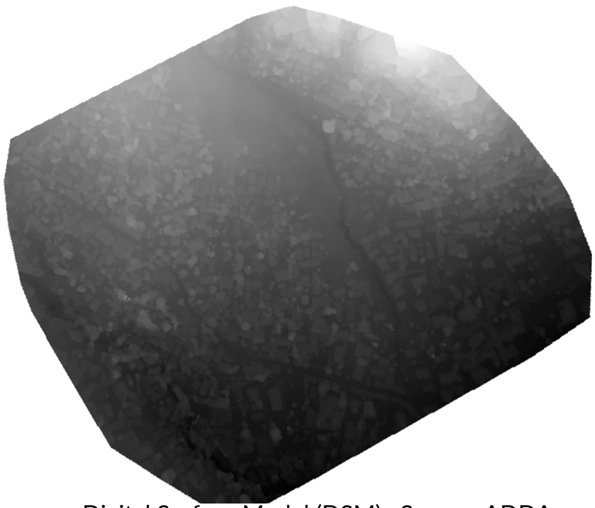
POINT CLOUD

A point cloud is a collection of three-dimensional points representing the surface of an object or the Earth's terrain. It is created by capturing a large number of data points from aerial imagery using remote sensing techniques like LiDAR (Light Detection and Ranging). Point clouds are used for detailed terrain modeling, volumetric calculations, 3D visualization, and precise measurements. They are particularly valuable in applications such as urban modeling, forestry, transportation planning, and infrastructure design.

3D MODEL

A 3D model is a digital representation of objects or surfaces in three-dimensional space. Aerial imagery can be processed to generate accurate 3D models of the terrain, buildings, and other structures. These models provide a realistic visualization of the environment and are used in modelling, urban planning, architecture, virtual reality applications, simulations, and visual effects.

3D Model Source: ADDA



Digital Surface Model (DSM) Source: ADDA

DIGITAL SURFACE MODEL (DSM)

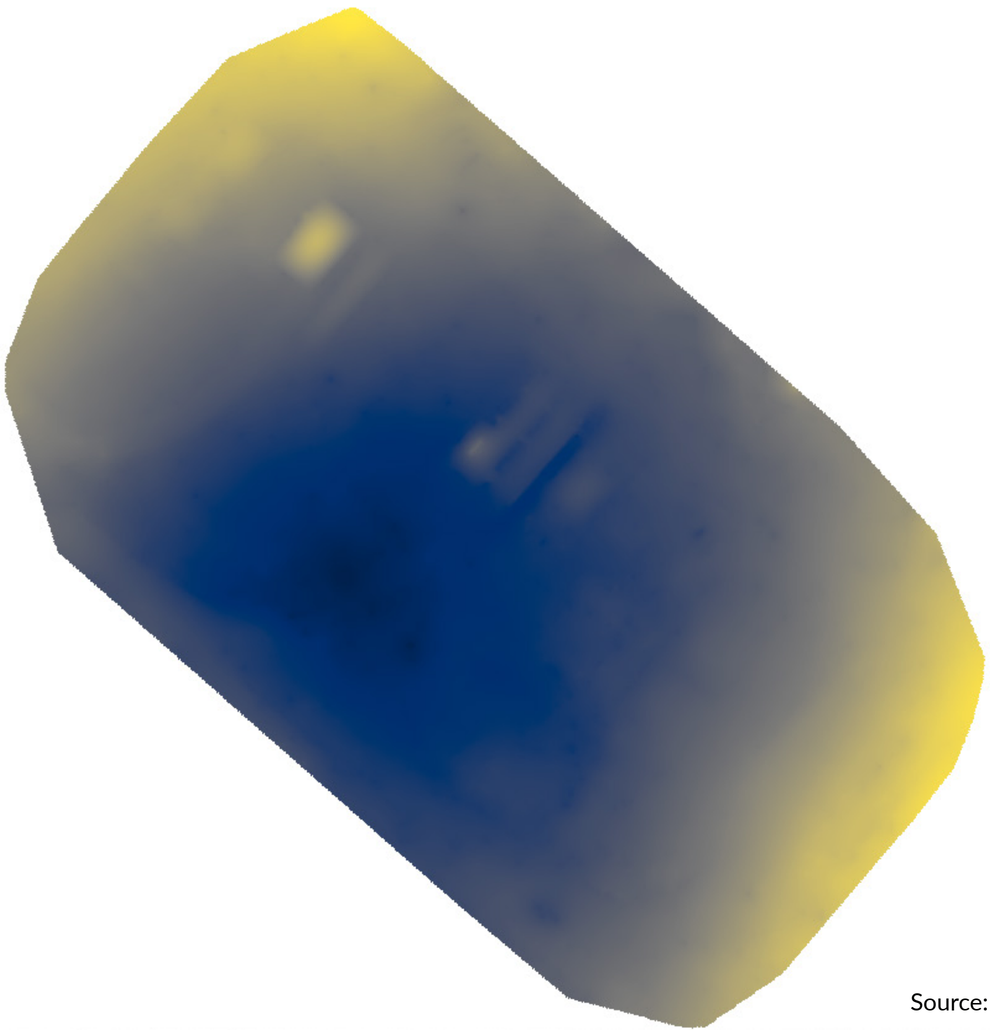
A Digital Surface Model represents the Earth's surface, incorporating both natural and built elements. It Includes both the terrain elevation and the height of above-ground features. DSMs are used in urban planning, 3D modelling, hydrological modelling, engineering design, and landscape planning.

ORTHOMOSAIC

An orthomosaic is a high-resolution, geometrically corrected image that combines multiple aerial images to create a seamless, accurate visual representation of the Earth's surface. It eliminates distortions caused by terrain variations and camera angles, providing a true-to-scale view. Orthomosaics are commonly used for mapping, land cover classification, urban planning, damage assessments, and environmental analysis.

DIGITAL TERRAIN MODEL (DTM)

A DTM represents the bare Earth's terrain, excluding above-ground objects, like buildings and vegetation. DTM provides elevation values for each point in each area and focuses solely on the elevation of the terrain providing information about the shape and topography of the surface. DTMs are commonly used in terrain analysis, flood modeling, slope analysis, and other applications.



Source: ADDA

CONTOUR LINES

Contour lines are derived from elevation data and represent lines of equal elevation on a map. They provide valuable information about the shape and steepness of the terrain, enabling contour-based analysis such as watershed delineation, visualization of landforms, and site selection for infrastructure projects like roads and pipelines.

LAND COVER OR LAND USE CLASSIFICATION

Aerial imagery can classified into different land cover/use types, such as forests, agriculture, water bodies, and more. This analysis can be performed using machine learning algorithms and image classification techniques Land cover maps are useful for monitoring land use changes, urban growth, habitat assessment, environmental monitoring, and natural resource management.

VEGETATION INDICES

Vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), are calculated from multispectral aerial imagery and provide insights into the health and density of vegetation. The calculated NDVI values can be visualized as a grayscale or colour-coded map, where areas with higher NDVI values conventionally appear greener, indicating healthier vegetation. These maps provide insights into crop health, stress areas, vegetation growth, diseases detection or nutrient deficiencies, supporting various applications such as agriculture management, ecological studies, forest and environmental management, and land cover analysis. Other spectral indices can be calculated to represent water (NDWI), soil (NDSI), or built-up areas (NDBI) for example depending on which spectral bands the sensor provides.

ABOVE GROUND BIOMASS (AGB)

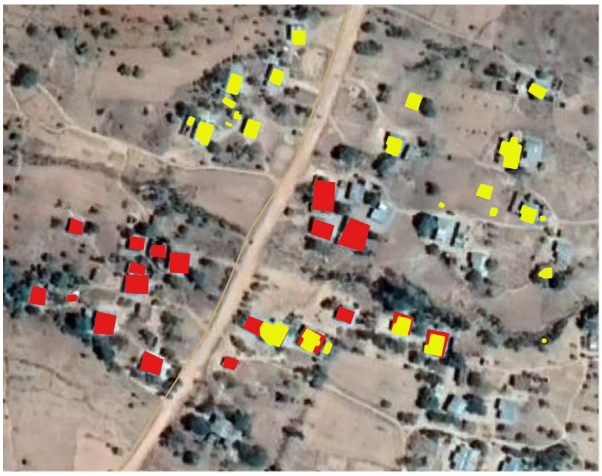
The difference between the DSM and DTM returns the volume of objects above the ground. If this is combined with land cover and vegetation indices, it is possible to identify which parts of the dataset represent vegetation and thus estimate the above ground biomass.

OBJECT DETECTION AND FEATURE EXTRACTION

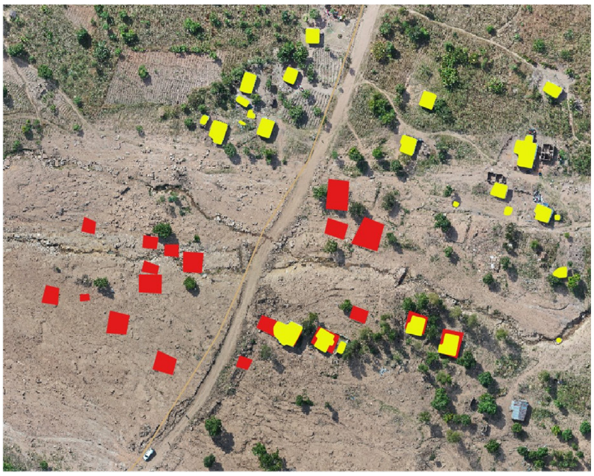
Aerial imagery can be analyzed to identify and extract specific features or objects of interest. This includes detecting buildings, roads, vehicles, trees, and other infrastructure elements. Object detection and feature extraction are crucial in applications like disaster response, planning, damage assessment, asset management, and many more.

CHANGE DETECTION

By comparing aerial images acquired at different time intervals, it is possible to identify and analyze changes that have occurred on the ground. Change detection can be used for monitoring urban expansion, land cover changes, deforestation, natural disasters, and other dynamic processes. It helps in assessing the impact of human activities and supporting decision-making processes.



2021 Google satellite imagery



2023 drone imagery after a landslide

Source: ADDA

USE CASES

FLOOD, LANDSLIDE, OR OTHER SURFACE RISK ASSESSMENT

Description: Aerial imagery combined with various data sources can identify factors contributing to risks, such as slope instability, elevation, vegetation cover, soil erosion, or inadequate drainage systems. This information assists in assessing the severity of hazards and prioritizing mitigation efforts. High-resolution orthomosaics, point clouds, and digital elevation or digital surface models are created for flood/ landslide modeling and risk assessment. The data is crucial for early warning, impact-based forecasting, and anticipatory actions as part of disaster risk reduction and resilience-building efforts.

Specific requirements: Accurate georeferencing requires additional equipment, as well as sensors like LIDAR might be used, flood modeling software is used; Flood and water management competencies required.
Sector of application: The application can be used in different sectors, including Emergency response, WASH, Health, Education, Social Protection, and others. Using aerial surveys significantly improves the accuracy of the flood modeling, contributing to more accurate forecasts and flood risk assessments that lead to better response, preparedness, and resilience
Type of geospatial data collected: Digital Terrain Model and Digital Surface Model
More info: https://www.unicef.org/malawi/stories/drones-resilience

MOSQUITO BREEDING SITE IDENTIFICATION

Description: Drone imagery creates high-resolution maps of malaria-endemic areas, identifying stagnant water bodies and aquatic vegetation as mosquito breeding sites. This application can play a crucial role in vector control activities to combat mosquito-borne diseases like malaria. By mapping these breeding sites, authorities can implement targeted interventions and effectively manage mosquito populations. The use of drones enhances the efficiency and accuracy of identifying and addressing potential disease vectors, contributing to effective disease prevention and control strategies.

Specific requirements: Object classification tools/software, epidemiological and public health competence.
Sector of application: Mainly used in the health and vector control sector. Areas identified as mosquito breeding sites can then be drained or treated through the vector control programmes that work to minimize the Malaria burden.
Type of geospatial data collected: Water bodies and aquatic vegetation are identified in the aerial imagery (orthomosaic) using manual methods and geographical object-based image analysis
More info: https://www.unicef.org/stories/drones-vs-mosquitoes-fighting-malaria-malawi

DISEASE OUTBREAK MONITORING AND RISK ASSESSMENT

Description: Drones serve as valuable tools for outbreak monitoring and risk assessment, particularly for diseases like cholera. Real-time aerial surveillance and mapping using drone imagery can detect potential sources of contamination, such as open water bodies or compromised water and sanitation infrastructure. Overlaying aerial imagery with data on land use, water sources, and population density helps identify disease hotspots and patterns that may contribute to the spread of the disease. Health authorities can then prioritize intervention efforts in high-risk areas. Aerial maps assist in understanding the spatial distribution of cholera cases and potential risk factors.
Specific requirements: Object classification tools/software, epidemiological and public health competencies.
Sector of application: The application can be used in WASH, Health and Emergency sectors. High resolution imagery can aid an effective disease control and containment strategies as well as can help provide data that serves for preparedness purposes.
Type of geospatial data collected: Orthomosaics are used for object detection and GIS analysis
More info: https://medium.com/@unicef_malawi/drones-for-cholera-response-innovating-for-children-in-malawi-6dcab2c4de53

INFRASTRUCTURE RISK ASSESSMENT

Description: High-resolution aerial imagery, including orthomosaics or 3D models, complements the assessment of the condition and damage to various infrastructures, such as roads, bridges, schools, health facilities, and other structures. Drones provide detailed visual data, enabling infrastructure managers and engineers to evaluate the state of assets efficiently. By conducting aerial inspections, maintenance and repair teams can identify issues, plan interventions, and prioritize resources effectively, ultimately improving the safety and longevity of critical infrastructure.

Specific requirements: Civil engineering structural assessment competencies.
Sector of application: The application can be used in several sectors, such as WASH, Education, Health, Construction, and others. More detailed and accurate assessment of the infrastructure, improving safety of work.
Type of geospatial data collected: Orthomosaics and 3D models are generated for analysis purposes with GIS software

ENVIRONMENTAL MONITORING

Description: Drones play a vital role in environmental monitoring, enabling wildlife preservation, forest volume estimation, and monitoring land use changes over time. Aerial imagery helps monitor wildlife habitats, assess forest health, estimate vegetation volume, and identify changes in land use patterns. This information is crucial for conservation efforts, resource management, and understanding the impact of human activities on the environment. Drones provide an effective and non-intrusive way to gather data across vast and remote areas, contributing to better-informed environmental policies and sustainable practices.

Specific requirements: Environmental / ecological sciences competence.
Sector of application: The application can be used in WASH and Climate programmes. Drones offer early detection of environmental issues, accurate monitoring, conservation efforts, contributions to advocacy and SDG work in the areas of climate and environment.
Type of geospatial data collected: Indices maps, orthomoisaics, 3D models and point clouds are generated for subsequent analysis with GIS software.

AGRICULTURE

Description: Drones find multiple applications in agriculture, including monitoring plant health, performing plant counts, optimizing plant return on investment, and assessing losses after major weather events. Aerial imagery captures crop health indicators, such as NDVI (Normalized Difference Vegetation Index), helping farmers identify stressed areas and apply targeted treatments. Drone data also aids in yield estimation and resource allocation, resulting in increased efficiency and reduced environmental impact. By providing real-time information, drones empower farmers to make data-driven decisions and improve overall agricultural productivity.

Specific requirements: Environmental / ecological/agricultural sciences competence.
Sector of application: The application can be used in Nutrition and Social Protection sectors. Drone imagery can increase crop yields, reduce resource usage, and improve pest control leading to more effective agricultural practices.
Type of geospatial data collected: Indices maps and orthomosaics are used for specialized crop/ plan analysis

SEARCH AND RESCUE OF MISSING PEOPLE

Description: Drones are invaluable for conducting aerial searches over expansive areas, providing a broad overview of the terrain and access to ground-level details. Equipped with thermal cameras, drones can detect heat signatures and identify signs of human presence, such as individuals, vehicles, or structures. During search and rescue missions, drones significantly enhance the efficiency of operations, covering large territories more quickly than ground-based teams. The visual data captured by drones aids rescue teams in identifying potential locations of missing persons, enabling timely and targeted search efforts.

Specific requirements: Thermal and/or high zoom capacity cameras used. Emergency management, coordination and communication and search and rescue competencies.
Sector of application: The application is primarily used in emergency operations. Drone imagery in SAR operations offer enhanced coverage of search area, improve safety, provide with a rapid deployment capability, improve detection in challenging conditions, and enhance overall efficiency of search operations.
Type of geospatial data collected: Standard image analysis is conducted to review aerial photos (visual or thermal) or videos and identify objects of interest.

GENERAL SITUATIONAL AWARENESS (DURING NATURAL DISASTERS)

Description: Drones provide rapid general assessment and enhance coordination and resource allocation during early stages of natural disasters by offering overviews of affected territories.

Specific requirements: Emergency management, coordination and communication competencies.
Sector of application: The application is primarily used in emergency operations. Drone imagery enhances situational awareness, improves safety, and makes emergency coordination and management more effective.
Type of geospatial data collected: Aerial photos and aerial videos are used to create a general situational awareness.
More info: https://www.unicef.org/malawi/stories/adda-alumni-aid-cyclone-response-swift-tech-solutions; https://www.unicef.org/malawi/stories/using-drones-speed-response-efforts-cyclone-ana

POST-DISASTER DAMAGE/IMPACT ASSESSMENT

Description: Aerial imagery from drones accurately estimates the impacts of natural or man-made disasters on infrastructure, environment, households, and populations. Drone imagery, unlike other tools, can provide rapid and accurate damage assessment which leads to targeted and efficient response and recovery planning. This data is crucial for disaster response and recovery efforts, applicable to events like landslides, floods, earthquakes, fires, post-cyclones, and more.

Specific requirements: Emergency management, coordination and communication competencies required.
Sector of application: The application is used by several sectors such as Health, WASH, Nutrition, Shelter, Education, Social Protection, and others.
Type of geospatial data collected: Orthomosaics are used for geospatial object detection (flood extent, affected houses, etc.)
More info: https://www. unicef.org/malawi/stories/adda-alumni-aid-cyclone-response-swift-tech-solutions; https://www.unicef.org/malawi/stories/using-drones-speed-response-efforts-cyclone-ana

CONSTRUCTION

Description: Drones enhance various stages of the construction process, especially for surveying construction sites, creating high-resolution topographic maps, and generating accurate 3D models of the terrain. These aerial surveys aid in project planning, site design, and construction progress monitoring. Drones also enable frequent and cost-effective inspections of tall structures, such as buildings and bridges, enhancing safety and reducing manual labor. With real-time data acquisition and analytics, construction teams can make informed decisions, identify potential issues, and streamline workflows.

Specific requirements: Accurate georeferencing requires additional equipment, as well as sensors like LIDAR might be used. Civil engineering competence.
Sector of application: Application can be used in infrastructural projects across several sectors such as WASH, Shelter, and others. Using drones can improve the overall efficiency of construction process and reduce hazards on site.
Type of geospatial data collected: Orthomosaics and 3D models are used for measurements and analysis.

CINEMATOGRAPHY

Description: Drones have revolutionized the cinematography and videography industries, allowing filmmakers and content creators to capture stunning aerial shots and perspectives. Equipped with high-quality cameras and stabilized gimbals, drones can smoothly record cinematic footage that enables filmmakers to add dramatic aerial sequences to movies, commercials, and documentaries, enhancing storytelling and visual appeal. Drones are also used for aerial photography in various industries, such as real estate, tourism, and event coverage.

Specific requirements: Higher-resolution cameras, and specific video/photo editing software; skills in creative videography and photography might be needed.
Sector of application: Application can be used in advocacy, communications, and resource mobilization sectors.
Type of geospatial data collected: Videos or photos are used with post-processing software to edit and retouch them for publications.

DATA RESPONSIBILITY

Organisations and governments are constantly finding ways of using new technology and the data such new technology generates to strategise or organise interventions, as well as to support post impact assessments and relief efforts. Data is especially crucial in humanitarian preparedness and response: it can used to track the spread or assess the potential impact of a disease (Weitzberg et al., 2021), to monitor and assess needs among affected communities, to study and understand disaster patterns to prepare for or mitigate the impact of eventual new disasters etc. As such, efficient disaster response necessitates the promotion and incorporation of optimal data usage and novel technology. There are, however, concerns as regards privacy and/or data protection: it has already been documented that while data can be and are used to make well-targeted predictions and decisions, these decisions may or may not always be in favour of the masses (Zuboff, 2019; Tene & Polonetsky, 2011). Protecting individuals in a crisis equally involves protecting their personal [and non-personal] information, which is an integral part of protecting their life, dignity and integrity (Kuner et al,2020). Information relating to persons (Personally identifiable information-PII), groups of persons or communities (Demographically identifiable Information-DII) can be used to enhance accurate response but can also be misused to maliciously target the people (the case of Harvard's Signal Program in South Sudan in 2011 - Taylor, 2017) or for other non-humanitarian purposes like humanitarian experimentation (Sandvik, 2017).

The ideal approach therefore would be data responsibility: how to ensure that the data collected for humanitarian purposes or generated via humanitarian intervention processes, alongside accompanying technology, satisfy humanitarian objectives while avoiding or at least limiting any violations to the physical or digital human rights of the people. To fulfill their mandate of intervention without discrimination, humanitarian organisations are often obliged to make use of data and available technologies, even where such technologies could be privacy-invasive or run the risk of violating data protection requirements. This is especially the case when the realities and context of the place make these technologies the only option feasible for the specific, needed process. With data protection being essentially risk-based (Gellert, 2015) i.e. more protection around data representing higher risk to individuals, it may be ideal to allow humanitarian organisations explore data and technology to full capacity, while introducing safeguards to foster data protection or limit/mitigate related violations.

In Malawi, and as demonstrated in the above use-cases table, drones are one of those technologies which offer novel, reliable, cheap and less-risky means of collecting ground data. However, they also present risks as regards privacy or data protection: they certainly collect DII (e.g. images which could show the presence of farms, types of crops grown (hence food security levels), economic situation of the people, religious affiliation, vulnerability to disasters like flooding etc) and could also collect PII when flown at lower altitudes. This consequently prompts the dilemma of fully optimising drone data collection and processing while observing basic data protection principles (data minimisation, proportionality, data quality, fairness in collection and processing). The tables below addresses this by trying to identify specific risks presented by drones when deployed for the above use-cases, and how they could be mitigated.

Personally identifiable information (PII): any information relating to an identified or identifiable individual. An identifiable individual is one who can be identified directly or indirectly, in particular by reference to (i) an identifier such as a name, an identification number, audiovisual materials (like images, videos, drawings), location data, an online identifier, (ii) one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of the individual or iii) assessments of the status and/or specific needs, such as in the context of assistance programmes.

Demographically identifiable information (DII): either individual and/or aggregated data points that allow inferences to be drawn that enable the classification, identification, and/or tracking of individuals, groups of individuals, and/or multiple groups of individuals according to ethnicity, economic class, religion, gender, age, health condition, location, occupation, and/or other demographically defining factors. DII can include online data, geographic and geospatial data, environmental data, survey data, census data, and/or any other data set that can – either in isolation or in combination – enable the classification, identification, and/or tracking of a specific demographic categorization constructed by those collecting, aggregating, and/or cross-corroborating the data. In other words, data is DII when it is specific enough or can be made specific enough to determine further, unobvious, unnoticeable, hidden and probably sensitive information about a group of persons or a community.

RISKS RELATED TO PRIVACY/PERSONAL INFORMATION

Risk	Mitigation
During aerial surveys, drones could capture facial images (depending on the devices used on the drones) especially e.g. for search and rescue when they have to fly lower to get accurate field data.	• Automatic facial-image blurring technology (available on the market, depends on the quality and capacities of the attached camera). • Post-editing of the images to remove any personally identifiable information that may be visible (currently applied).
Where drones are used to deliver medical supplies to individuals or households, (precise) location data could be collected, which could be sensitive e.g. if the drugs were for HIV patients.	• Data protection by design: limiting access to the target's health info only to the health professionals of the organisation, without the (local) pilots knowing the contents of the delivered package (this can be applied via staff-access measures within the organisation). • Real-time encryption using so-called partial private keys (in a Malawi context this could be for the future). • Encryption of the stored location data with decryption key accessible to limited staff (can be applied via organisational measures).

Important considerations for any privacy-related mechanisms regarding drones:

- **Effort of the data subjects/community** - Ethically, because the community residents are at the receiving end of drone or new tech and considering their vulnerability in a humanitarian context, they must be protected as much as possible. Adopted privacy mechanisms should require minimal effort from them, with the drone controllers taking the bulk of the responsibility i.e. drone data controllers should ease consent mechanisms, facilitate implementation of no-fly zones (e.g via the use of an app), facilitate DII access and deletion requests.
- **Practicality** - For example, how feasible is it to: provide apps to community leaders through which live done data can be shared with them, map out sacred areas in the community and input them in a default no-fly zone database.

CONCERNS RELATED TO CULTURAL CONSIDERATIONS

Consideration	Mitigation
During aerial surveys, drones could capture images of cultural festivals (masquerade performances, funeral processions, elite group meetings) or other places considered sacred (graveyards)	• Communication and consultation with local authorities before flying; prior data impact assessments in collaboration with community leaders; real time deletion requests over mobile apps provided to community leaders (in an interview a participant mentioned that community leaders are consulted before flying. However, their real-time participation alongside the pilots may be for the future) • During flights, pilots who are locals of or resident in the community may be preferred, as they are of the community, understand the culture and are more likely to know what would be sensitive to the community. • Installing the coordinates of sacred areas in the drones as no-fly zones (i.e. geofencing) (available technology the market) ; • In collaboration with government and community leaders, establishing default or risk-based no-fly zones on areas which might be sensitive (e.g. refugee camps, graveyards, or areas where cultural activities may take place) and making this publicly accessible. Similar to the database of https://www.noflyzone.nl/ (this could be for the future)

RISKS RELATED TO SAFETY OF THE DRONE OPERATOR OR COMMUNITY MEMBERS

Risk	Mitigation
During aerial surveys (e.g. environmental monitoring) drones could capture or fly over illegal activities (e.g poaching) and the criminals may seek revenge on local community leaders	• Communication and consultation with local authorities before flying; prior data impact assessments in collaboration with community leaders; setting up clear risk assessment and data management practices before flights.
Risk of violent reactions from a panicked or rebellious community who may respectively find the drones suspicious, or who may not want images of their community captured and processed.	• Getting informed consent from the community before flying, despite the possibility under the Malawi Data Protection Bill* to bypass consent if the drones are justifiably flown for a humanitarian initiative. Also consider having a few aerial images of other communities to display, and possibly explain how these images aided your response in those communities, and how they can now aid your crisis response process in the present community.

*Malawi Data Protection Bill 2021 applies to processing of personal information, which does not include community or group data. However, in the absence of substantive group privacy legislation, it may be relied on for legal support.

DATA PROTECTION/RESPONSIBILITY PRINCIPLES*

Principle	Compliance suggestion
Transparency: Always informing the community leaders why we are flying, and how the data will be used	• Communication and consultation with local authorities before flying; coming back to inform them in case the data collected needs to be used for another purpose.
Consent	• Getting informed consent from the community before flying, even if consent can legally be dispensed with.
Collect only what is needed **Process** only what is needed	• Ensure drone sensors or cameras cannot capture further information (like the presence of natural resources).
Proportionality	• Where people or human settlements are involved, use drones only if really necessary and appropriate for the data needed (otherwise GIS or other data collection methods may be used).
Storage Limitation	• Drone data or data derived from drone imagery may be expensive to collect and may always be useful later. Always monitor political contexts to ensure DII of a group or community is not sensitive and may still be kept after use
Storage Limitation	• Drone data or data derived from drone imagery may be expensive to collect and may always be useful later. Always monitor political contexts to ensure DII of a group or community is not sensitive and may still be kept after use

*Kuner, Christopher, Massimo Marelli, Julia Zomignani Barboza, and Lina Jasmontaite. *Handbook on data protection in humanitarian action*. International Committee of the Red Cross, 2020.

DATA AGENCY CONSIDERATIONS

Principle	Compliance suggestion
Informed participation: inform the community how DII that may include them, will be acquired and used.	• Getting informed consent from the community before flying, even if consent can legally be dispensed with. • Providing community leaders with real-time control of what images are being taken e.g. a mobile app where drone images are shared as they are captured, and the leaders can request the deletion of specific aspects to the drone operators via the app. • Data Privacy Impact Assessments (DPIAs): Prior privacy or data impact assessments should be done in consultation/collaboration with the community leaders, so they can point out any contextual ethical concerns, so as to figure out possible mitigation strategies.
Risk of access	• Have procedures in place to easily show the community, upon request, what drone-related data about them was collected and is being processed.
Risk to rectify data	• Have technical capacities in place in case the community wishes that some data be taken off the datasets due to cultural or other reasons.
Risk to object to processing or request deletion	• Have mediation or negotiation schemes in place in case the people request a halt in the processing or deletion of drone data (some requests could be politically motivated due to conflicts within the community).

REFERENCES

Gellert, Raphaël Maurice. “Understanding data protection as risk regulation.” Journal of Internet Law 18, no. 11 (2015): 3-15.

Kuner, Christopher, Massimo Marelli, Julia Zomignani Barboza, and Lina Jasmontaite. Handbook on data protection in humanitarian action. International Committee of the Red Cross, 2020.

Sandvik, Kristin Bergtora, Katja Lindskov Jacobsen, and Sean Martin McDonald. “Do no harm: A taxonomy of the challenges of humanitarian experimentation.” International Review of the Red Cross 99, no. 904 (2017): 319-344.
Taylor, Linnet. “Safety in numbers? Group privacy and big data analytics in the developing world.” In Group privacy: New challenges of data technologies. Vol. 126. Springer, 2016.

Tene, Omer, and Jules Polonetsky. “Privacy in the age of big data: a time for big decisions.” Stan. L. Rev. Online 64 (2011): 63.

Weitzberg, Keren, Margie Cheesman, Aaron Martin, and Emrys Schoemaker. “Between surveillance and recognition: Rethinking digital identity in aid.” Big Data & Society 8, no. 1 (2021): 20539517211006744.

Zuboff, Shoshana. 2019. The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power. London, England: Profile Books.

ADDITIONAL INFORMATION

Humanitarian UAV Code of Conduct & Guidelines, by the Humanitarian UAV Network: https://uavcode.org/

Global drone regulations database: https://droneregulations.info/

Malawi Remotely Piloted Aircraft (RPA) Toolkit, VillageReach, UNICEF, https://www.updwg.org/wp-content/uploads/2019/12/Malawi-RPA-Toolkit-2019_Dec.-Final.pdf

Guidance note: Managing the risks of unmanned aircraft operations in devleopment projects, the World Bank: https://documents1.worldbank.org/curated/en/895861507912703096/pdf/Guidance-note-managing-the-risks-of-unmanned-aircraft-operations-in-development-projects.pdf

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