Flying Labs

We Robotics

DRONES IN MANGROVE CONSERVATION AT FLYING LABS

CO-AUTHORS

Amrita Lal, WeRobotics
Dania Isabel Montenegro Chong, Panama Flying Labs
Leka Tingitana, Tanzania Flying Labs
Sonja Betschart, WeRobotics

INTRODUCTION

Mangroves are coastal forest ecosystems of salt-tolerant plants with intricate roots and broad evergreen leaves (Biswas & Biswas, 2019). Commonly found at tropical and subtropical latitudes, mangroves cover at least 75% of all tropical coastlines worldwide (Stocken et al., 2019). Mangroves are valuable ecosystems as it provides goods and services such as food, fuel, pollution filtering, coastal stabilisation, carbon sequestration as well as erosion, and flood control. As it is home to rich biodiversity, mangroves provide productive, protective, and economic benefits to coastal communities and marine life.

Despite their usefulness, mangroves have been under threat for years, and most of the threats have anthropogenic origins. These threats range from climate change and sea level rise affecting the mangrove habitat, deforestation for development and aquaculture, overharvesting to biological invasions, and particularly the introduction of invasive plants in mangrove ecosystems (Biswas & Biswas, 2019).

Several communities and organisations have continued safeguarding this valuable resource by traditional means of planting and monitoring, but in some cases, more is needed or has the potential to improve. With new and innovative technologies like drones becoming more applicable and accessible by the day, it is time for these communities and organisations to adapt for better results. This is where the global Flying Labs network can help.

ROLES OF FLYING LABS AND DRONES IN MANGROVE CONSERVATION

Flying Labs are a global network of independent knowledge hubs convening local experts in professional drone, data, robotics, and AI services. We shift power with local experts and lead local solutions to accelerate social good projects in Africa, Latin America, Asia, and beyond. We are doing the same for mangrove conservation efforts. Since the network's inception in 2015, multiple Flying Labs worldwide have been exploring the use of drones and applying them for mangrove conservation and awareness projects. These applications range from aerial seeding for mangrove restoration to mapping coastal environments for monitoring purposes.

This report documents some of the projects Flying Labs have conducted in their respective countries for the past few years.

AERIAL SEEDING AND MANGROVE RESTORATION IN PANAMA

PROJECT DURATION	PROJECT STAKEHOLDERS	PROJECT PARTNERS
1 Week	Communities in the Central Province of Panama - Oeste and Coclé	β - Earth

In 2021, Panama Flying Labs partnered with WeRobotics' engineering team to complete test flights with drones for an aerial seeding and mangrove restoration pilot in Panama. The pilot was carried out in Oeste and Coclé in the Central Province of Panama and included a team of local community members, engineers, drone pilots, and various stakeholders. To prove the effectiveness and convenience of using drones for long-term sustainable reforestation, the team carried out multiple test flights with specially adapted drones, release mechanisms, seed balls, and mangrove propagules.

Fig 1.1: Panama Flying Labs Coordinator Dania makes attaches mangrove propagules to the drone prior to its flight.

Mangroves store five times more carbon in their soils by surface area than tropical forests and ten times more than temperate forests. They also provide shelter for marine life, a protective barrier against storm surges, and absorb microplastics. Essentially they are a valuable and protected resource, but anthropogenic factors have threatened their survival in many places in Panama.

Before the trial, the reforestation method in the two communities was hand planting. While being useful, hand-planting seeds for native trees and mangroves can be tedious, time-consuming, and cumbersome in muddy terrain and hard-to-reach areas.

Therefore, Panama Flying Labs chose to test drones to potentially scale up and accelerate the restoration efforts.

The drone-optimized release system developed by WeRobotics' engineering team for this pilot could carry 750+ seed balls per load and distribute them accurately in less than five minutes over one hectare. For mangroves, this meant 120 propagules dispersed near coastal regions. In addition, the propagules dropped from the fully autonomous system at an altitude of 2-3 meters showed promising results, as a good percentage of them could penetrate and enter the soil successfully.

The drone-optimized release system showed that it could load, store and release the seed balls and fresh mangrove propagules as designed. This optimisation dramatically sped up the planting efforts, outperforming traditional hand-planting practices while dispersing seeds and mangrove propagules where the terrain was not accessible.

Panama Flying Labs also led several community engagement activities to ensure the long-term protection of the newly planted areas. Through these community engagement activities, Pastoral Social-Cáritas offered their eight hectares of land to develop the demonstration, including the valuable presence of the Los Pollos community's members as witnesses of the trial. In addition to this, another land plot was restored at the Penonomé community, on the grounds of the Penonomé Penitentiary Centre. The follow-up of this particular plot will be in the hands of the inmates, and through the social integration program, they will support comparing the effectiveness of drone planting vs hand planting.

A QUICK GLANCE AT THE NUMBERS

A total of 20 flights over 3 days

5000 seed balls and 120 mangrove propagules dispersed

4.1 ha covered via drone flights

Fig 1.2: Ground team in Panama maintaining line of sight as the drone takes flight.

CAPACITY BUILDING WORKSHOP FOR INTEGRATING DRONE TECHNOLOGY FOR MARINE CONSERVATION AND ECOSYSTEM MANAGEMENT IN TANZANIA

PROJECT DURATION	PROJECT STAKEHOLDERS	PROJECT PARTNERS
1 WEEK	Tanzania Marine Parks and Reserves Unit	World Wildlife Fund Tanzania Duke University Marine Lab

In 2019, Tanzania Flying Labs successfully conducted drone training to build local capacity in marine conservation and ecosystem management. The 5-day training occurred at Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP), Mtwara Rural District in Tanzania. It focused on key aspects through practical exercises and theoretical knowledge sharing. The practical aspect included understanding drone technology, current Tanzanian UAS regulations, and operating it responsibly and ethically. On the other hand, the theoretical aspects covered understanding how to derive information from drone data and conduct preliminary analysis. It also included learning how to identify and map critical areas of interest for management in MBREMP.

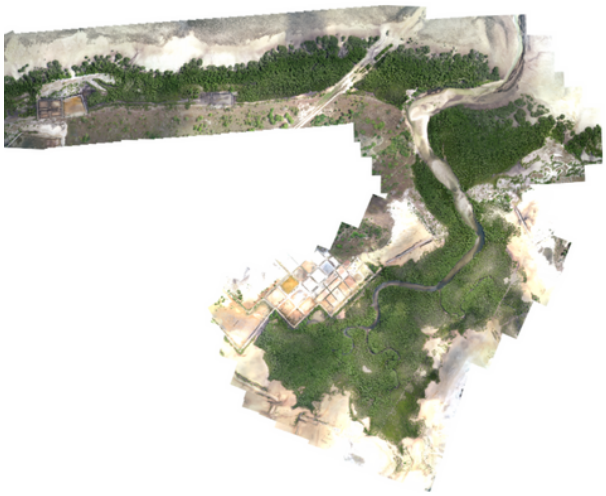

Fig 2.1: One of the orthomosaics which were the result of the training. This one shows an aerial view of the Kilindini area in Tanzania.

The training was focused on Mnazi Bay-Ruvuma Estuary Marine Park as it is one of Tanzania's largest Marine Protected Areas (MPA) and home to a diverse range of flora and fauna, including mangroves. Due to its sheer size and importance, multiple representatives from universities (both in Tanzania and abroad), government departments, NGOs, and Village Liaison Committees participated in this training to better understand how they can use drone technology to monitor and protect this MPA.

By the end of the workshop, participants could identify and prioritise key areas of interest for mapping inside park boundaries, plan and fly their own missions with both fixed-wing and multirotor drones, and produce habitat maps for analysis.

A QUICK GLANCE AT THE NUMBERS

Both fixed wing and multirotor drones used

11 organizations benefitted from the training

670 ha - total area mapped during the training

MANGROVE AND SEA LEVEL MONITORING IN THE ZAPATILLA ISLANDS, PANAMA

PROJECT DURATION	PROJECT STAKEHOLDERS	PROJECT PARTNERS
1 MONTH	Naturaleza Foundation Panama	Eco Ideas

In 2019, Panama Flying Labs successfully conducted a mapping mission of the uninhabited North and South Zapatilla Islands. The two uninhabited islands lie within the Bastimentos Island National Marine Park in Bocas del Toro, Panama.

Due to its protected status, the Naturaleza Foundation routinely monitors the islands for the adverse effects of rising sea levels. Before the Panama Flying Labs project, the monitoring method consisted of physically taking samples at control points on site and comparing how much the sea had risen. That is where drones were introduced into the workflow to make the process quicker, more accurate, and more efficient.

Fig 3.1: Panama Flying Labs Coordinator Dania monitors a drone in flight from a boat offshore.

Intending to monitor both sea-level rise and the mangroves of the two islands, the team used multirotor drones and collected imagery data. This data delineated the boundaries of the mangrove forests and helped create orthomosaics, Digital Terrain Models, and Digital Surface Models. With these data products, the team produced preliminary flood models to give linear forecasts using ArcGIS Pro and created baseline data for monitoring and analysis with subsequent future datasets.

In addition to this, the team also collected ground control points and data to calculate Leaf Area Index (LAI).

The orthomosaics and models derived from this project were published in the Monitoring Protocol for the Panamanian Mangrove Ecosystem and shared with local institutions and organisations for the strategic planning and conservation of mangroves.

As the next steps, the Panama Flying Labs team plans to continue monitoring the Zapatilla Islands in collaboration with Naturaleza Foundation and is working towards starting reforestation efforts on both islands.

Fig 3.2: Orthomosaic of Zapatilla Northern Island

Fig 3.3: Orthomosaic of Zapatilla Southern Island

A QUICK GLANCE AT THE NUMBERS

A total of 6 flights flown to cover both islands

11 community members engaged in the project

More than 89 ha - total area mapped for both islands

CHILDREN'S BOOK SERIES - ARIEL & FRIENDS IN THE MAGIC OF MANGROVES

PROJECT DURATION

17 MONTHS

PROJECT PARTNERS

Panama Flying Labs

The Ariel & Friends children's book series was successfully launched in late 2021 with the help of Panama Flying Labs. The idea behind the series is to highlight the true stories of local communities tackling real-world problems with the help of drone technology, also known as flying robots! Designed for children who are ten years old or below, these stories aim to help children learn not only about drones, but also about the importance of diversity, determination, teamwork, and problem-solving.

Fig 4.1: Cover of the Ariel & Friends in the Magic of Mangroves childrens' book

Funded through a Kickstarter campaign and WeRobotics, the first book in the series focuses on the story of a young girl named Claudia from the indigenous community of Bocas del Toro in Panama. The story follows young Claudia as she embarks on a journey to discover better ways of protecting her island home after a devastating storm strikes one night. On this journey, she befriends Ariel, a flying robot, and together they discover the magic of mangroves. The Magic of Mangroves is the story of a young leader in the making who inspires her friends to help protect the environment around her. The story focuses on the real project that Panama Flying Labs conducted in 2021 (see Seeding Project on pages 2 and 3).

Local illustrators from Mexico, India and Malawi brainstormed with the Panama Flying Labs and WeRobotics team to create authentic characters to which children could relate. For storytelling, editors from Mexico and design specialists from India were also brought on board to translate the book into Spanish and design the layout.

A QUICK GLANCE AT THE NUMBERS

More than 5800 CHF raised. Surpassing the goal of 3000 CHF

106 pledges on Kickstarter

Global Team of 10 people from 7 countries

YOUTH PROGRAMS IN THE FIJI ISLANDS FOR MANGROVE CONSERVATION AWARENESS

PROJECT DURATION	PROJECT FUNDING	PROJECT PARTNERS
2 YEARS (2018 - 2019)	Australian Government Department of Foreign Affairs and Trade	Pacific Flying Labs

From 2018 to 2019 in the Fiji Islands, two youth programs were designed and conducted with several high schools in the Central and Western divisions. These programs were Fly Like A Girl (for female youth) and Aerial Adventure (for male youth). Both programs focused on raising awareness about the importance of mangroves and STEM fields using drones.

Fig 5.1: Youth putting together their presentation and data at a high school in Nadi, Fiji.

The Fly Like A Girl program focused on mapping mangroves near an informal settlement with drones. The settlement selected was battling several issues due to improper planning and, as a result, impacting the mangrove forest nearby. Through this program, young girls inspected the mangroves, mapped them with drones, and created orthomosaics with photogrammetry software back at the lab. As a part of the analysis phase, large maps were printed out and analysed to understand how anthropogenic factors affected the mangroves.

The Aerial Adventure program, on the other hand, focused solely on mapping mangroves near the coastline, identifying them, and understanding their importance from a cultural and scientific perspective. Through this program, participants mapped small patches of mangroves with their drones and identified them with a guidebook and their notes from the field.

Both the programs also touched on the importance of STEM education and local experts in the field of GIS/Remote Sensing to help participants understand the different career paths they can select in the near future.

A QUICK GLANCE AT THE NUMBERS

12 High Schools and 2 Orphanages engaged

More than 150 students participated in the programs

Students presented their projects at the GIS/RS User Conference, Fiji - 2019

THE WAY FORWARD

Flying Labs have adopted meaningful ways of addressing mangrove conservation issues in their local communities. Some have selected technical approaches like mangrove seed dispersal in Panama, while others have chosen to engage with youth and raise awareness among future leaders.

Due to the ever-evolving nature of drone technology and applications, more Flying Labs will be coming on board in the near future and adapting to existing practices or creating their own.

Regardless of their approach, Flying Labs are committed to protecting mangrove ecosystems as they understand its importance and will continue doing so with continuous support from WeRobotics.

REFERENCES

Biswas, P.L., Biswas, S.R. (2019). Mangrove Forests: Ecology, Management, and Threats. In: Leal Filho, W., Azul, A., Brandli, L., Özuyar, P., Wall, T. (eds) Life on Land. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-71065-5_26-1

Stocken, T. *et al*. (2019) 'A general framework for propagule dispersal in mangroves', *Biological Reviews*, 94(4), pp.1547-1575