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Drones & Data for Flood Management in Africa.

Drones and Data for Flood Management in Africa

Technical Report

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Cover: Drone flying over debris, photo by South Africa Flying Labs

INTRODUCTION

Climate change continues to be witnessed around the world, with water-related disasters such as floods, landslides, droughts, and storms being the most common natural disasters affecting most people globally. Over the past two decades, floods alone have affected over two billion people worldwide: we have lost over 300,000 lives and borne a financial toll of $1.7 trillion in damages.

Effective disaster management hinges on access to accurate, up-to-date information about the affected area, aiding resource allocation and mobilization. This is where the synergy of technology, local knowledge, and community action comes into play. With emerging technologies from local experts working with stakeholders in their local communities, a more resilient future is possible.

Among the most promising tools today are drones—lightweight, cost-effective, and able to navigate even the most hazardous environments. What makes drones particularly powerful is their ability to provide high-quality, on-demand, actionable data. Combined with advancements in artificial intelligence and geospatial technologies, they enable disaster preparedness and response teams to work smarter and faster. For flood management, this means being able to pinpoint risk areas, assess damage, conduct real-time monitoring, and support relief operations with unprecedented accuracy.

When disasters strike, countries in the Global South bear the brunt of the impact. This is why the Flying Labs Network remains at the forefront of disaster risk reduction in Africa, Latin America, the Caribbean, and Asia/Pacific. In 2023, we created a collaborative space between Flying Labs, WeRobotics, and external partners to ideate on how to scale the impact and reach of projects and training. The outcome of the ideation phase is a new concept we call the “Drones, Data and AI Solutions Platform for Climate and Disaster Resilience”. More information on this new concept will be available in February 2025 on WeRobotics’ website.

A key strength of the Solutions Platform is its emphasis on localized solutions. By leveraging local knowledge and expertise, the Platform ensures that strategies and technologies are practically and contextually appropriate. This localized approach enhances community resilience and empowers local disaster preparedness and response teams to plan effectively and act swiftly in emergencies, strengthening ownership and ensuring long-term impact.

This resource showcases how the Flying Labs Network is reshaping disaster risk management through locally-led applications of drones, data, and AI in Africa. The use cases presented provide real-world examples of how drone technology can be incorporated into three of the four stages of disaster actions: mitigation, preparedness, and response. From the integration of cutting-edge technologies and traditional disaster management practices comes high-precision and timely data that paves the way for efficient and effective decision-making processes in disaster risk reduction, ultimately inspiring a safer world for all.

MITIGATION

MITIGATION

2023 | SACRED SPACE, MODERN SOLUTIONS: DRONE MAPPING TOUBA'S URBAN CHALLENGES

The holy city of Touba in Senegal attracts millions of pilgrims every year for the Grand Magal of Touba. But this major celebration of deep culture and faith coincides with the rainy season—and the floods that accompany it. With every downpour, the city becomes nearly impossible to navigate, with houses submerged and streets cut off.

More than a mere concern, Touba's flooding issues are a pressing matter that affects approximately 1 million people, with 57 neighborhoods identified as particularly vulnerable. Current flood management methods, such as using trucks and motor pumps, have proven ineffective, prompting the need for a more comprehensive approach.

In March 2023, Senegal Flying Labs undertook a mission to create detailed 3D maps of the iconic Great Mosque in the city and 2D maps of other flood-prone neighborhoods. Developed in close collaboration with the Touba Town Hall, religious leaders, and the local community, the project’s ultimate goal was to find long-term solutions to the city's flooding and infrastructure problems.

Fig. 1 The holy city of Touba in Senegal

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MITIGATION

The project began with extensive community engagement, which played a central role in its success. Meetings with local authorities and religious leaders helped secure the necessary permissions, and community members were briefed on the importance of the data collection activities. This collaboration ensured that mapping efforts targeted the areas most impacted by flooding, aligning the mission with local priorities.

Fig. 2 One of the pilots from Senegal Flying Labs in action

The high-resolution drone imagery collected allowed the Senegal Flying Labs team to map land use, drainage networks, and flood-prone areas. Alongside flood mapping, they produced a 3D map of the Great Mosque of Touba, capturing the architectural details of one of the city's most revered landmarks. Despite logistical challenges, the team completed the mission within four days, producing orthomosaics, DTMs, and DSMs that they shared with local authorities.

In the short term, the maps identified critical areas needing immediate intervention, including abandoned buildings, damaged roads, and potential flood zones. These insights will help local authorities develop more effective flood prevention strategies. In the long term, the data will be used to create permanent solutions to Touba's infrastructure challenges, helping the city prepare for future growth and mitigate the effects of climate change. Additionally, the maps could also potentially be used to significantly improve urban planning and enhance tax collection through the creation of a spatial database for the city.

Following the project, Senegal Flying Labs continues engaging with local stakeholders to ensure the data is used effectively. Plans are underway to extend the mapping efforts to other parts of Touba and to train local authorities on using geospatial data for urban planning and flood management. By involving the community and ensuring that local knowledge is incorporated into the mapping process, the project has laid the groundwork for a more resilient and sustainable future for the city.

PROJECT IN NUMBERS

LOCATION

Country: Senegal
Areas Covered: Darou Khoudoss, The Great Mosque of Touba, Ndam, and Ndamatou

SUSTAINABLE DEVELOPMENT GOALS

PLATFORM & DURATION

Platform: Phantom 4 RTK
Project Duration: 1 week
Processing Time: 4 days

DATA COLLECTION

Area Mapped: 121.9 ha
Data Volume: 4632 images (90 GB)
Flight Height: 70 - 120 m
Image Resolution: Varied depending on location (1.9 - 3.3 cm/pixel)

DATA PROCESSING & ANALYSIS

Data Products: An orthomosaic of the targeted areas, Digital Terrain Model, Digital Surface Model, and Point clouds

Analytical Outputs: Map of hydrographic networks and watersheds and land use map

PARTNERS & COMMUNITY

Project Partners: Touba Mosque Commune and Touba community

People Impacted: Approximately 1 million Darou Khoudoss, Ndamatou, Ndam and Touba residents.

FOR MORE INFORMATION

Use Case: 3D Mapping of the Great Mosque of Touba and 2D Mapping of Flood Zones
Blog: Revitalizing a Holy City: Senegal Flying Labs' Drone-Powered Vision for Touba's Future
Video: Senegal Flying Labs Preservation of the Holy City of Touba
Website: Senegal Flying Labs

2022-2023 | SEJWETLA INFORMAL SETTLEMENT: A CASE OF URBAN FLOODING

In 2022, South Africa Flying Labs launched a pioneering project to showcase the power of drone technology in disaster risk reduction, targeting Sejwetla, an informal settlement in Alexandra Township, Johannesburg. Home to over 5,000 residents, Sejwetla is perched along the banks of the Jukskei River, just a stone's throw from affluent Sandton, and faces significant flood risks. Seasonal summer rains can bring over 120mm of precipitation, and upstream rainfall in the Jukskei River catchment frequently triggers flash floods, putting the community at constant risk.

The project aimed to address these vulnerabilities and strengthen Sejwetla's resilience by using drones to generate data that could guide flood mitigation. It unfolded in three steps: engaging stakeholders, gathering data, and processing and analyzing that data to create actionable maps.

Stakeholder engagement began with extensive physical and virtual consultative workshops. These workshops included diverse stakeholders, from unemployed youth and Ward Committee members to the City of Johannesburg, the Provincial Government, and the National Disaster Management Centre.

Fig. 3 Three different aerial views of Sejwetla Informal Settlement

From the drone data collection, processing, and analysis emerged two main maps.

A flood risk map: Identified dwellings most susceptible to flood risk, that is, those along the Jukskei River (lowest elevation, closest to the highest water flow and accumulation area).
A fire risk map: Identified dwellings most susceptible to fire risk, that is, those closest to vegetation and those built with easily flammable/combustible material.

These maps enabled the team and the stakeholders to closely examine Sejwetla's landscape, including its dwellings, roads, rivers, and vegetation. The insights gained were foundational for both immediate interventions and long-term planning.

MITIGATION

In early 2023, severe flooding along the Jukskei River, triggered by a heatwave followed by heavy rains, called attention to the urgency of this work. South Africa Flying Labs promptly launched a second phase, building on the findings from the initial project to assess the impact of the flooding. The drones were deployed once again, following extensive stakeholder engagement.

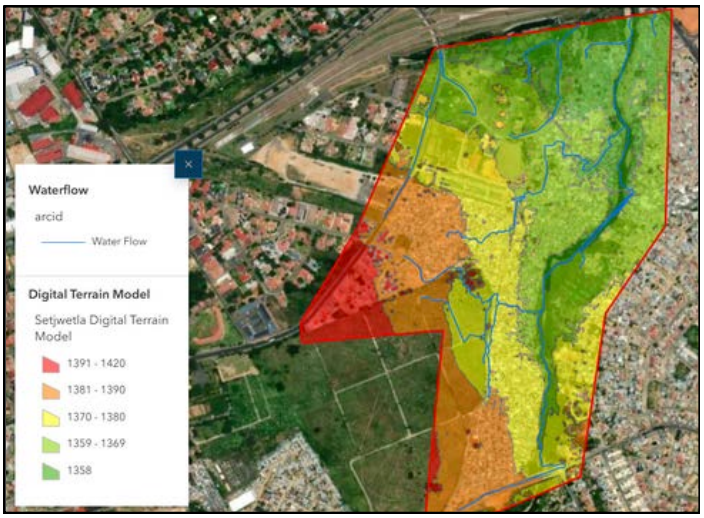

Fig. 4 Maps showing the boundaries of the area studied.

The project's second phase confirmed previously identified flood-prone areas in Sejwetla and detected changes such as expanded dumping sites and increased water levels in the Jukskei River. Additionally, it included simulations to evaluate potential flooding impacts at 2m, 5m, and 10m water rises. These simulations compared April 2022 river levels with projected scenarios, highlighting areas at risk of soil erosion and identifying households that would be affected.

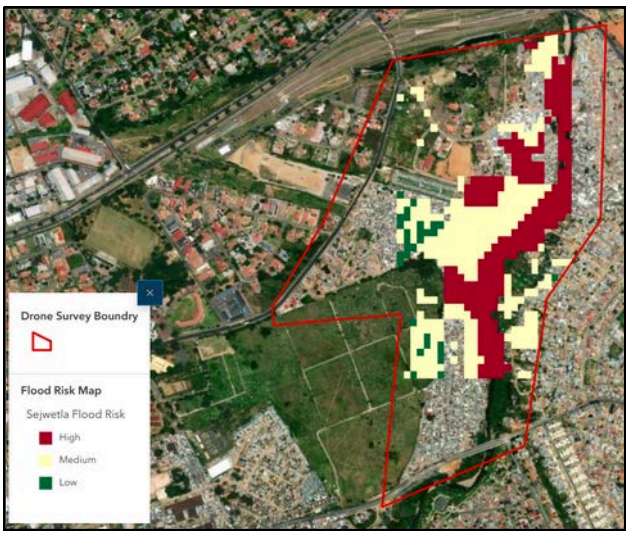

Fig. 5 Maps of Sejwetla Informal Settlement showing areas of flood and fire risks

This project also provided accredited training for unemployed youth to strengthen local disaster risk management capacity. Findings from this second phase were presented to stakeholders, offering valuable insights for future disaster preparedness efforts and highlighting the potential of drone technology to foster resilience in vulnerable communities.

PROJECT IN NUMBERS

LOCATION

Country: South Africa
Areas Covered: Sejwetla Informal Settlement

SUSTAINABLE DEVELOPMENT GOALS

PLATFORM & DURATION

Platform: DJI Phantom 4 Pro
Project Duration: 3 months
Processing Time: 1-2 week

DATA COLLECTION

Area Mapped: 150 ha
Data Volume: 2028 images
Flight Height: 80 m
Image Resolution: 2.6 cm/pixel

DATA PROCESSING & ANALYSIS

Data Products: Point cloud, orthomosaic, and Digital Elevation Model

Analytical Outputs: Flood and fire risk maps

PARTNERS & COMMUNITY

Project Partners: Gautenge Government Department, City of Johannesburg, United Nations International Children's Fund South Africa (UNICEF SA), Community of Alexandra (Stjwetla Informal Settlement)

People Impacted: Approximately 2000 people impacted.

FOR MORE INFORMATION

Storymap: Turning Data into Action - Drones in Disaster Management
Blog Post: South Africa Flying Labs Responds To Devastating Floods Using Drones
Video: South Africa Flying Labs Responding to Devastating Floods with Drones
Website: South Africa Flying Labs

MITIGATION

2020 | MAPPING FLOOD RISKS: GIS ANALYSIS OF TURKWEL DAM AND ITS WATERSHEDS

In October 2020, a brewing crisis surrounded Kenya's Turkwel Dam. Heavy rains had driven water levels to a dangerous height of 147 meters—just two meters shy of spilling over, threatening to flood the Turkwel basin and endanger the lives of nearly 16,000 people.

In response, Kenya Flying Labs joined forces with the West Pokot County Government, the Kerio Valley Development Authority (KVDA), and the Kenya Red Cross Society to launch a flood risk assessment project. The County Government of West Pokot provided local knowledge and logistical support; the KVDA contributed its expertise in water resource management, while the Kenya Red Cross Society brought its experience in disaster response.

Fig. 6 Turkwel Dam, Kenya

The project unfolded in two key phases. The first phase focused on studying the situation at Turkwel Dam by comparing the October 2020 water levels with historical data, including the driest month ever recorded in the region. The second phase focused on the basins surrounding the dam, creating flood models to predict the potential scale and impact of flooding if the dam overflowed. The models generated during the project were instrumental in addressing essential questions:

Who would be affected?
To what extent?
What would the volume of floodwaters be?

Armed with this data, Kenya Flying Labs and their partners could craft. a targeted evacuation plan and other preparedness measures, reducing the potential impact on the 16,000 at-risk residents.

MITIGATION

Yet the project's success hinged on gaining community support—a challenge initially met with skepticism. Kenya Flying Labs initially intended to use high-resolution drone data for the project. However, for many locals, drones were synonymous with military operations, sparking distrust.

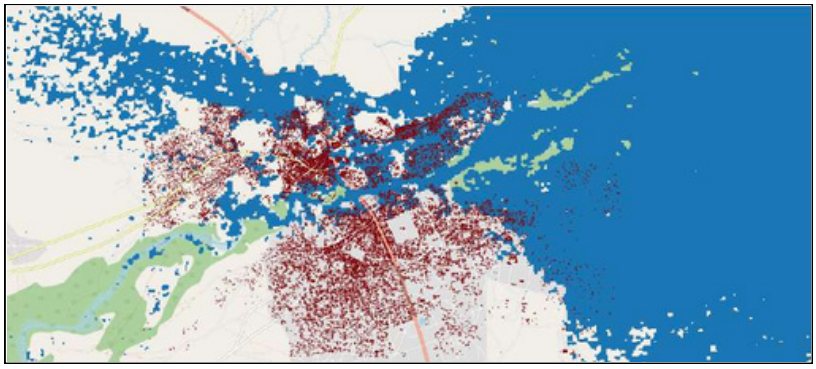

Fig. 7 Flood model of Ladwar Town, one of the basins in the Turkwel region. The red polygons depict the building footprints and the blue represents the floods at a specific level

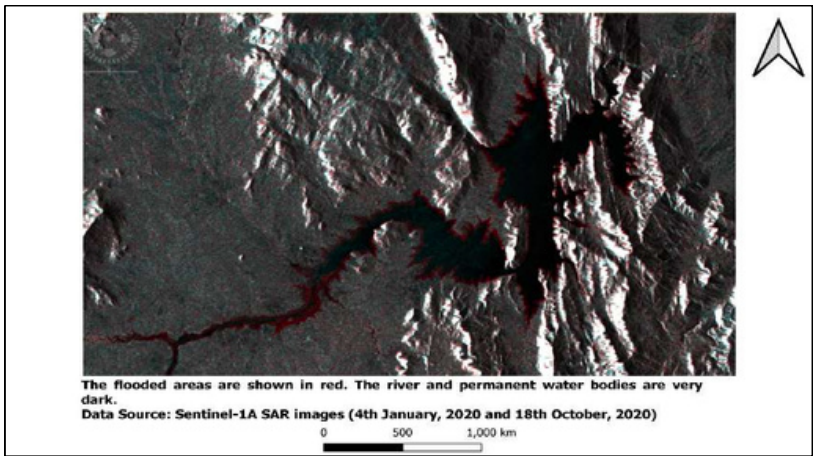

Fig. 8 Satellite image showing flooded areas in red.

Recognizing this, the team held workshops and meetings with key local stakeholders, explaining the role of drones in disaster preparedness. They even conducted a flight demonstration, showcasing how drones could aid in flood management. These efforts helped build trust and collaboration, leading to a significant shift in community perception. Although it was satellite data that ultimately saved the day, the project initiated broader discussions about using drones as well as satellite technology for disaster preparedness in Kenya.In the aftermath, Kenya Flying Labs signed a Memorandum of Understanding with the County Government of West Pokot to integrate drones into flood management and other disaster response efforts. This marked a crucial step in institutionalizing drone technology for public safety, particularly in remote regions, paving the way for more data-driven disaster management approaches.

PROJECT IN NUMBERS

LOCATION

Country: Kenya
Areas Covered: Turkwel Dam

SUSTAINABLE DEVELOPMENT GOALS

PLATFORM & DURATION

Platform: Satellite - Sentinel 1 (C-band SAR)
Project Duration: 4 months
Processing Time: 2-3 weeks

DATA COLLECTION

Area Covered: Turkwel basin, which covers 2 374 000 ha
Data Volume: Unknown
Flight Height: Unknown
Image Resolution: 10 m spatial resolution

DATA PROCESSING & ANALYSIS

Data Products: Satellite imagery

Analytical Outputs: Flood maps and models

PARTNERS & COMMUNITY

Project Partners: County Government of West Pokot, Kerio Valley Development Authority, and Kenya Red Cross Society

People Impacted: Approximately 16,000 residents of the Turkwel basin.

FOR MORE INFORMATION

Use case: Using GIS to assess, model and analyse floods A case study at Turkwel dam and its basins
Blog Post: When the Dam Breaks: Using GIS Data For Flood Disaster Preparedness
Website: Kenya Flying Labs

PREPAREDNESS

PREPAREDNESS

2023 | BUILDING A GEOSPATIAL AND DRONE DATA ECOSYSTEM FOR ENHANCED CAPACITY AND RESPONSE IN NIGERIA

In 2023, Ondo State, Nigeria, faced its worst flooding in five years, with the capital, Akure, experiencing unprecedented losses to life and property. For two relentless days in June, rain poured over Akure for 17 consecutive hours, flooding key areas and overwhelming local infrastructure. As residents struggled with the aftermath, Nigeria Flying Labs partnered with local authorities to launch a mission aimed at transforming flood management in the region using drone technology.

The team set out to address two challenges. The first challenge focused on enhancing the state actors' capacity to implement drone and geoinformation-based systems for the assessment of flood disaster vulnerability. The second challenge focused on tackling poor waste management and the indiscriminate dumping of refuse, which often obstructs water channels and exacerbates flooding.

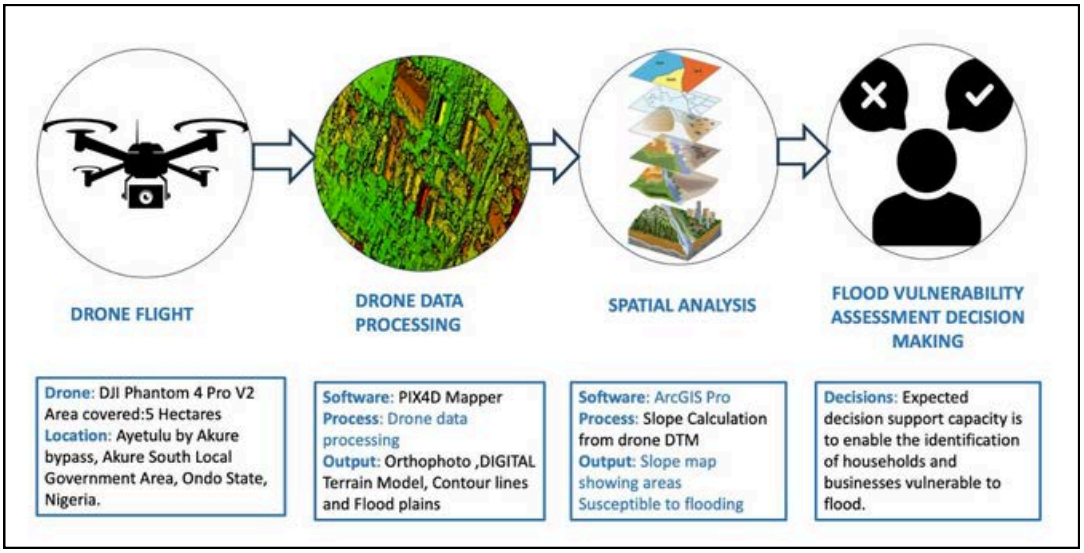

Fig. 9 One of the many visuals used by Nigeria Flying Labs to illustrate the workflow of drone application workflows

The team conducted drone flights in Akure South Local Government Area, home to over 500,000 inhabitants, to map and identify flood-prone areas. High-resolution images collected from multiple flights were then processed using various photogrammetry software to generate DTM, DSM, orthomosaics, and contour maps. These data products formed the basis of a complete disaster vulnerability assessment, identifying households and businesses at risk of flooding in the upcoming wet season in 2024.

PREPAREDNESS

In addition, the team also conducted a two-day training on Drone Operation and GIS for technical officers of Ondo State Environmental Protection Agency (OSEPA)., This hands-on training deepened local knowledge of the power of drone data and geospatial information in disaster response, building capacity for more effective flood management.

Community engagement was at the heart of this project. By involving residents and stakeholders, the team ensured transparency, gained critical insights into how the floods affected daily life, and built local trust in drone technology.

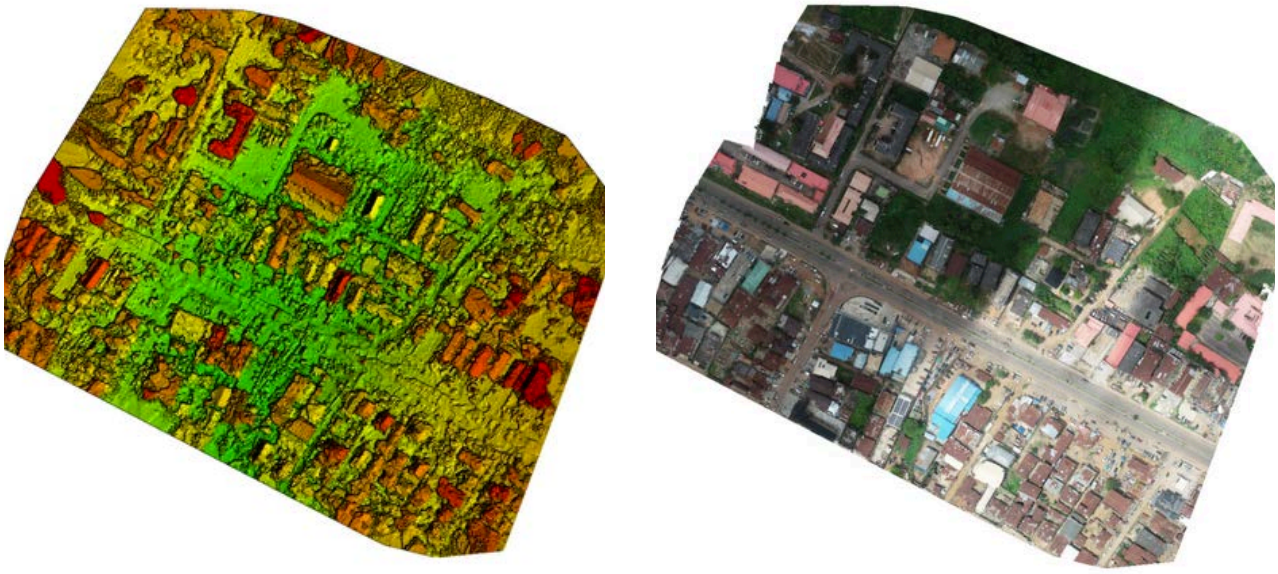

Fig. 10 Data products generated from drone data during the training to visualise the capabilities of drones.

The creation of these flood maps was a major achievement—not only providing actionable insights but also offering lasting tools for local authorities to understand and mitigate flood risks. This data-driven approach encouraged long-term planning for more resilient infrastructure, instilling local confidence in Ondo State's ability to withstand future disasters.

RESPONSE

RESPONSE

2024 | KENYA FLYING LABS AND KENYA RED CROSS JOIN FORCES TO COMBAT FLOODING

In response to unprecedented torrential rainfall and severe flooding across Kenya since March 2024, Kenya Flying Labs partnered with the Kenya Red Cross to provide critical disaster response and assessment and assist in search and rescue. The heavy rainfall led to widespread devastation, resulting in significant loss of life, the displacement of thousands, and substantial damage to infrastructure and communities. The collaboration aimed to address urgent needs by deploying drones to assess the situation swiftly and effectively, enabling responders to map affected areas, gauge the extent of damage, and identify high-risk zones.

Fig. 11 Two different aerial views showing the extent of the damage in Kenya after the flood

Drones equipped with high-resolution cameras and advanced sensors allowed for rapid aerial surveys, capturing real-time imagery and video to support the evaluation of damage and highlight areas needing immediate intervention.

Fig. 12 The Kenya Flying Labs team on the ground providing assistance with drones

This comprehensive aerial perspective proved instrumental in directing resources efficiently and prioritising areas for emergency response. The information gathered helped the Kenya Red Cross and other relief teams strategise and coordinate their efforts, ensuring that resources quickly reached the most impacted communities.

This use of drones has underscored the value of technology in disaster management, particularly in enabling faster and more effective responses.

As this is quite a recent disaster and as the situation continues to unfold, Kenya Flying Labs and Kenya Red Cross remain committed to their joint efforts to support affected populations and work toward a more resilient Kenya prepared to face future natural disasters.

RESPONSE

2019 | DRONE-DRIVEN FLOOD MAPPING INITIATIVES IN KEUR MASSAR

In 2019 in Keur Massar, Dakar, emergency responders faced an all-too-familiar dilemma: without current data, they were in the dark about the full scale of the recent floods. Roads had vanished underwater, neighborhoods were isolated, and damage was spreading, but there was no clear map of where to deploy resources first.

In the wake of this, the Senegalese Red Cross Society sought out Senegal Flying Labs for a flood-mapping project, recognizing the power of real-time aerial data to provide up-to-date spatial information quickly and guide their response. Additionally, this data was necessary to help secure disaster relief funding from governmental and international agencies.

Fig. 13 An aerial view of the floods in Dakar, captured by Senegal Flying Labs team

Senegal Flying Labs began by informing local communities about the project, explaining its objectives, and outlining the areas that would be mapped. This step was crucial in building awareness, ensuring safety, and gaining the trust of residents who were understandably concerned about the flooding. Then, the team conducted a preliminary site visit, conducted their drone flights to collect high-resolution imagery, and thereafter processed it to produce detailed maps and models of the flood zones.

One of the project's key outcomes was the creation of a land cover map, which provided critical information about the extent of the flood and the affected infrastructure. This map allowed emergency responders to quickly identify damaged buildings and assess road accessibility, which is vital for prioritizing rescue and relief operations. The project also significantly reduced damage assessment time, allowing the Red Cross teams to make faster decisions about where to deploy resources and personnel.

RESPONSE

Another critical aspect of the project was integrating aerial data with ground data collected by local volunteers. This approach allowed for a more detailed and visually accurate representation of the flood's impact, giving responders a clearer picture of the situation on the ground.

Fig. 14 Senegal Flying Labs team members in the field preparing to conduct flights

In addition to the immediate impact on disaster response efforts, the project had longer-term implications for capacity building within the Senegalese Red Cross. Senegal Flying Labs trained the Red Cross team to integrate drone data into their workflows. By combining aerial imagery with ground-level data, the Red Cross could improve its disaster preparedness and response capabilities for future emergencies. This training would enable the organization to use similar technologies to respond more efficiently to floods and other disasters across Senegal.

RESPONSE

PROJECT IN NUMBERS

LOCATION

Country: Senegal
Areas Covered: Keur Massar, Dakar

SUSTAINABLE DEVELOPMENT GOALS

PLATFORM & DURATION

Platform: DJI Phantom 4 with RGB Camera
Project Duration: 1 month
Processing Time: 2 days

DATA COLLECTION

Area Mapped: 3 ha
Data Volume: 112 images
Flight Height: 60 m
Image Resolution: 2.63 cm/pixel

DATA PROCESSING & ANALYSIS

Data Products: KML orthomosaics, and presentation

Analytical Outputs: Flood maps and models and landuse/landcover maps

PARTNERS & COMMUNITY

Project Partners: Senegalese Red Cross Society

People Impacted: Residents of Keur Massar

FOR MORE INFORMATION

Use case: Flood mapping using drone data in Keur Massar
Website: Senegal Flying Labs

RESPONSE

2018 | TANZANIAN DRONE PILOTS RESPOND TO WORSE FLOODING IN 100 YEARS

In October 2017, Tanzania Flying Labs' tuk-tuk driver arrived at their office with nothing but the clothes on his back. He had lost everything. This was the highest October rainfall Dar es Salaam had experienced since records began in 1918. Living along the riverbank had been affordable and convenient, but the raging flood waters had changed his life overnight.

In collaboration with the Dar es Salaam Multi-Agency Emergency Response Team (DarMAERT), Tanzania Flying Labs used drones to survey key areas of the city, assessing damage and identifying blockages in drainage systems.

Fig. 15 A closer look at the damage caused by the flooding, captured by Tanzania Flying Labs

The project took a comprehensive approach, focusing on two significant aspects of flood management: immediate disaster response and long-term prevention efforts.

For immediate disaster response, drones were deployed to survey large areas, capturing high-resolution images and videos. These images helped authorities identify and prioritize areas requiring urgent attention. The team was able to quickly locate critical infrastructure that needed intervention, such as roadways, homes, and businesses that were entirely submerged or isolated.

RESPONSE

For long-term prevention efforts, experts analyzed imagery and flood patterns to identify systemic issues within the city's drainage network and propose strategic solutions.

Fig. 16 An orthomosaic showing the area covered with the use of drones.

The data showed how certain parts of Dar es Salaam were particularly vulnerable to flooding due to poorly maintained drainage systems and urban sprawl, which increased the volume of water in low-lying areas. This information allowed urban planners to recommend improvements in drainage capacity and identify areas where development should be regulated or prevented to minimize future risk.

As part of the project, Tanzania Flying Labs also equipped local drone pilots with the skills to handle such disasters effectively. Given Tanzania's shortage of specialized disaster response resources, this was a crucial step in building local capacity.

The success of this initiative demonstrated the potential of integrating drones into disaster management and recovery, offering a hopeful vision of faster, safer, and more comprehensive assessments than are achieved by traditional methods.

As one of the earlier examples of a successful collaborative approach to disaster management projects, this project served as a model for other Flying Labs in the region facing similar challenges. The partnership between the Flying Labs, local authorities, and global experts exemplified how a multi-sectoral approach could offer holistic solutions. In the long term, the data gathered through these operations will continue to serve urban planners and policymakers as they work toward reducing flood risks in Dar es Salaam and beyond.

THE WAY FORWARD

Integrating drones, geospatial data, and localised expertise represents a paradigm shift in flood management. By leveraging these technologies alongside community-driven approaches, the Flying Labs Network has demonstrated the power of precise, real-time data to enhance disaster preparedness, response, and mitigation. These initiatives not only address immediate flood-related challenges but also empower communities to build a foundation for sustainable, long-term resilience in vulnerable regions.

Currently, most of the use cases from Flying Labs are in three of the four essential categories of disaster risk management: mitigation, preparedness, and response. For instance, drones have been used for rapid damage assessment, geospatial data for flood risk mapping, and localised expertise for community-based early warning systems. Recovery applications are currently low but are expected to rise as stakeholder understanding of drone technology grows. This application will be a cyclic process, with more accessible applications being adapted and applied far more often than those with less immediate impacts.

As climate-related disasters grow in frequency and intensity, adopting these innovative, scalable, and community-centric solutions is imperative for safeguarding lives, infrastructure, and ecosystems globally. The scalability of these solutions ensures their adaptability in different contexts, providing reassurance in the face of changing disaster scenarios.