TRAINING REPORT ON USE OF UNMANNED AERIAL VEHICLES (UAVs) AND REMOTE SENSING FOR CROP MONITORING

This report was prepared by the Regional Centre for Mapping of Resources for Development (RCMRD) following the implementation of a Technical Assistance provided to the Eswatini National Disaster Management Agency (NDMA) and joint implementation with the Kenya Red Cross Society (KRCS). Funding for this implementation was provided by the UNFCCC Climate Technology Centre and Network (CTCN). Opinions, expressions and representations provided in this report do not reflect the official position of the CTCN.

February, 2021.

Overview

The Kingdom of Eswatini is experiencing an upward trend in mean annual temperature across the different parts of the country, as well as increased drought and flood incidences. Coupled with an increase in pests and diseases, and exacerbated by unemployment and increasing food commodity prices, major constraints have been placed on food security. The country's vulnerability assessment information still relies on pre-planting and post-harvest assessments, and oftentimes the annual National Agricultural Survey which aims to provide information on cropped area through questionnaires and field surveys is not consistently conducted due to resource and technology constraints. As a result, the country lacks continuous crop growth monitoring and assessment tools and technologies for quick and early detection of undesirable threats and occurrence of risks and hazards to food security. With Unmanned Aerial Vehicles (UAV) technology and satellite earth observations (EOs), it is expected that such assessments can be done with minimal human resources and during any phase of crop growth in order to deliver timely interventions. The Climate Technology Centre and Network (CTCN) implemented a Technical Assistance activity in the country through the Regional Centre for Mapping of Resources for Development (RCMRD) and national stakeholders to demonstrate the benefits of using UAVs and satellite remote sensing for crop growth monitoring using a case study approach.

LIST OF FIGURES

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Training objectives

The overall objective was to build the technical capacity of the NDMA alongside other Eswatini institutions such as University of Eswatini, Eswatini Meteorological Services, Departments of Forestry, Water Management (river basins), Disaster Risk Management and Ministry of Agriculture on the use of UAVs and Remote Sensing (RS) / Earth Observation (EO) for future crop monitoring assessments. Thereby strengthening the country's capacity to identify, plan for and respond to climate-induced vulnerabilities and food insecurity situation in the country. The training was conducted jointly with RCMRD and the Kenya Red Cross Society.

Summary of activities

The 6-days training of 17 participants drawn from various institutions as listed above took place at the Hilton Garden Inn hotel. The training focused on 4 main sections including introduction to GIS and photogrammetry, UAV standard operation procedures, UAV pre-mission planning, UAV flight field demonstration using NDMA's newly acquired *wingtra generation 2* fixed-wing drone, imagery pre-processing using WebODM and feature extraction such as spectral indices and classification from pre-processed UAV and sentinel 2 imagery in R programming language.

To make the training interactive, daily *kahoots* were used in order to evaluate participants' understanding of the training modules. *Pre* and *post* training evaluations were also administered amongst participants with an aim of gauging their level of understanding on the training subject matter as well as obtaining their positive feedbacks after the training.

Due to unavoidable circumstance, the KRCS team were unable to physically attend the training. However, they were able to cover their 3 days training session virtually with the support of the UAV pilot from NDMA and RCMRD.

Training agenda

The training agenda contained several modules that addressed key agricultural monitoring indicators that can be measured using UAVs and EO satellites.

Day 1

On the first day the stakeholders were provided with an overview of the CTCN project here (annex 1). This included the project brief, objectives, results and achievements. This was followed with an introduction to RCMRD and the SERVIR ESA project. The participants were able to share their training expectations by filling in a pre-training evaluation form here (annex2). The form was designed to capture the participants' training needs. They were also taken through the 6-days training outline (found here – annex 3) which highlighted all the training sessions to be undertaken.

Below are some snapshots from the pre-training evaluation.

Majority of the participants had never taken a drone mapping training before.

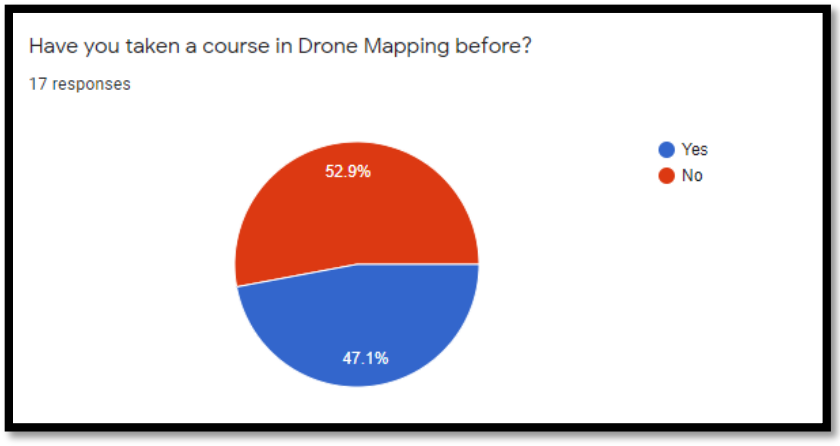


FIGURE 1 HAVE YOU TAKEN A COURSE IN DRONE MAPPING BEFORE?

Many of the participants are required to take drone mapping as part of their job.

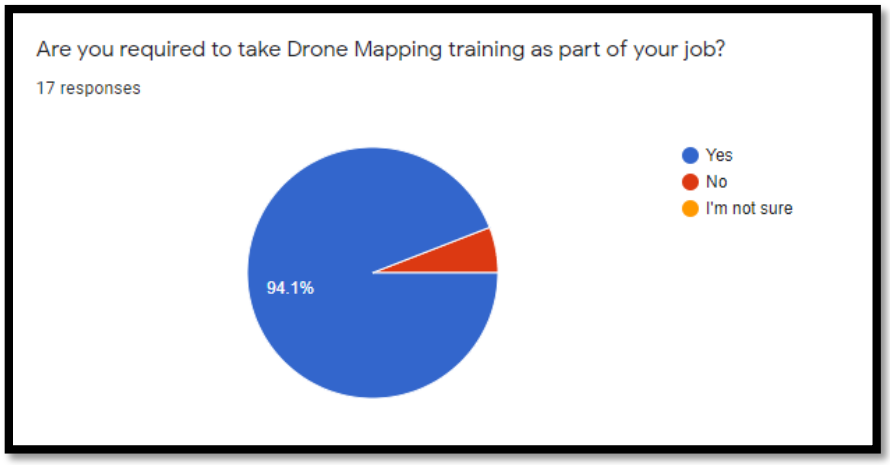


FIGURE 2 ARE YOU REQUIRED TO TAKE DRONE MAPPING TRAINING AS PART OF YOUR JOB?

Most of the participants expected to learn new skills that they can put to use immediately.

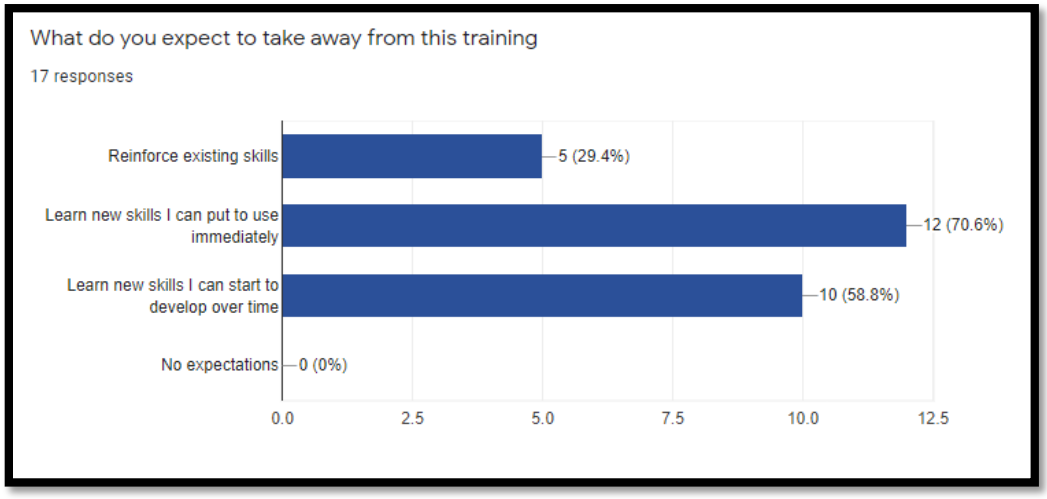


FIGURE 3 WHAT DO YOU EXPECT TO TAKE AWAY FROM THIS TRAINING

Most of the participants had beginner drone mapping skills.

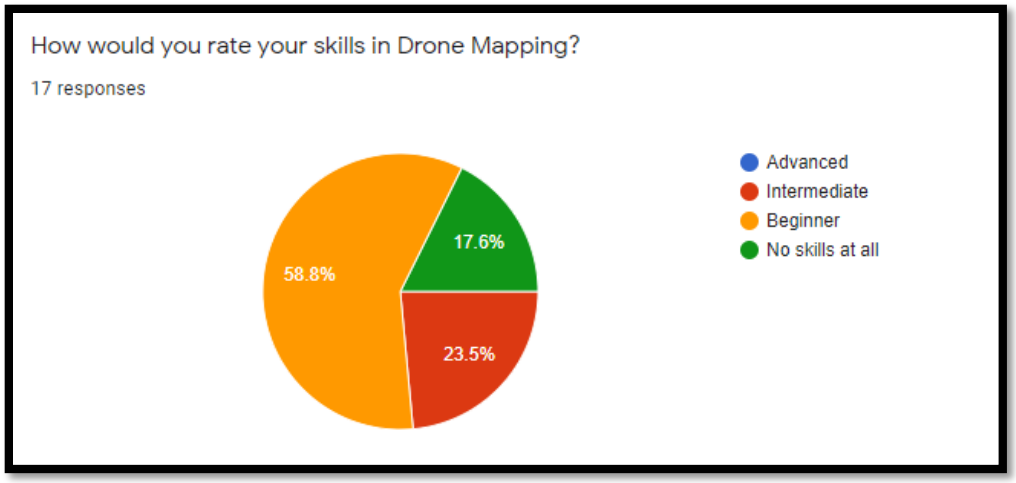


FIGURE 4 HOW WOULD YOU RATE YOUR SKILL IN DRONE MAPPING?

More results from pre-training evaluation can be found here in annex 4.

The KRCS began with a presentation highlighting the importance of using UAVs for mapping. This was supplemented with a video tutorial than can be found here (annex 5) that showcases five key benefits of using UAVs in surveying and mapping.

RCMRD provided a presentation on introduction to GIS. The participants were able to learn about the key components that make up GIS that includes people, data, software and hardware. They were able to learn about the various data sources for geographically referenced data such as UAVs and EO as well as the different software that can enable one to input, query, visualise, manipulate and process georeferenced data. More on this presentation can be found here (annex 6).

Afterwards, the participants were taken through introduction to photogrammetry. They were able to learn more about what photogrammetry is, the fundamental principles of photogrammetry, branches of photogrammetry, types of photogrammetry, the basic requirements of

photogrammetry and many more. The presentation slide on photogrammetry can be found here (annex 7)

The afternoon session began by the KRCS giving a presentation on their UAV use cases and journey. They were able to highlight the type of UAVs that they have together with their respective uses. Their UAV use cases are institutional documentation, crop monitoring, flood risk mapping, risk and damage assessment, search and rescue and lastly, emergency operation planning. They also highlighted the main challenges they face in implementation of UAV related activities such as high cost of UAV equipment, stringent UAV regulation in Kenya, staff turnover amongst those trained to be UAV pilots, competition from other institutions that do offer UAV services among others. Types of Mapping Drones. More on this can be found here (annex 8)

To end the day, the KRCS gave out a presentation on UAV standard operating procedures (SOPs) and checklists. These include equipment and supplies checklist, pre-site survey, security and emergency plan, crew briefing and in-flight checklist. More on this can be found here (annex 9).

Day 2

The day started off with a recap of day 1. The participants played a kahoot that gauged their understanding of what was taught in day 1. The set of kahoot questions can be found here (annex 10).

Overall Performance	
Total correct answers (%)	60.20%
Total incorrect answers (%)	39.80%

FIGURE 5 DAY 1 RECAP OVERALL PERFORMANCE

From the kahoot evaluation, majority of the participants understood the module that was covered in day 1.

The KRCS team gave a presentation on UAV pre-mission planning (site survey). The site survey highlighted some of the pre-requisites to be undertaken by the UAV crew prior to going out to the field for mapping. This includes getting the flight location coordinates, checking for the flight location's airspace type, getting notice to air-men (NOTAMS) if necessary, determining the nearest aerodrome, aerodrome operator, mandatory frequency for the area control centre, the maximum flight altitude, checking for Meteorological Aerodrome Report (METAR) and Terminal Area Forecast (TAF). More on the site survey can be found **here**. Once completed, the site survey form is to be shared with the civil aviation authority and other security agencies for approval at least 48 hours to the actual flight day. The KRCS gave out a series of website links that could assist in site survey and they include:

1. https://metar-taf.com/
2. https://www.windy.com/
3. https://www.uavforecast.com/
4. https://www.world-airport-codes.com/
5. https://skyvector.com/
6. https://app.airmap.com/
7. https://www.dji.com/flysafe/geo-map

The RCMRD gave out a demonstration on how to conduct pre-mission planning using open GIS tools such as Google earth and QGIS. Google Earth is a free GIS software that has functionalities such as visualisation, overlay and creation of GIS data. It is ideal for GIS beginners who are interested in learning more on basic processes and tools. QGIS (Quantum GIS) is also an open source geographic information system (GIS) whose advantages are highlighted below:

- It's free. Installing and using the QGIS program comes at no cost
- Extensive help and documentation is available. There are extensive online documentations from other QGIS users

- It's free in liberty. One is at liberty to add extra functionalities in QGIS or sponsor the development of a functionality
- It's constantly developing. Because anyone can add new features and improve on existing ones, QGIS never stagnates. The development of a new tool can happen as quickly as you need it to.
- Cross-platform. QGIS can be installed on MacOS, Windows and Linux.

Pre-mission planning entails determination of safe areas to be mapped by the UAV. It is always recommended to operate a drone within a visual line of site i.e. within a geo-fence of 1 kilometer. It also involves determination of safe geo-locations to set up the take-off and landing zones for the UAV and also areas to assign visual observers (VO) to ensure a watchful eye of the UAV at all times. The participants were taken through how to use the 2 open GIS tools to derive mission areas of interests (AOIs). The digitized AOIs– which were in google earth format – were to be uploaded onto the drone's mapping application. Two GIS technical manuals were developed to provide practical guidance on pre-determining areas to be mapped by UAVs as well as safe areas to set up take-off and landing zones. The 2 manuals can be found here (annex 11) and here (annex 12).

Day 3

Day 3 also started off with a recap of day 2. The participants played a kahoot that gauged their understanding of what was taught in day 2. The set of kahoot questions can be found here (annex 13).

Overall Performance	
Total correct answers (%)	54.55%
Total incorrect answers (%)	45.45%

FIGURE 6 DAY 2 RECAP OVERALL PERFORMANCE

From the kahoot evaluation, majority of the participants understood the module that was covered in day 2.

The KRCS team was able to take through the participants through drone equipment preparations and stakeholder engagements on UAV mission approvals. The participants were also taken through UAV crew briefing, on-site risk assessment and UAV equipment checklist. The participants were also taken through UAV security and emergency protocols. The participants were taken through the need to ensure that:

- The UAV will not be operated in areas of high radio frequency contamination, such as near radar sites.
- The UAV will not be operated in areas of high radio frequency contamination, such as near radar sites.
- Flights will not take place over the general public and bystanders and, only the UAV operation crew, associated property and structures.
- Personnel outside the flight crew will be informed to remain indoors or behind the flight line in the defined safe areas, supervised by the Visual Observer/Ground Supervisor.

The KRCS team took the participants through what a UAV emergency constitutes. They highlighted that any UAV emergency comprises of the following:

1. Contact with another aircraft or object while in flight
2. Any unintended contact between the UAV and person(s) causing injury or requiring medical attention
3. Any unintended contact between the UAV and vehicles, vessels or other structures causing damage
4. Command and control link failure
5. Loss of visual contact
6. Control Station Failures

7. Emergency Landing (e.g. engine failure, fuel starvation, aircraft malfunction, damage to aircraft)
8. Fly-aways

More on the UAV security and emergency protocols can be found (here - annex 14) and (here – annex 15).

The NDMA UAV pilot was able to demonstrate to the participants on how to set up of their newly acquired *wingtra generation 2* fixed-wing drone. Due to bad weather in Motshane area, the scheduled *wingtra generation 2* flight test did not take place as planned in the afternoon. RCMRD was thus able to take through the participants on introduction to drone imagery software. Participants were taken through the various available open source and commercial photogrammetry software, their merits and demerits. More from this presentation can be found here (annex 16). The day ended with the RCMRD team taking through the participants on how to install the WebODM – a free, user-friendly open source software for drone imagery processing. WebODM generates geo-referenced maps, point clouds and textured 3D models from aerial UAV images. Prior to installing WebODM, the participants were taken through how to install Git, python and docker. More on WebODM installation can be found be found here in annex 17.

Day 4

Day 4 also started off with a recap of day 3. The participants played a kahoot that gauged their understanding of what was taught in day 3. The set of kahoot questions can be found here (annex 18).

Overall Performance	
Total correct answers (%)	59.60%
Total incorrect answers (%)	40.40%

FIGURE 7 DAY 3 RECAP OVERALL PERFORMANCE

From the kahoot evaluation, majority of the participants understood the module that was covered in day 3.

The day started off with the RCMRD team taking through the participants on how to initiate WebODM through the localhost address connection i.e http://localhost:8000 via the web browser. The participants were taken through how to create their WebODM log-in credentials. Additionally, they were taken through some key features contained in WebODM's graphical user interface (GUI) that would allow them to create orthomosaics, point clouds, elevation models and other features. More on the WebODM training manual can be found here (annex 19).

Using a sampled UAV images collected in Sidzakeni using the *Wingtra One* fixed-wing drone, the participants were taken through how to do imagery pre-processing using WebODM. The images were pre-processed using WebODM's multi-spectral settings which resulted in orthomosaics, plant health maps and digital terrain and surface models. The participants were taken through how to visualize the resultant outputs in WebODM as well as downloading them in GeoTiff formats.

In the afternoon, the participants were taken through how to access and download sentinel 2 imagery from the European space agency (ESA) sci-hub. RCMRD gave out an overview of the sentinel 2 mission (more here - annex 20) as well as how to access their acquisition plans (more here – annex 21). The acquisition plans will guide the NDMA on the appropriate date and time to capture UAV images based on sentinel 2 overpass.

The participants were able to create accounts in ESA's sci-hub. The accounts enabled them to log into the sci-hub in order to search for a sentinel 2 imagery in Sidzakeni. The participants were able to define their search criteria based on dates, datasets and cloud cover. They were able to search for the sentinel 2A (S2A). Afterwards, they were able to download the sentinel 2 imagery for Sidzakeni which will later on be used in spectral fusion with UAV imagery. More on accessing sentinel hub and downloading imagery can be found here (annex 22). The participants were taken through how to pre-process the downloaded sentinel 2 images using QGIS' semi-automatic classification plug-in (SCP). More so, to convert sentinel 2's Red, Green, Blue and Near-Infrared spectral bands from digital numbers to surface reflectance values. More on SCP pre-processing can be found here – (annex 23).

Day 5

With the weather conditions being favourable in Motshane, this offered an opportune moment for the NDMA to conduct a flight demonstration using their newly acquired *Wingtra Gen 2* fixed-wing drone. Participants were able to travel to Motshane which is approximately 15 km away from Mbabane on the eastern side. The area of interest (AOI) that was generated in Google Earth and QGIS was uploaded on the *Wingtra Hub* flight planning software in order to determine UAV flight and safety parameters such as maximum flight altitude, flight direction, overlap among others. The NDMA team was able to take the participants through the UAV standard operation procedures which included going through the equipment checklist, pre-site survey, security and emergency plan, crew briefing and lastly the in-flight checklist. The *wingtra gen 2* drone was able to conduct approximately a 45 minutes' flight over farmlands in Motshane using the multispectral camera.

Participants were able to appreciate it's flight capability of acquiring a larger areas within a short timeframe. The participants were able to travel back to the Hilton Garden Inn for lunch.

In the afternoon, we took the participants through installation of R and Rstudio programmes. Afterwards, the participants were taken through how to install the relevant packages required in remote sensing analysis. Lastly, the RCMRD gave out a practical demonstration on how to set up working environments in R studio. This included declaring variables and data paths to access UAV imageries for Sidzakeni. At the same time, setting up folders to store all processed outputs.

Day 6

On the final day, the participants were taken through introduction to spatial data exploration and manipulation with R. In this context, the main focus was on exploring, manipulating and visualising raster datasets from the pre-processed UAV imageries for Sidzakeni as well as exploring and visualising the vector dataset for Sidzakeni.

The participants were taken through stacking of spectral bands, the various spectral band composites, re-sampling of images, mosaicking images and generation of maps in R. The R scripts used for the demonstration can be found in Annexes 24,25 and 26.

With time running out, the participants were taken through how to generate vegetation indices such as NDVI from the mosaicked UAV and sentinel 2 images. The NDVI map products highlighted variation in vegetation health among the various vegetation types in Sidzakeni. Most notably was that there was variation in maize crop health across several farm fields in Sidzakeni. More on NDVI analysis in R can be found in Annex 27.

Lastly, the participants were taken through some of the map products that were generated through classification of UAV and sentinel 2 images using various algorithms such as maximum likelihood (MLC) and randomforests (RF). The maps showcased the spatial extent of areas where crops such as maize were cultivated at that time. With such maps, the participants were able to explicitly generate inferences such as the amount of cropland that would be potentially harvested at that time in Sidzakeni. More on classification in R can be found in Annex 28.

Post-evaluation was conducted in the afternoon. This was done using google forms with an aim of obtaining feedback from the participants with regard to the training. The post-evaluation training form used can be found here. – annex 29. Below are some of the snapshots from the post-evaluation exercise.

Majority of the participants acknowledged that they were indeed trained on drone mapping.

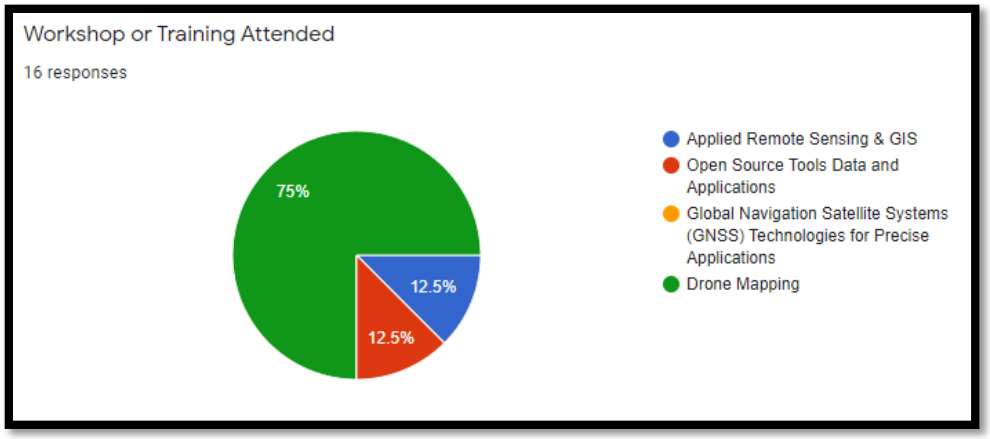


FIGURE 8 WORKSHOP- OR TRAINING ATTENDED

Participants agreed that the training had clear objectives, the content was well organized and that the training met their expectations.

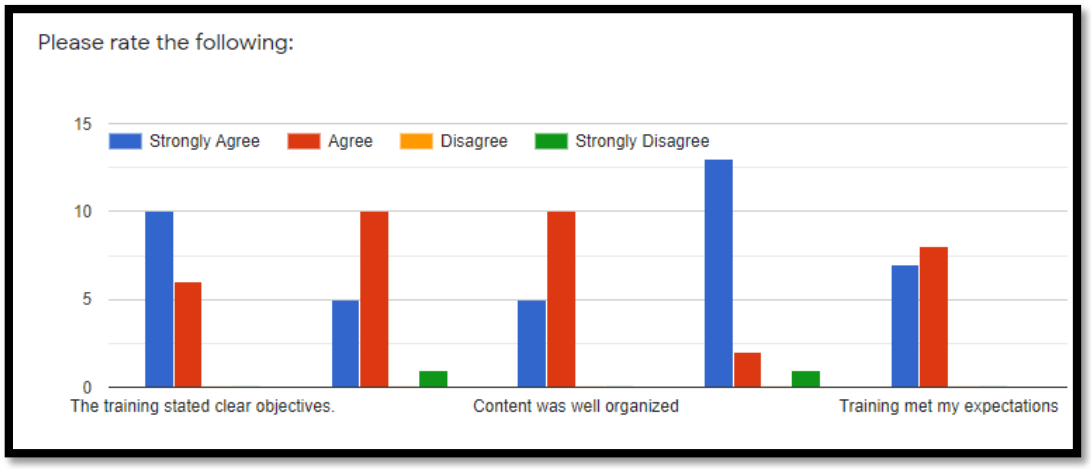
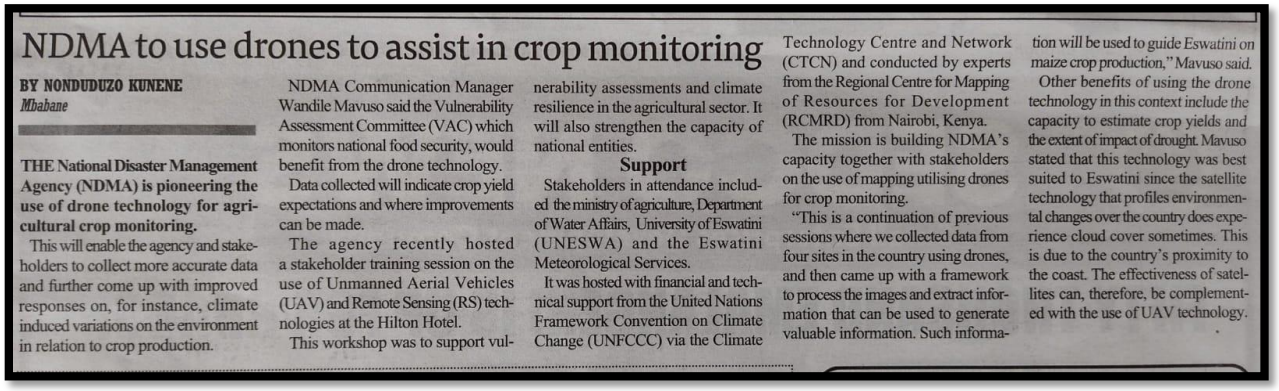


FIGURE 9 PLEASE RATE THE FOLLOWING

More results from post training evaluation can be found here..- annex 30.

LESSONS LEARNT AND OPPORTUNITIES FROM THE MISSION

One of the major outcomes from the training was about media coverage. A story about the training was published in one of the Eswatini newspapers as illustrated below.



NDMA to use drones to assist in crop monitoring

BY NONDUDUZO KUNENE
Mbabane

THE National Disaster Management Agency (NDMA) is pioneering the use of drone technology for agricultural crop monitoring.

This will enable the agency and stakeholders to collect more accurate data and further come up with improved responses on, for instance, climate induced variations on the environment in relation to crop production.

NDMA Communication Manager Wandile Mavuso said the Vulnerability Assessment Committee (VAC) which monitors national food security, would benefit from the drone technology.

Data collected will indicate crop yield expectations and where improvements can be made.

The agency recently hosted a stakeholder training session on the use of Unmanned Aerial Vehicles (UAV) and Remote Sensing (RS) technologies at the Hilton Hotel.

This workshop was to support vulnerability assessments and climate resilience in the agricultural sector. It will also strengthen the capacity of national entities.

Support

Stakeholders in attendance included the ministry of agriculture, Department of Water Affairs, University of Eswatini (UNESWA) and the Eswatini Meteorological Services.

It was hosted with financial and technical support from the United Nations Framework Convention on Climate Change (UNFCCC) via the Climate Technology Centre and Network (CTCN) and conducted by experts from the Regional Centre for Mapping of Resources for Development (RCMRD) from Nairobi, Kenya.

The mission is building NDMA's capacity together with stakeholders on the use of mapping utilising drones for crop monitoring.

"This is a continuation of previous sessions where we collected data from four sites in the country using drones, and then came up with a framework to process the images and extract information that can be used to generate valuable information. Such information will be used to guide Eswatini on maize crop production," Mavuso said.

Other benefits of using the drone technology in this context include the capacity to estimate crop yields and the extent of impact of drought. Mavuso stated that this technology was best suited to Eswatini since the satellite technology that profiles environmental changes over the country does experience cloud cover sometimes. This is due to the country's proximity to the coast. The effectiveness of satellites can, therefore, be complemented with the use of UAV technology.

FIGURE 10 TRAINING MAKING HEADLINES IN ONE OF THE ESWATINI DAILY NEWSPAPERS

The other major outcome was that we were able to conduct a UAV flight demonstration using NDMA's *wingtra generation 2* drone.

FIGURE 11 *WINGTRA GENERATION 2* DRONE DEMONSTRATION

The training event was also captured in various social media platforms including Facebook and twitter as illustrated below.

FIGURE 12 FACEBOOK POSTS FROM RCMRD AND NDMA

NEXT STEPS

The next step is for RCMRD alongside stakeholders in Eswatini to put up a proposal to solicit funding from the Green Climate Fund (GCF) for scaling up the project at a national scale.

SNAPSHOT OF TRAINING PHOTOS

FIGURE 13 MR RUSSELL DLAMINI- CEO NDMA – GIVING OPENING REMARKS

FIGURE 14 MR ERIC SIYAMA – HEAD OF RESEARCH & EARLY WARNING – NDMA GIVING OPENING REMARKS

FIGURE 15 GROUP PHOTO OF TRAINING PARTICIPANTS

FIGURE 16 MR MICHAEL OSUNGA –RCMRD – HANDING OVER A PRESENT FROM RCMRD TO THE CEO NDMA – MR RUSSEL DLAMINI

FIGURE 17 MISS SWABIRA ABDULRIZAK FROM KRCS TAKING THROUGH PARTICIPANTS THROUGH DRONE USE CASES

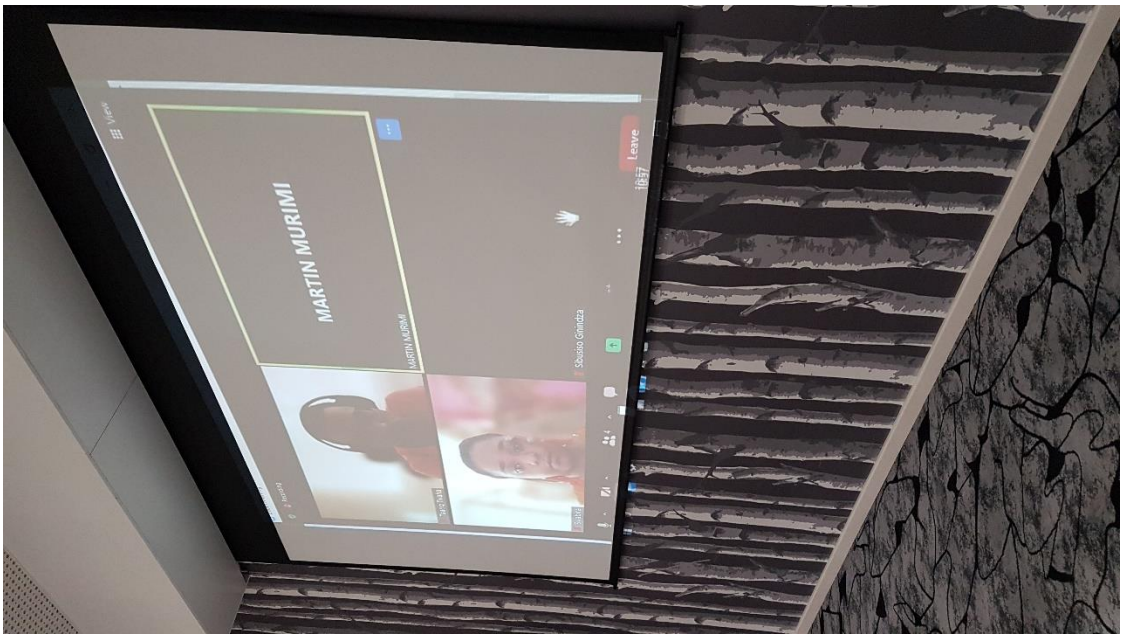


FIGURE 18 MR TAARIQ TWAHA FROM KRCS LEADING A SESSION VIRTUALLY ON UAV STANDARD OPERATION PROCEDURES

FIGURE 19 MR SIBUSISO GININZA – A UAV PILOT FROM NDMA DEMONSTRATING THE USE OF DJI PHANTOM 4 DRONE

FIGURE 20 MR MARTIN MURIMI GIVING A PRESENTATION ON OPEN SOURCE TOOLS USED IN DRONE IMAGERY PROCESSING

FIGURE 21 MR MICHAEL OSUNGA DEMONSTRATING HOW TO ASSEMBLE THE WINGRA GENERATION 2 FIXED-WING DRONE

PARTICIPANTS LIST

#	NAME	ORGANIZATION
1	Majahonke Mamba	National Disaster Management Agency
2	Sacolo Sanele	National Disaster Management Agency
3	Eric seyama	National Disaster Management Agency
4	Sibusiso Ginindza	National Disaster Management Agency
5	Samkele Sikhulile Tfwala	UNESWA
6	Gcebile Dlamini	National Disaster Management Agency
7	Sindy Mthimkhulu	Water management- River Basins
8	Tenanile Nomkhosi Dlamini	Eswatini Meteorological Services
9	Nkosinathi Britewell Jele	Forestry
10	Siboniso Mavuso	Disaster Risk Management
11	Nobuhle Mbonane	National Disaster Management Agency
12	Dube Lungile	NDMA (Research and Early warning)
13	Dr Bonokwakhe H. Sukati	UNESWA, Crop Production Department
14	Daniel Dladla	Ministry of Agriculture
15	Victor Mahlalela	National Disaster Management Agency
16	Ntabeni Msibi	Research and Early Warning Department
17	Sizwe Mabaso	UNESWA

TRAINING PROGRAMME

SESSION	TIME	FACILITATORS(S)
Monday, 24 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Introduction to RCMRD/SERVIR/ CTCN project	0830 hrs - 0930 hrs	RCMRD
Introductions /Trainings Expectations/ Pre-training evaluation / Training outline / Overview	0930 hrs - 1000 hrs	RCMRD/KRCS
Importance of Drones for Mapping	1000 hrs - 1030 hrs	KRCS/NDMA
TEA BREAK		
Introduction to GIS	1100 hrs - 1200 hrs	RCMRD
Introduction to photogrammetry	1200 hrs - 1300 hrs	RCMRD
LUNCH BREAK		
KRCS use cases & Journey	1400 hrs - 1430 hrs	KRCS
Types of Mapping Drones	1430 hrs - 1500 hrs	KRCS
UAV Standard Operating Procedures	1500 hrs - 1600 hrs	KRCS/NDMA
TEA BREAK / CLOSE OUT		
Tuesday, 25 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Recap of Day 1 (Kahoot)	0830 hrs - 0900 hrs	RCMRD/KRCS
UAV Pre-mission Planning (Site Survey)	0900 hrs - 1030 hrs	KRCS
TEA BREAK		
UAV Pre-mission Planning (Site Survey) continuation	1100 hrs - 1130 hrs	KRCS

Software installations - QGIS & Google earth	1130 hrs - 1300 hrs	RCMRD
LUNCH BREAK		
UAV Pre-mission Planning Practicals	1400 hrs - 1600 hrs	RCMRD
TEA BREAK / CLOSE OUT		
Wednesday, 26 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Recap of Day 2 (Kahoot)	0830 hrs - 0900 hrs	RCMRD/KRCS
Drone equipment preparations	0900 hrs - 1000 hrs	KRCS/NDMA
Stakeholder engagements on mission approvals	1000 hrs - 1030 hrs	KRCS/NDMA
TEA BREAK		
UAV Crew Briefing	1100 hrs - 1130 hrs	KRCS/NDMA
On-site risk assessment	1130 hrs - 1200 hrs	KRCS/NDMA
Equipment checklist	1200 hrs - 1230 hrs	KRCS/NDMA
Onsite UAV setup	1230 hrs - 1300 hrs	KRCS/NDMA
LUNCH BREAK		
Wingtra One flight test	1400 hrs - 1600 hrs	NDMA/RCMRD
TEA BREAK / CLOSE OUT		
Thursday, 27 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Recap of Day 3 (Kahoot)	0830 hrs - 0900 hrs	RCMRD/KRCS
Overview of the data collected by Wingtra One	0900 hrs - 1000 hrs	RCMRD/KRCS
Introduction to Drone Imagery Software	1000 hrs - 1030 hrs	RCMRD
TEA BREAK		
WebODM installation	1100 hrs - 1200 hrs	RCMRD

Overview of WebODM	1200 hrs - 1300 hrs	RCMRD
LUNCH BREAK		
Pre-Processing UAV images using WebODM	1400 hrs - 1600 hrs	RCMRD
TEA BREAK / CLOSE OUT		
Friday, 28 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Recap of Day 4 (Kahoot)	0830 hrs - 0900 hrs	RCMRD/KRCS
Acquisition sentinel 2 Imagery	0900 hrs - 1000 hrs	RCMRD
Pre-processing sentinel 2 imagery in QGIS	1000 hrs - 1030 hrs	RCMRD
		TEA BREAK
Pre-processing sentinel 2 imagery in QGIS (continuation)	1100 hrs - 1200 hrs	RCMRD
Introduction to R Programming	1200 hrs - 1300 hrs	
		LUNCH BREAK
UAV & Satellite Imagery Analysis using R	1400 hrs - 1600 hrs	RCMRD
TEA BREAK / CLOSE OUT		
Saturday, 29 January 2022		
Participants Arrival	0800 hrs - 0830 hrs	
Recap of Day 5 (Kahoot)	0830 hrs - 0900 hrs	RCMRD/KRCS
Image Interpretation (Training Sites Development)	0900 hrs - 1000 hrs	RCMRD
Vegetation indices and Classification	1000 hrs - 1030 hrs	RCMRD
		TEA BREAK
Vegetation indices and Classification (continuation)	1100 hrs - 1300 hrs	RCMRD
		LUNCH BREAK

Accuracy Assessment & Generation of final maps	1400 hrs - 1600 hrs	RCMRD
Post training evaluation, Group photos & Closing remarks	1600 hrs - 1630 hrs	RCMRD/NDMA
TEA BREAK / CLOSE OUT		

ANNEXES

Annex 1

UAV and Satellites in Eswatini_CTCN_UNIDO_Workshop_Sep2021 - here

Annex 2

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WebODM installation guide

ODM Installation and Getting Started

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Kahoot day 3 questions can be found here

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WebODM training manual can be found here

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Overview of the sentinel 2 mission here

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How to access sentinel 2 acquisition plans here

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Accessing Sentinel hub and downloading Imagery found here

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QGIS SCP Guide can be found here

R Scripts (**Annex 24-28**):
https://drive.google.com/file/d/10Mmu5tgyQyrkdNwkIPZMOx9dg1wcYuDA/view?usp=sharing

Annex 29

The post-evaluation training form can be found here.

Annex 30

Post training evaluation results be found here

Annex 31 - Training photos

Training_photos.zip