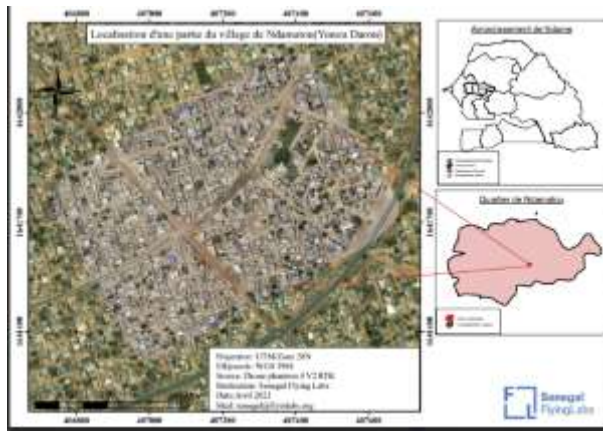
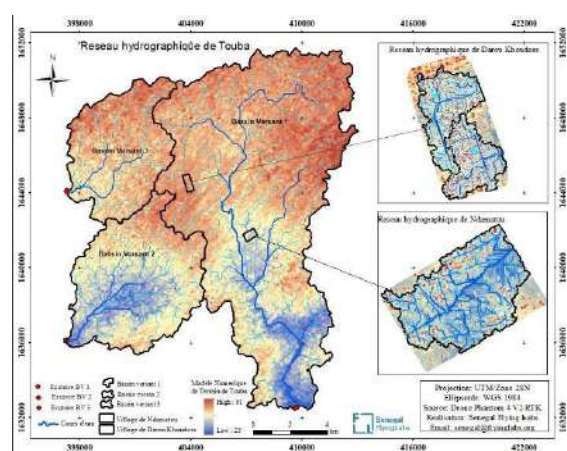


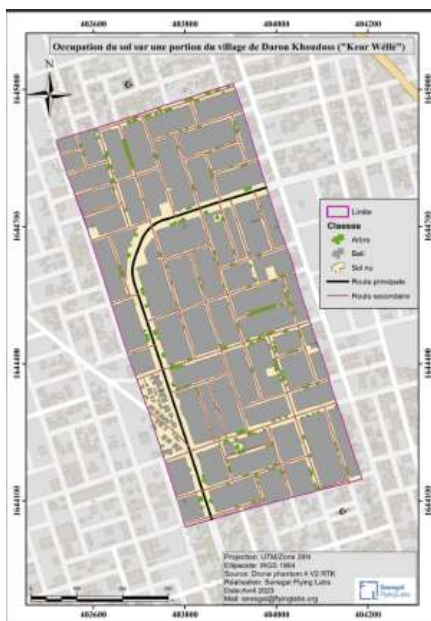
3D Mapping of the Great Mosque of Touba and 2D Mapping of Flood Zones



Ndamatou location



Touba watersheds and drainage network



Land use in Ndamatou (Yonou Darou)



Land use in Darou Khoudoss (Keur Welle)



Senegal Flying Labs team

OVERVIEW	
Flying laboratories	Senegal Flying Labs
Geographical area	Touba
Date range	13th to 16th March, 2023

Sector program	DevRobotics
Main SDGs	GOAL 3: Good health and well-being GOAL 6: Clean water and sanitation GOAL 9: Industry, innovation and infrastructure GOAL 11: Sustainable cities and communities

SCOPE	
Project stakeholders	Touba Town Hall
People affected	<ul style="list-style-type: none"> • Short-term affected population – Darou Khoudoss (Keur Welle), Ndamatou (Yonou Darou) and Ndam. • Population affected in the long term – residents of Touba town.
Number of people affected	Approximately 1 million residents of Darou Khoudoss, Ndamatou, Ndam and Touba.
Problem statement	<ul style="list-style-type: none"> • As the holy city of Touba grows, so do its sanitation problems. During the rainy season, the streets are almost cut off by surface runoff while some houses are submerged. • The worrying terrain causes distress to the residents of Touba, with 57 neighborhoods experiencing flooding. • Currently, there is no permanent solution to this problem despite attempts to use emptying trucks, motor pumps, and retention basins, which have not proved effective. With every downpour, moving around the holy city becomes difficult and nearly impossible.
Project objectives	The objective of this mission is to have a 3D map of the Great Mosque of Touba and also a 2D map of certain target flood zones.
Scope	<p>The activities undertaken to achieve the project objectives were divided into four stages:</p> <ul style="list-style-type: none"> • Community involvement: This entailed organizing a meeting with the Touba Mosque commune authorities to inform the communities in advance of the activity that will take place. • Collection mission planning: The team prepared equipment, planned flight missions, and examined weather conditions.

	<ul style="list-style-type: none"> • Site mapping: Using the Phantom 4 V2 RTK drone, we followed the flight path and collected high-resolution images at each time interval. • Image processing: Data collected was processed by photogrammetry software.
Outcomes	<ul style="list-style-type: none"> • In total, 121.9 ha were mapped, resulting in 4632 high-resolution images (90 GB of raw data). • The results obtained in the short term enabled us to identify flood-prone areas, buildings under construction or abandoned, bare plots of land, and to detect damage to roads, networks, building permits, and so on.
Impact	Our project results will enable us to propose long term solutions to reduce the risk of flooding in Touba. These include preventing the risk of flooding and strengthening the work of the tax authorities by creating a spatial database for the city of Touba.
Challenges	<p>On the first day of data collection, we encountered some major problems with the calibration of the gimbal and Inertial Measuring Unit (IMU). The process to acquire flight authorization was slow, therefore, we engaged the Xiidmatoul Khadim Dahira (a religious organization) in charge of Touba's Grand Mosque to ensure we had flight authorization from the Mayor or a member of his cabinet.</p> <p>Finally, so as not to waste the day, we decided to start with 2D mapping of flood-prone areas such as Darou Khoudoss, where we set off first to plan our first flight mission.</p> <p>After lengthy negotiations, we were able to obtain authorization to begin 3D mapping of the Grand Mosque of Touba, but after viewing the 3D images of the Grand Mosque we decided to re-do the mission in order to obtain clearer images.</p>
Next steps	Follow-up with stakeholders on data use and large-scale mapping of Touba and its environs.

COMMUNITY INVOLVEMENT AND STAKEHOLDER SUPPORT

Consent for data acquisition	On our first visit, we met the town's mayor, Mr. Abdoul Akhad KA, to explain why we had targeted the town of Touba, and we agreed to begin the necessary steps to start the collection mission.
Community involvement activities	We met with Mr. Guorgui Mbaye, the Cabinet Director of the Mayor of the Touba Mosque Commune, to discuss the objectives

	of the mission and also to provide us with some information on the areas to be mapped. He then put us in touch with Ms. Ngone Ndiaye Diouf, a road network agent, who joined the Senegal Flying Labs team and accompanied us throughout the data collection mission.
Community groups engaged with	Touba community in general.
Community attendance	Seven (7) people attended the meeting.
Community feedback	The community representatives recommended starting the mapping exercise in the center, then extending to the outskirts of the city.
Stakeholder support	The team explained the software and maps produced and proposed a certification training for the focal points.

DATA ACQUISITION

Zone size	<ul style="list-style-type: none"> ● Darou Khoudoss: 34.3 ha (0.343 km²) ● The Great Mosque of Touba: 27.6 ha (0.276 km²) ● Ndam: 30 ha (0.3 km²) ● Ndamatou: 30 ha (0.3 km²)
Drone	Phantom 4 RTK
Sensor(s)	CMOS
Flight plan software	DJI GS RTK
Flight height	<ul style="list-style-type: none"> ● Darou Khoudoss: 70 m ● The Great Mosque of Touba: 120 m ● Ndam: 70 m ● Ndamatou: 70 m
GSD (Accuracy)	<ul style="list-style-type: none"> ● Darou Khoudoss: 1.92cm/pixel ● The Great Mosque of Touba: 3.29cm/pixel ● Ndam: 1.92cm/pixel ● Ndamatou: 1.92cm/pixel
Number of images acquired	<ul style="list-style-type: none"> ● Darou Khoudoss: 1555 ● The Great Mosque of Touba: 1499 ● Ndam: 201 ● Ndamatou: 1377
Number of flights	<ul style="list-style-type: none"> ● Darou Khoudoss: 5 flights/day ● Touba Grand Mosque: 5 flights/day ● Ndam: 2 flights/day

	<ul style="list-style-type: none"> ● Ndamatou: 4 flights/day
Time invested in data acquisition	<ul style="list-style-type: none"> ● Darou Khoudoss: 63m 10s ● The Great Mosque of Touba: 48m 23s ● Ndam: 54m 55s ● Ndamatou: 55m 18s
Georeferencing	N/A

DATA PROCESSING AND ANALYSIS

Processing software	<ul style="list-style-type: none"> ● PIX4Dmapper ● ArcGIS 10.5
Processing time	4 days
Data products	<ul style="list-style-type: none"> ● An orthomosaic of the targeted areas ● Digital Terrain Model ● Digital Surface Model ● Point clouds
Analysis tools	<ul style="list-style-type: none"> ● ArcGIS 10.5 ● Global Cartographer
Analysis outputs	<ul style="list-style-type: none"> ● Map of hydrographic networks and watersheds ● Land use map
Final outputs shared with stakeholders	Mapping report
Data sharing	Hard disk