Inception Report

Flying Sensors for Ultra-High Resolution Flood Risk Identification at Local Scales

September 2016

Authors
Martijn de Klerk
Jan van Til
Peter Droogers

FutureWater Report 155

Content

1. Background

The Global Facility for Disaster Reduction and Recovery (GFDRR) and the UK Department for International Development's (DFID) new competitive Challenge Fund seeks to pilot new and innovative approaches to overcome these challenges and strengthen disaster and climate risk decision-making in developing countries. This Challenge Fund seeks to provide small grants to projects that address the challenge in bridging the gap between technology and on-the-ground user needs in the field of disaster risk identification. Risk identification is seen at the foundation of all disaster risk management decision-making, whether risk reduction, preparedness, financial protection, or resilient recovery. The Fund seeks to support the development of data, products and approaches to support disaster risk management decision making and build resilience, including through better information, but also strengthening key steps in moving from information to insight and behaviour change.

This Inception Report summarizes the activities as undertaken in the context of the project "Flying Sensors for Ultra-High Resolution Flood Risk Identification at Local Scales" over the period 9-Nov-2015 to 1-Sep-2016.

2. Executive Summary

- 12 Flying Sensor Operators have been trained: 8 employees of ARA-Centro in Beira and 4 employees of Regadio Baixa Limpopo. These operators are able to perform the technical aspects and are now being further trained in using the obtained information to inform both policy makers as well as the beneficiaries living in the flood prone areas.
- Potential beneficiaries in the two pilot areas are over 50,000 people living in flood prone areas.
- Two complete Flying Sensor toolkits, including all related components, have been handed over to the Flying Sensor Operators.
- Based on input received from the participants in Beira and Xai-Xai, FutureWater/HiView has further refined the analysis procedure for flood risk assessment.
- Partnerships have been formed with RBL, HICEP, ARA-Centro, ARA-SUL, ISPG and further collaboration was with UCM, Hunze en Aa's, the Dutch Embassy in Mozambique, and sugarcane plantation Tongaat Hulett in Mafambisse.
- Software from the public domain is used.

3. Introduction

Mozambique's major rivers (Limpopo, Incomati and Zambezi) flood on a regular basis with in some years devastating impact (e.g. 2000) creating attention of high-level decision makers. However, floods happen every year in the country and on-the-ground water managers are confronted with big challenges to make decision on controlling and regulating these floods. Especially, the smaller infrastructure, such as small dikes and levees, are key in controlling and managing risks of the very regular flooding that is not always taking lives directly, but has a huge impact on peoples' lives. As mentioned in the risk literature: a devastating disaster brings aid, while the recurrent small disasters destroy peoples' resilience.

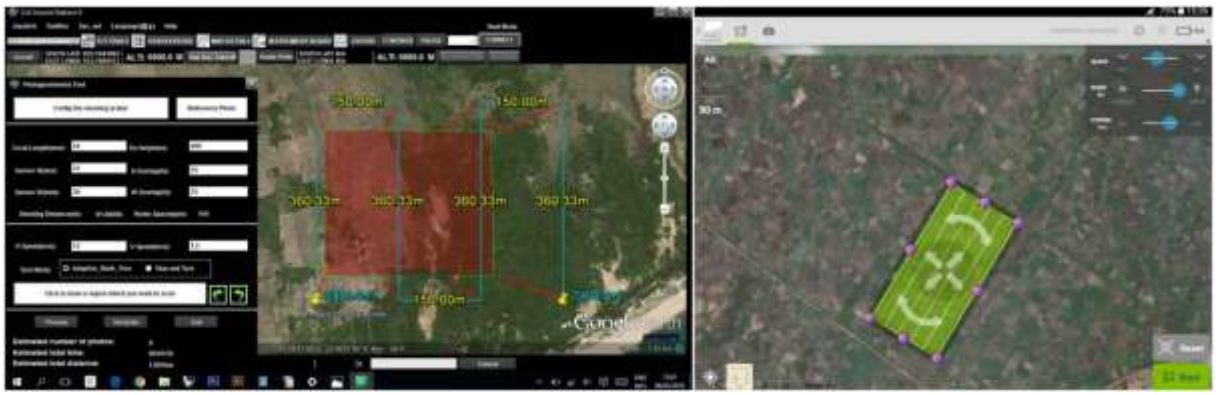
Lack of information is considered as one of the major limitations to risk identification to these floods. This lack of information is both on the assessment of vulnerable dikes and levees, as well as the information during floods on appropriate responses and mitigation. Furthermore, information is often at relatively course resolutions and focused towards high-level decision makers and managers; so leaving the decision makers on-the-ground empty-handed. Focus of this project is at on-the-ground data and tools to analyze risks.

4. Flying Sensor toolkit

A prototype of the Flying Sensor toolkit to monitor dikes was already developed and tested in the Netherlands. However, since every situation asks for a different approach, the tool was first tested in Mozambique during this project. This has led to further refinement of the tool, especially in a more robust setup for data gathering and a tailor-made data analysis approach.

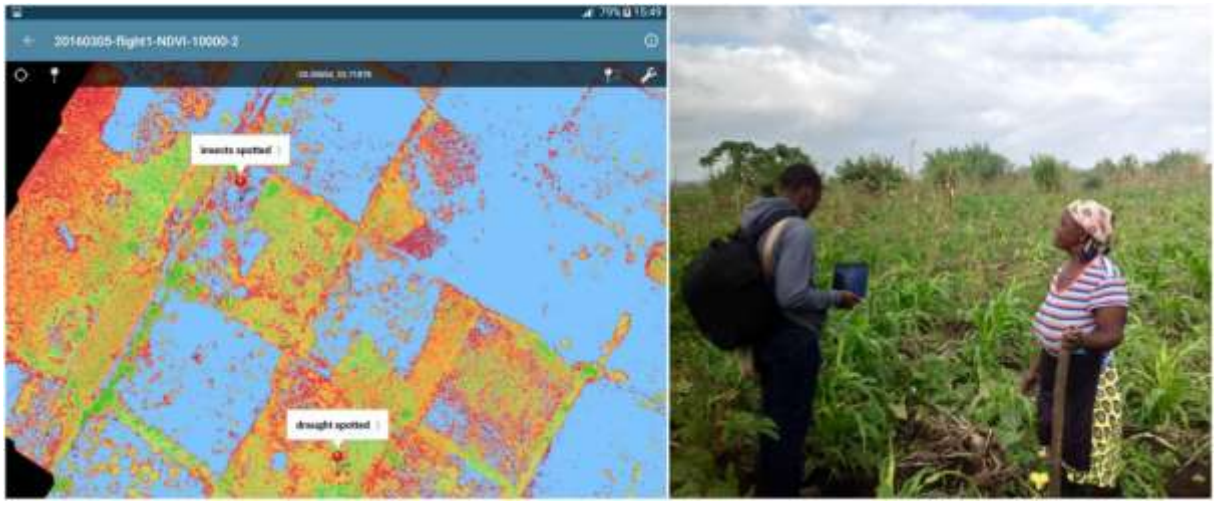
Permission to fly was handled through Cenacarta (Centro Nacional de Cartografia, Ministério de Agricultura; Mr Quembo, CEO). We obtained clearance from Min. of Defense and Cenacarta was informed by Civil Aviation Authority (the Mozambicuan FAA) that there are no restrictions for the use of Flying Sensors. Moreover, our partner ARA-Centro has ensured us that governmental organizations have permission to fly for the sake of disaster management. It goes without saying that FutureWater/HiView respects and promotes all international safety measures with respect to controlling a Flying Sensor. To name a few examples: a) a max altitude of 400ft, b) protocols for flight preparation including battery management and equipment inspection, c)launch area survey, d) applying flight certification.

Based on input from participants in Beira and Xai-Xai, FutureWater/HiView further refined the Flying Sensor toolkit. An example of this refinement is the adoption of a new flight mission system which is much easier to use and more user friendly. First, the flights were planned on a laptop with the use of software which required extensive training. Now, the missions are made on a tablet, which is much easier, faster and has a brighter screen, making it better visible in the Mozambican sun.



Complex flight planning with the old system (left) vs. easy flight planning with the improved system (right).

Moreover, the flying sensor itself was upgraded to the newest generation, having the advantage of i) a much longer range, ii) longer endurance, iii) geo-referenced images, and iv) live video streaming. Additionally we developed ‘tablet mapping’, a tool for easier management of data on maps. Input from all Flying Sensor Operators was used to improve the system: 10 males and 2 females.



Tablet mapping.

5. Training

So far, introduction and training was given to a total of 12 Flying Sensor Operators in Beira (8 employees of ARA-Centro) and in Xai-Xai (4 employees of Regadio Baixa Limpopo). Trainings took place in Beira in 2015: 11/11-20/11 and in 2016: 14/03-18/03 and 18/07-22/07. Trainings in Xai Xai took place in 2015: 25/11-27/11 and in 2016: 10/03-11/03 and 21/03-22/03. Aim of the trainings was that the two water management institutions could obtain Flying Sensor information on flood risk reduction and flood management by themselves. The training focussed on undertaking flights, collecting information, imagery analysis and interpretation of the data.

In Beira the following Flying Sensor Operators were trained:

- Mr. Antonio Melembe (head technical staff): Introduction.
- Mr. Tarcisio Omega (member technical staff): Introduction & training.
- Mr. Junior Castro (member technical staff): Introduction & training.
- Mr. Daniel Nhantumbo (member technical staff): Introduction & training.
- Mr. Agnelo Jorge (member technical staff): Introduction & training.
- Mr. Delton Nhaia (hydraulics engineer): Introduction & training.
- Ms. Felisbela Mulaveia (associate): Introduction & training.
- Ms. Caçilda Machava (president of ARA-Centro): Field presentation & training.

In Xai-Xai the following Flying Sensor Operators were trained:

- Mr. Eladio Chambe (extension officer): Introduction & training.
- Mr. Carlton Luis Pedro Malimbe (hydraulics engineer): Introduction & training.
- Mr. André M. Manuel Chengo (hydraulics engineer): Introduction & training.
- Mr. Roberto (chief of the department of topography): Only partial training.

The focus of the training was on:

- Control of the Sensy Flying Sensor in order to be able to do survey flights with visual cams in case of disaster/floods and scenes related to floods like bridges, roads, aquaducts, curvets, inondulation areas. See training manual Sensy.
    - FPV (first pilot view= real time video monitoring of disaster area)
    - Advanced FS control skills
- Processing aerial images. Processing of orthomosaic, dem, kzm, See training manual processing.
    - Tablet Mapping
    - DEM processing
    - Integration into open source view tools (Google Earth)
- Interpretation & advisory. In discussion with the technical staff geographical points of interests are to be determined. Contribution of aerial imagery information to i) prevention of floods ii) a response plan for floods iii) immediate action in case of flooding.

Results of the training are:

- Control of the Sensy Flying Sensor
    - Manual flying skills: starting-stopping, lift up-land, flying in all directions.
    - Automatic flying with Ground Control Station.
- In field practising (flying and recording aerial imagery)
    - Beira region
        - Mafambisse sugar cane plantation (Nov. 2015; March 2016; July 2016)
        - Bedding of Pongwe River (Nov. 2015; March 2016; July 2016)
        - Fields near Dondo (July 2016)
        - Dyke of Buzi River, near Vila Buzi (July 2016)
    - Xai Xai region
        - Fields of irrigation scheme (Nov. 2015; March 2016)
        - Dykes of River Limpopo (Nov. 2015; March 2016)
- Processing aerial images
    - Photoshop (from Agisoft)
    - Initiation to QGis
    - Photoscan
    - Creating KMZ/KML
    - Introduction in visualisation techniques: Sketchfab.
- Handover of two Sensy Flying Sensor toolkits
- Appointment of responsible flood manager./focal point. In Beira: M. Junior Castro. In Xai Xai: mister Rogerio Manhauselle.
- Building up Flood management Manual comprising a.o.
    - Dyke aerial inspection checklist
    - Flood manangement contact list
    - Flight preparation protocol
    - Operational Flight protocol
    - Post Disaster protocol

The introduction to aerial photography and the opportunities that come with the use of Flying Sensors meet the needs of a good monitoring tool that ARA-Centro and RBL have. It awakens the interest in the contribution of aerial imagery to i) anticipate upon floods by developing an appropriate response plan to floods, ii) immediate action in case of a flooding, and iii) assisting recovery efforts after floods.

The longer-term projection is that other water managers and decision makers will see the benefits of the use of Flying Sensors in their disaster risk reduction strategy. The main "selling-points" will be: i) affordable, ii) access to flooded areas, iii) locally collected and used, and iv) huge scaling potential.

5.1. Open Source Tools

Two Flying Sensor toolkits have been handed over to local decision makers of ARA-Centro and most software that is used for flying and processing of the images is open source and freely available.

For this project FutureWater used the following software from the public domain:

- UGCS ground station for drones. Available on http://www.ugcs.com.
- DJI ground station for drones. Available on https://www.dji.com/product/pc-ground-station.
- Capture (from Pix4D) ground station for drones. Available on https://www.pix4d.com/product/pix4dcapture-app/.
- Apache Open Office. Available on https://www.openoffice.org.
- Google Earth. Available on earth.google.com
- PDF Maps. Available on www.avenza.com

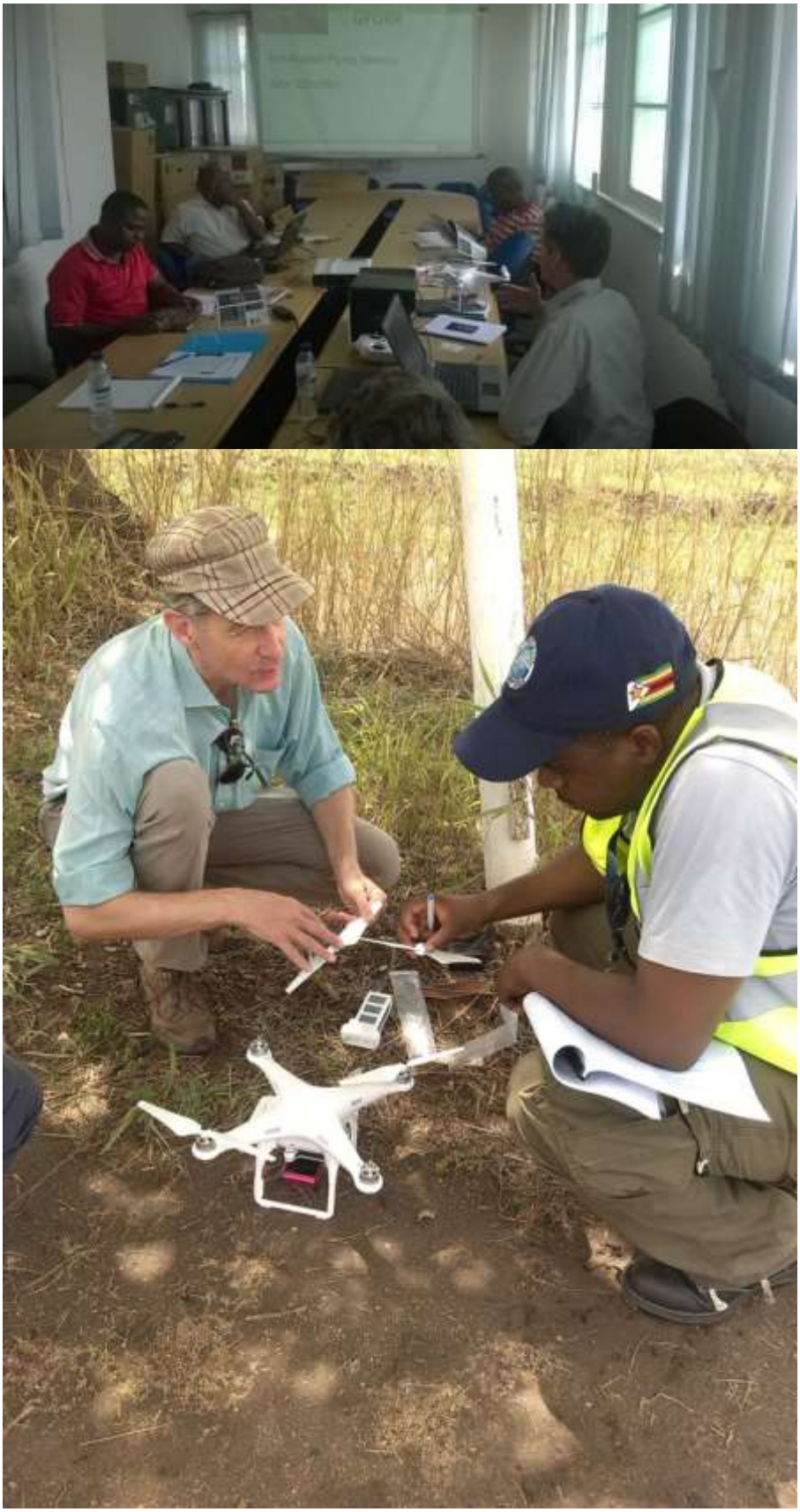
These tools are also used by the Flying Sensor Operators who have been extensively trained to use them.

5.2. Public Domain Platforms

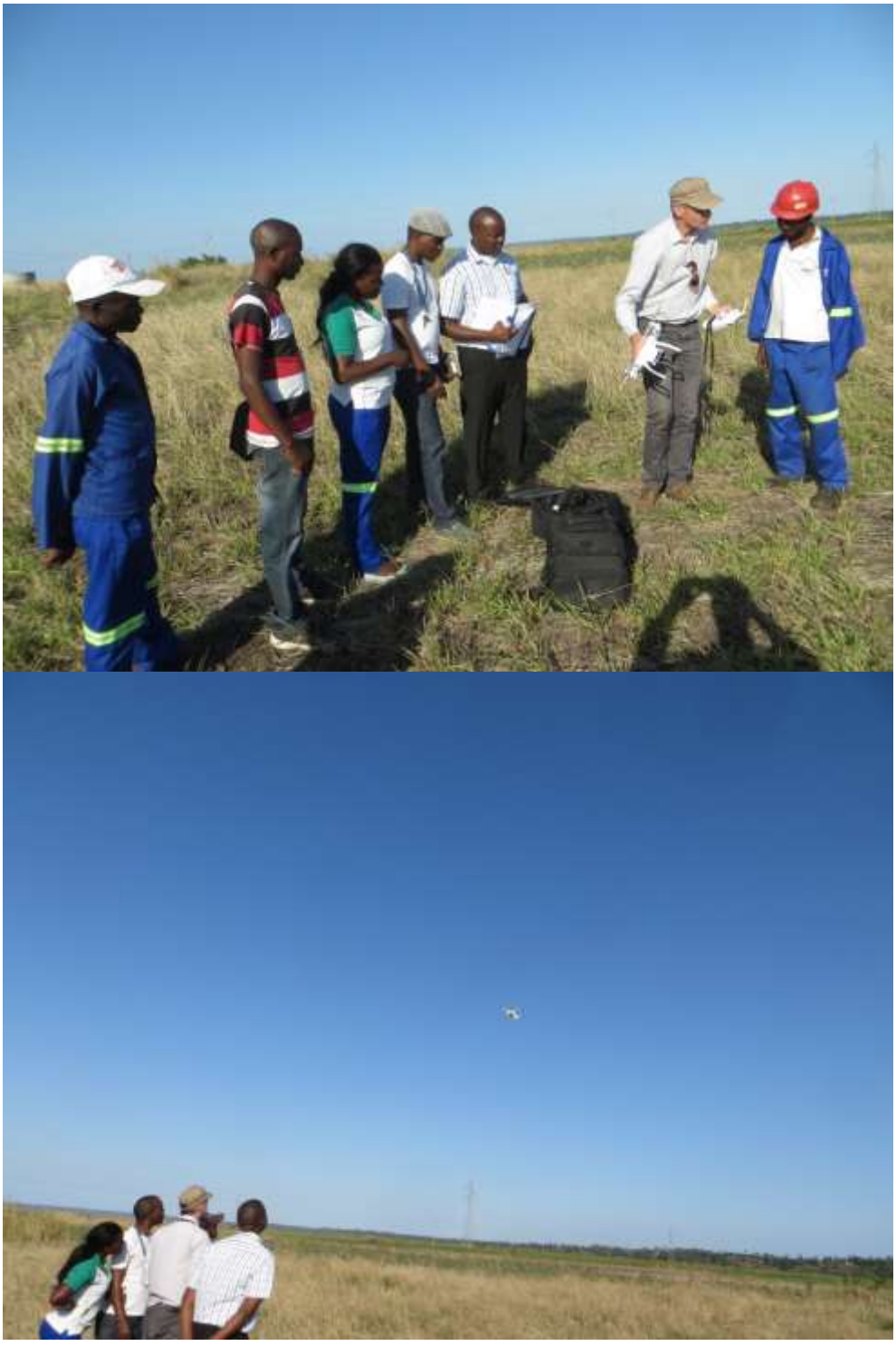
We have connected to the following platforms to publish maps and models:

- Inasafe: Inasafe is a platform that depicts disaster areas and offers realistic natural hazard impact scenarios based on 1. Exposure and 2. Impact. It will be activated in a short term. In addition Inasafe is also a QGIS plug-in that serves as a tool to publish flood related images. FutureWater has agreed Gavin Fleming from Kartoza[1] to publish on Inasafe as soon as possible.
- Sketchfab: FutureWater has its own account to publish flood related visualisation models.
- WaterMaps: Futurewater manages its own platform for sharing maps and models.

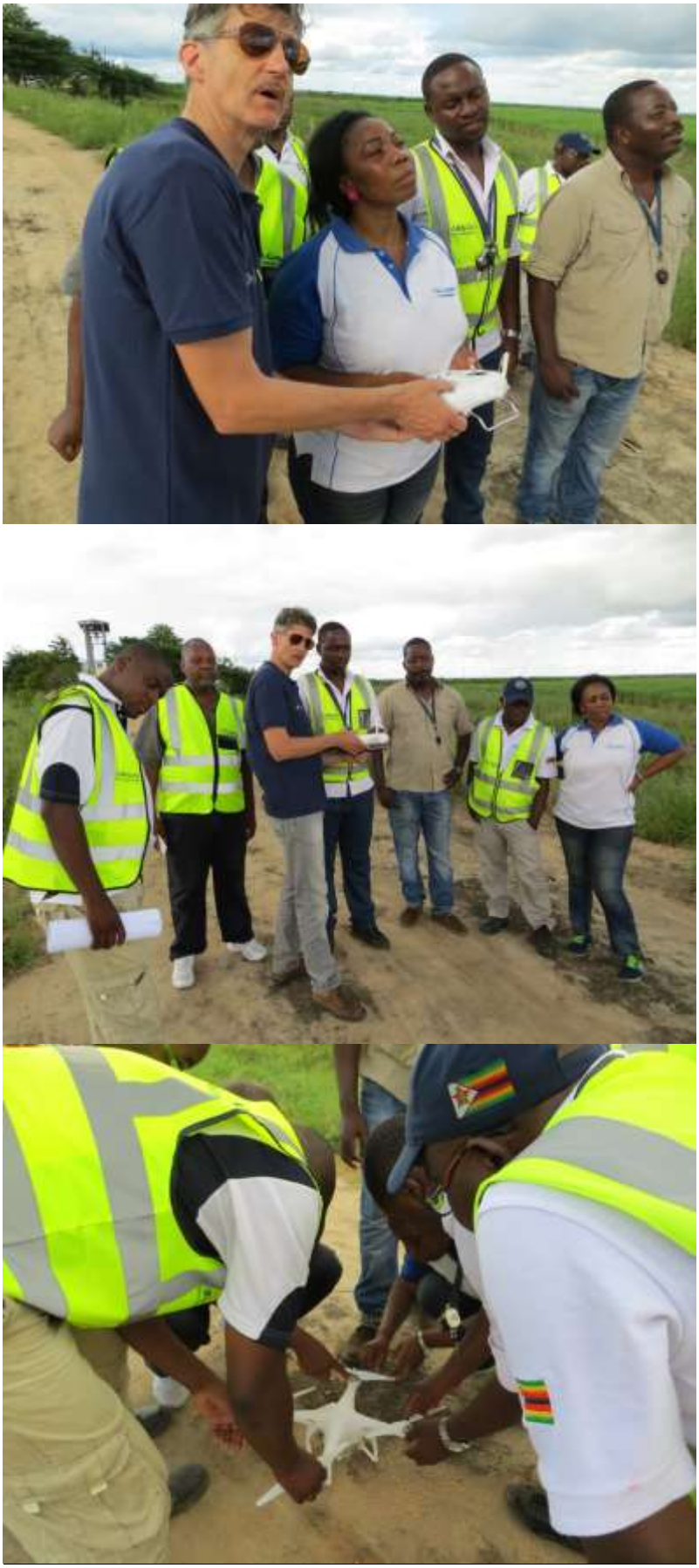
[1] gavin@kartoza.com



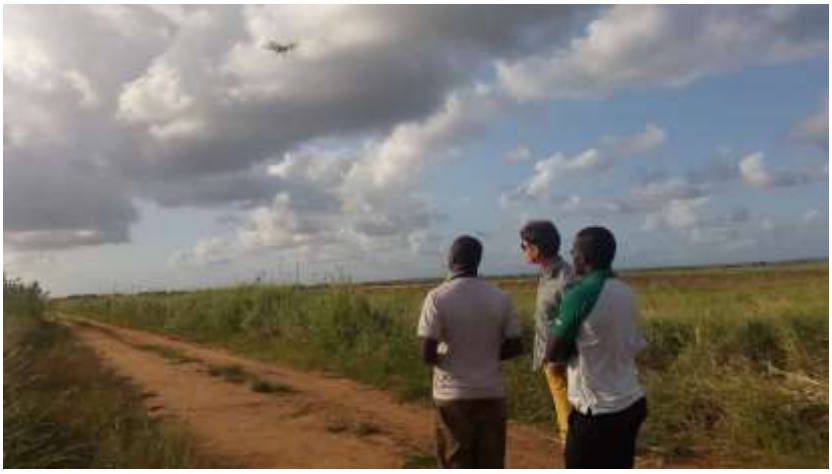
Training in Beira (November 2015).



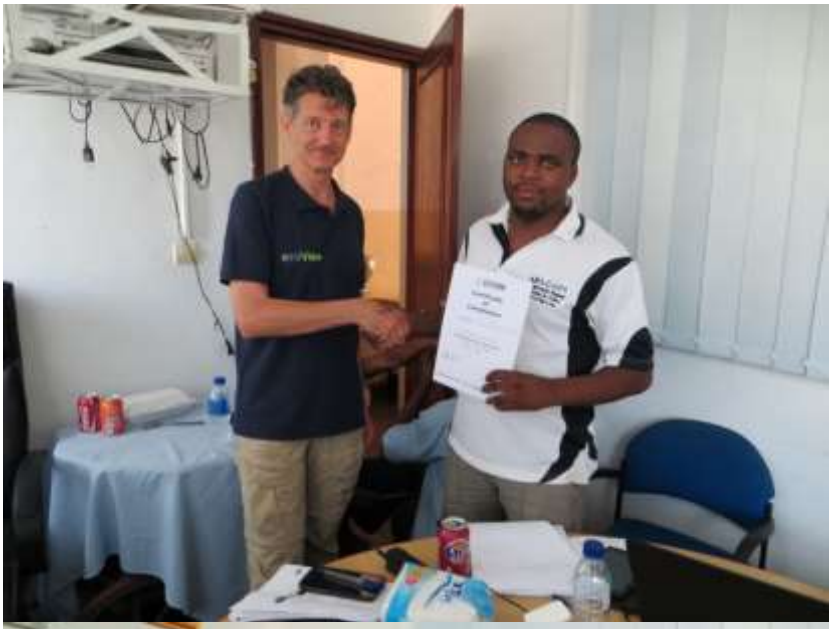
Training in Xai-Xai (November 2015).

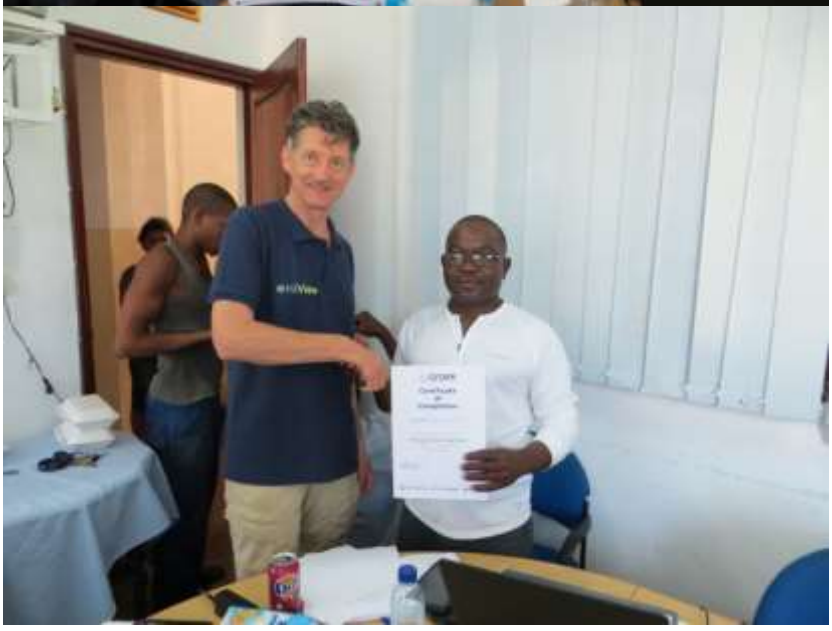


Training in Beira (March 2016).



Training in Xai Xai (March 2016).





Some of the candidates who received a certificate (March 2016).

6. Gender Incorporation

Two female Flying Sensor Operators have been trained out of the total of 12. Obviously, the overall beneficiaries, people living in flood prone areas, are fully gender balanced. Given the fact that improved flood risk identification is also very relevant to farmers (over 80% are female), a certain imbalance in gender can be expected.

A first estimate of the number of overall beneficiaries that are gaining from flood risk reduction and preparedness is 50,000 (people living in the flood prone areas and served by our services), of which 50% are woman. The number of beneficiary farmers is estimated to be 5000, of which 80% are women.

7. Partnerships

Partnerships were formed with:

- **Regadio Baixo Limpopo (RBL)**, Xai-Xai, Mozambique. This regadio is responsible for water management in the Xai-Xai region. They are the operators of the Flying Sensors, do the analysis and will use the information in their operational and strategic planning.
- **Empresa Pública Hidráulica de Chókwè (HICEP)**, Chókwè, Mozambique. HICEP is responsible for management of water and land in the Chókwè irrigation scheme.
- **ARA-Centro**, Beira, Mozambique. The ARA is responsible for water management in the center of the country. Employees of ARA-Centro are the operators of the Flying Sensors, do the analysis and will use the information in their operational and strategic planning.
- **ARA-SUL**, Maputo, Mozambique. This ARA is responsible for water management in the south of the country. ARA-Sul is involved as RBL is included in their management region.
- **Instituto Superior Politécnico de Gaza (ISPG)**, Chókwè, Mozambique. ISPG is a local public high educational institute funded in 2005 aiming to provide technical professional instruction in the field of water in the region of Gaza. Cooperation is of interest because of technical support that ISPG can deliver, notably because they dispose of a dGPS. More information can be found on http://ispg-mz.net/. A Memorandum of Understanding was signed with ISPG.
- **Netherlands Embassy**, Maputo, Mozambique, with which we are in close contact. Our contact person is Antje van Driel, who is working as water and sanitation expert in the Development Cooperation.

Further collaborations were with:

- **UCM (Universitade Cathólica de Moçambique)**. Cooperation is of interest because of technical support that UCM can deliver, notably because they

dispose of a dGPS. More information can be found on http://www.ucm.ac.mz/cms/

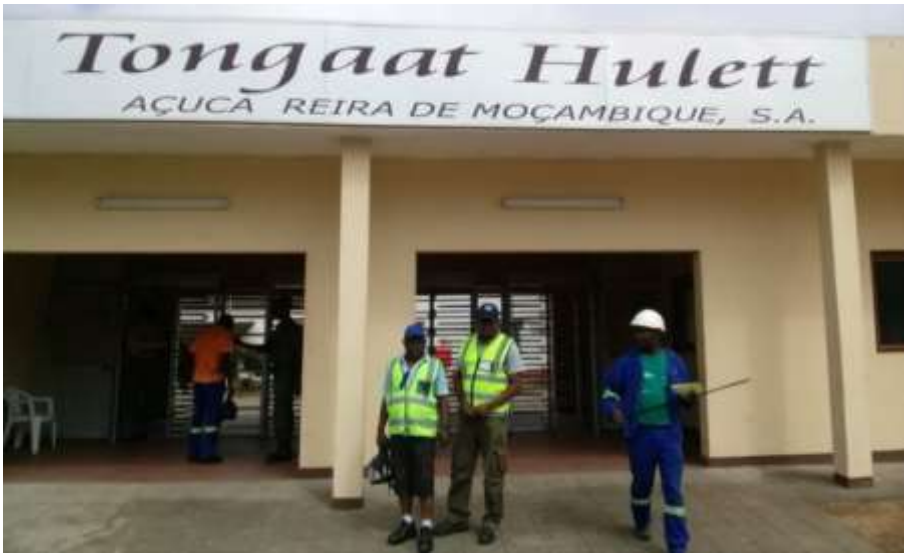
- **Dutch Waterboard 'Hunze en Aa`s'**. Person of contact is Mr. Jan den Besten. Cooperation is of interest because of the measuring of river beds and cross sections. More information can be found on http://www.hunzeenaas.nl/
- Freek Huthoff, Direcção Nacional de Gestão de Recursos Hídricos, Mozambique and HKV (arranged meeting in Maputo, end of July)
- Mister Matera, WorldBank Mozambique (arranged meeting in Maputo, end of July)
- INGD Mozambique

8. Leveraged Resources

FutureWater is in close contact with sugarcane plantation of Tongaat Hulett in Mafambisse (30 km from Beira) about monitoring dykes and other items that deal with land protection from water. Tongaat Hulett is interested in exploring the opportunities Flying Sensors can offer in its decision making process to improve their sugar cane production. FutureWater/HiView supports this initiative and can offer its services combined with ongoing activities in the region. After 2 meetings it was agreed to do a specific proposal for a combination of training & operational flights in an area of 500 ha, for 3 times a year.

Our drone technology itself was introduced in the context of the USAID ThirdEye project for agriculture. There is levering in two directions. GFDRR benefits from this first introduction of drones, while USAID benefits from expanding opportunities of using these drones in other applications (disaster preparedness and response). Although the application of the Flying Sensors is much different than for the GFDRR project, we got in touch with this company while working for the GFDRR project in the area of Beira. Therefore, we see this additional assignment as leverage of the GFDRR project.

A proposal for this was submitted to Tongaat Hulett and is awaiting approval.



Visiting the Tongaat Hulett plantation (November 2015).