TWIGA Flying Sensor Training
Flood mapping urban and rural areas

Report

Kumasi, Ghana
23 November-29 November 2018

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Client:
TWIGA project
Horizon 2020 (European Commission)

Location training:
KNUST University, Kumasi, Ghana,

Location flight operations:
Flood prone area Kumasi

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1 Introduction

1.1 Background and objectives

FutureWater (www.futurewater.nl and www.futurewater.es) and HiView (www.hiview.nl) have been partnering since 2014 to perform Flying Sensor (FS) operations and to set up FS organizations in different African countries. It started with the prestigious and still on-going ThirdEye project (supported by USAID, http://thirdeyewater.com/) in Mozambique and Kenya. ThirdEye aims at giving advice to farmers to improve water productivity and thus yield, by means of providing crop stress maps based on images from FSs. Next to that FutureWater and HiView execute commercial jobs (e.g. monitoring irrigation schemes in Mozambique 2016 or tree plantations in Ghana 2018), and conduct FS trainings and workshops on the use of FSs for different purposes like elevation measurement, land degradation (e.g. for IHE Delft in Netherlands in 2018 and Worldbank in Madagascar in 2018) and flood mapping (for Worldbank in Mozambique in 2016).
It is in the context of flood mapping that FutureWater and HiView are currently active as consortium partners in the TWIGA project that originates in the Horizon 2020 program from the EU. TWIGA is an acronym for `Transforming Weather and Water data into value-added Information services for sustainable Growth in Africa`. Its objectives: provide currently unavailable geo-information on weather, water, and climate for sub-Saharan Africa by enhancing satellite-based geo-data with innovative in-situ sensors and developing related information services that answer needs of African stakeholders and the GEOSS community.
Within TWIGA the FutureWater-HiView consortium is deploying its activities in two fields: mapping energy fluxes in relation to vegetation, and flood mapping. The training that was conducted at the KNUST University in Kumasi, Ghana, was focused on flood mapping in an urban area of Kumasi. The flood-prone area that has been identified to monitor is situated alongside the Ofin River. It comprises urban as well as agricultural parts.

The objective of the training was to prepare operators for the use of FSs with the focus on applications for flood monitoring. The training course consists of skills training and capacity building in the following areas:

- FS piloting (manual and automated flights)
- Safety management
- Image processing and interpretation
- Organizing (PC, equipment, flight missions)
- Representing the TWIGA project

Furthermore the training contained different complementary activities that are needed with respect to flood mapping:

- Measuring GCPs (ground control points)
- Capturing ground validation images
- Gauging water level of the Ofin river and its tributary stream
- Assessing a rough estimate of plastic waste

1.2 Practical details

In the framework of the TWIGA project the training on Flying Sensors took place at the KNUST University in Kumasi, Ghana, from 23 up to 29 November 2018. The training was conducted by Jan van Til (FutureWater/HiView). The participants belong to different university departments and spin-off companies (see list of participants in Appendix II). TWIGA partner Farmerline, represented by Joel Budu and Emmanuel Duah, was amongst the participants. Farmerline will be responsible for further following up in monitoring the flood-prone area around Agogo market and the Lake Road bridge.

On various days field visits were organized during which manual and automated flights were trained and series of RGB (Red Green Blue), NIR (Near InfraRed) and IR (InfraRed, or thermal) images were captured. The images were taken during automated flights with the Sensy-M Flying Sensor that is, next to the regular RGB camera, equipped with a NIR camera and a thermal camera. Impressions of the field visit are provided in figures 1, 2 and 4. Appendix I contains the full training program.

After the training was concluded the two Farmerline members, Joel Budu and Emmanuel Duah, were appointed to become the Flying Sensor operators for the project. Farmerline is to supply prone-area footage in the framework of TWIGA.
One Sensy-M kit was handed over to Farmerline comprising a.o. the FS and a tablet (for the complete inventory list see Appendix III). This material will remain property and at the disposal of the TWIGA project.

Two training manuals were prepared in English and shared with all 10 participants (Figure 3)

1. Manual Sensy-M
2. Manual Image Processing

For the image processing the following software was used:
-QGIS (open source)
-ICE (opensource)
-Avenza (licensed)

Figure 1. Training site near Ofin river affluent, Kumasi

Figure 2. Training site near Lake Road bridge and the Agogo market, Kumasi

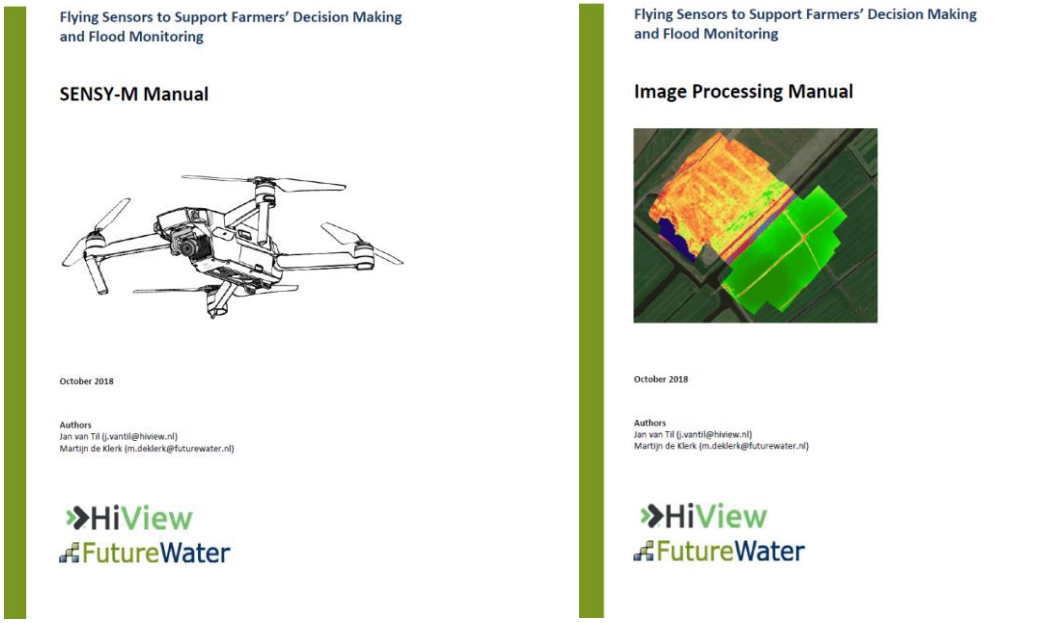


Figure 3. Manuals prepared for the training

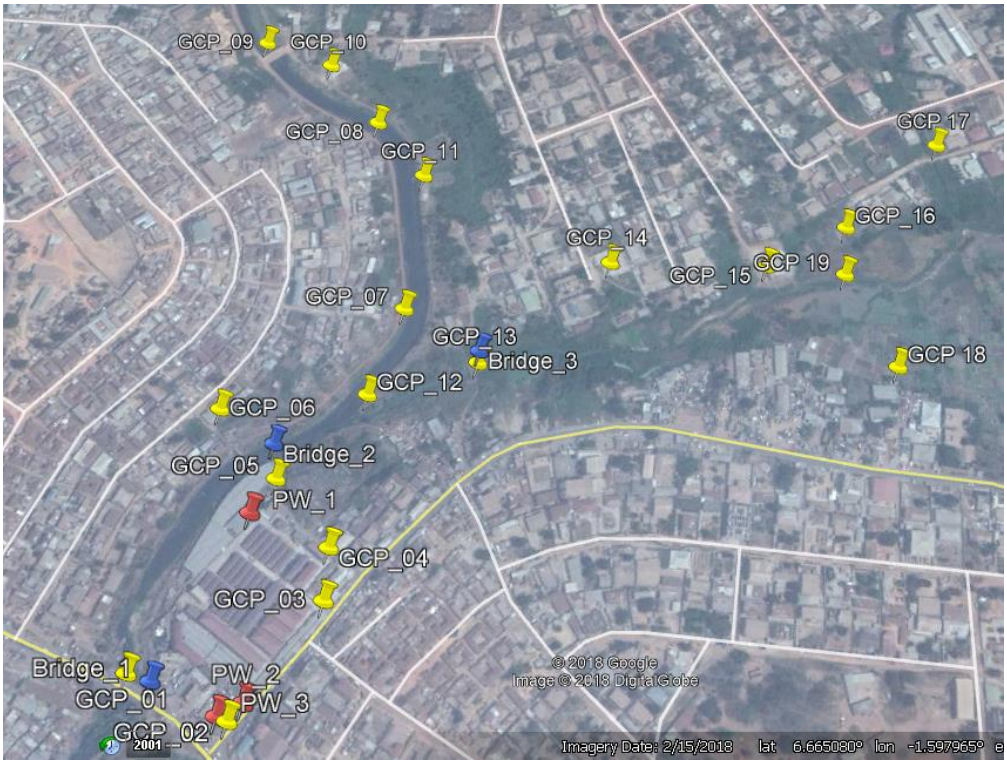
Figure 4. The training took place at the KNUST campus, Kumasi

1.3 Location of training sites

A flood-prone area has been identified in consultation with Marie-Claire ten Veldhuis and Nick van de Giesen. The area near to the Lake Road Bridge and the Agogo market was selected for different reasons:

- It concerns an urbanized area. A big market, the Agogo market, is situated inside the selected area.
- The main river, the Ofin river, and its affluent are partly canalized and partly have a natural shoreline
- Different kinds of water infrastructures are present (bridges, drainage canals)
- Alongside the river and in drainage canals a lot of plastic waste is compiled, causing problems for a good water discharge at heavy rain falls and thus causing floodings
- The area contains swamps and agricultural fields that regularly are flooded in the period from June up to September each year

Figures 5. Waste dump next to Lake Road



Figures 6 and 7. Lake Road Bridge area with GCPs (ground control points, in yellow), RLPs (river level points, in blue) and GVPs (ground validation points pointing out drainage bottlenecks, in red)

1.4 Flights in the training

Underneath is a list of the flights performed at the training.

27 November 2018

F01

Mavic: Farmerline (Mavic Pro Platinum)
Area: area_east
Cams: NIR+RGB
Height: 100m
Surface: 500x200m
Overlap: 80 %
Speed: 60%
Weather: cloudy

F02

Mavic: Farmerline (Mavic Pro Platinum)
Area: area north
Cams: NIR+RGB
Height: 100m
Surface: 500x200m
Overlap: 80 %
Speed: 60%
Weather: sunny

F03

Mavic: Farmerline (Mavic Pro Platinum)
Area: area south_1
Cams: NIR+RGB
Height: 100m
Surface: 710x150m
Overlap: 80 %
Speed: 60%
Weather: sunny

F04

Mavic: Farmerline (Mavic Pro Platinum)
Area: area_south_2
Cams: NIR+RGB
Height: 100m
Surface: 710x130m

Overlap: 80 %
Speed: 60%
Weather: sunny

28 November 2018

F01

Mavic: Farmerline (Mavic Pro Platinum)
Area: area_west from Lake Rd bridge (bridge 1)
Coord.?. Make a stitch with RGB images (geo-tagged) to find location.
Cams: Thermal(FLIR Duo-R)+RGB
Height: 30m
Surface: 50x50m
Overlap: 90 %
Speed: 40%
Weather: sunny

F02

Mavic: Farmerline (Mavic Pro Platinum)
Area: area_west and east from Lake Rd bridge (bridge 1)
Coord.?. Make a stitch with RGB images (geo-tagged) to find location.
Cams: NIR+RGB
Height: 60m
Surface: 100x200m
Overlap: 80 %
Speed: ?? (40% or 60%?)
Weather: sunny

2 Image processing workflow

Underneath you will find an example of the processing workflow as was practiced by the training participants during the training. All images below are derived from the flights that were undertaken during the training.

2.1 Single images

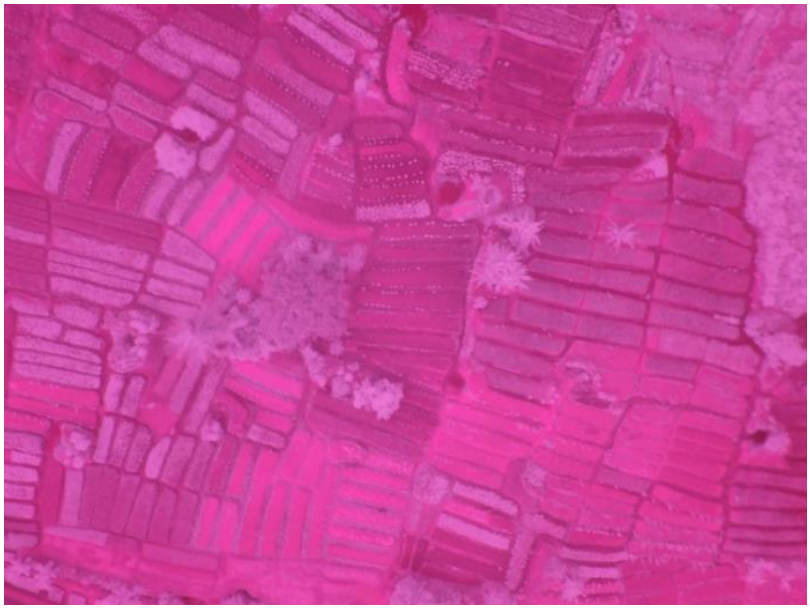
Flight operations details

Flying Sensor: Sensy-M

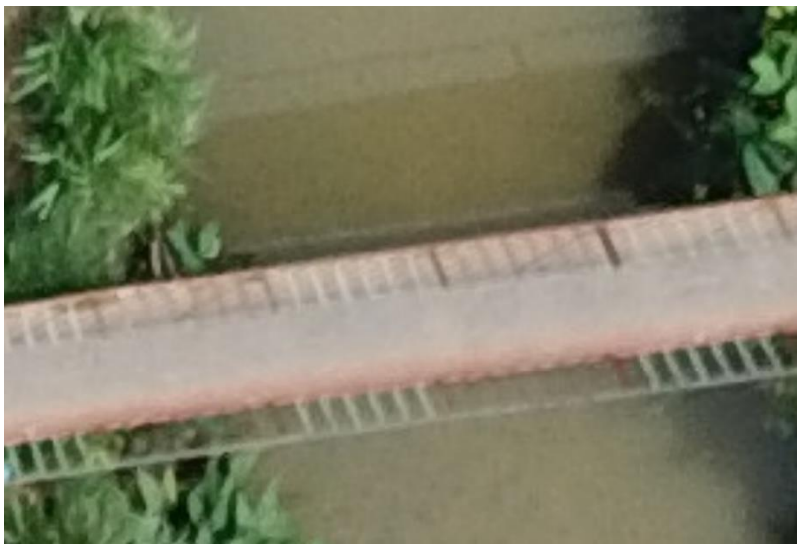
Flight number: 20181127_F01 (see above)

Sensor details

Figures 8 and 9. Single RGB images 1 and 2



Figures 10 and 11. Single NIR images 1 and 2 (false color)



Figures 12 and 13. Details from single RGB images 1 and 2

2.2 Processed images

The “raw” images can be processed into different derived products, which can subsequently be applied for different purposes related to sustainable land and water management. Examples of processed images are given below.

1 Orthomosaic RGB, below referred to as Ortho RGB
2 Orthomosaic NIR, below referred to as Ortho NIR
3 Geo-referenced NDVI map in grayscale, below referred to as Ortho NDVI_BW
4 Geo-referenced NDVI map in color scheme, below referred to as Ortho NDVI_color

Figure 14. Ortho RGB. Area east from Lake Road Bridge, projected in GE

Figure 15. Ortho NIR. Lake Rd Bridge projected in GE

Figure 16. Ortho NDVI_BW. Lake Rd Bridge

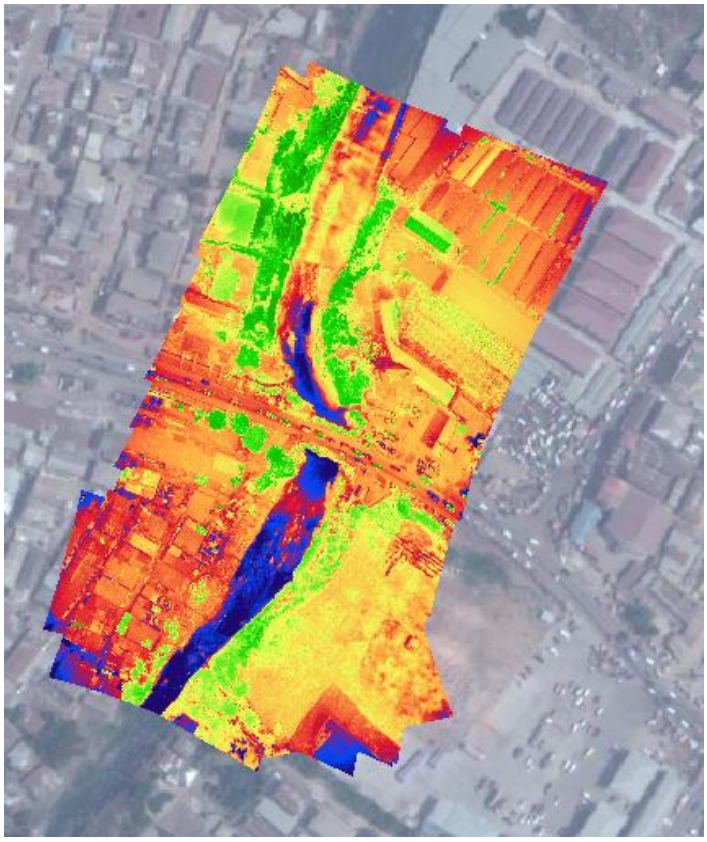


Figure 17. Ortho NDVI_color. Lake Rd Bridge projected in GE

3 Applications and benefits of processed images

The previous chapter demonstrates a number of derived products from FS imagery, all having very high resolution due to observation of the land surface from a relatively short distance. Each processed mosaic, map or model has its own features and potential applications. Different parameters can be determined, such as NDVI, volume, vegetation conditions, soil conditions and land cover type. Within the context of the TWIGA project, relevant applications include especially:

- Inspection of vulnerable infrastructure and possible drainage bottlenecks through RGB
- inspection of vegetation through NDVI and IR
- inspection of water stream blockage through NDVI and IR
- detection of plastic waste through NDVI and IR
- overviews
- land inspection

Table 1. Derived products of FS images and their relevant applications

Description	***Example applications***	***Resolution***
Ortho RGB	Overview image Visual inspection Deriving inputs for biophysical model	Max GSR: 2 cm Common GSR: 10 cm
Ortho NIR	Input for NDVI	Max GSR: 2 cm Common GSR: 10 cm
Ortho IR	Vegetation stress diagnosis Detection plastic waste	
NDVI map	Vegetation stress diagnosis Assessment land degradation (LD) maintenance Detection plastic waste Assessment bare soil Input for biophysical model	Max GSR: 2 cm Common GSR: 10 cm
Land cover map	Vegetation classification Forestry Land use / land cover change assessment Input for biophysical model	Max GSR: 2 cm Common GSR: 10 cm
DEM	Damage inspection LD volume assessment Evaluating SLM practices / terracing Input for biophysical model	Max x-y res. 5 cm; z res. 5-10 cm Common x-y res. 10 cm; z res. 10-20 cm
3D model	Visualization / dissemination Inspection tool for decision makers	Max x-y res. 5 cm; z res. 5-10 cm Common x-y res. 10 cm; z res. 10-20 cm
KMZ /KML	Localization in Google Earth Visualization / dissemination	Max x-y res. 5 cm; z res. 5-10 cm Common x-y res. 10 cm; z res. 10-20 cm

Appendix I: Training program

Fr 23 Nov
-9.00-12.00 am. Introduction. Location: venue
-12.00-1.00 pm. Lunch
-1.00-4.00 pm. Pilot skills. Location: venue /outdoors at campus

Mo 26 Nov
-9.00-12.00 am. Pilot skills. Location: venue /outdoors at campus
-afternoon: no training

Tu 27 Nov
-8.00-12.00 am. Automatical flights. Location: riverside in Kumasi. Departure from campus
-12.00-1.00 pm. Lunch
-1.00-4.00 pm. Processing images.& measuring GCPs Location: venue /outdoors at campus

We 28 Nov
-8.00-12.00 am. Automatical flights. Location: riverside in Kumasi. Departure from campus
-12.00-1.00 pm. Lunch
-1.00-4.00 pm. Processing images & measuring GCPs. Location: venue /outdoors at campus

Th 29 Nov
-8.00-12.00 am. Processing images. Location: venue
-12.00-1.00 pm. Lunch
-1.00-4.00 pm. Processing images. Location: venue

Appendix II: List of participants

1. Isaac Atia
2. Philemon Gumah
3. Clement Okyere
4. Leah Kwaku Nii
5. Evans Kwaku Agyeman
6. Appiah Caleb Kwaku
7. Emmanuel Duah
8. Joel Budu
9. Caroline
10. Rashid

(to be completed)

Figure 18. The training participants after completion of the training

Appendix III: Sensy Kit inventory list

1. The SENSY-M flying sensor Bag
2. The SENSY-M flying sensor Aircraft (Mavic quadcopter), 1x
3. The SENSY-M flying sensor RC (Remote Control), 1x
4. The SENSY-M flying sensor Batteries, 3x
5. The SENSY-M flying sensor Propellers, 8x
6. The SENSY-M flying sensor GoPro NIR Camera, 1x
7. Micro SD Memory card, 2x (in SENSY-M and in GoPro NIR Camera)
8. Tablet, Samsung Galaxy TAB A + charger/cable
9. USB cable for connection tablet/phone-RC
10. RC tablet holder
11. RC tablet sunshade
12. Charger for SENSY-M (including USB cable for RC)
13. Cleaning cloth for camera lens
14. Training Manuals, 2x
15. SD card adapter
16. USB cable for GoPro cam
17. Rubber bands