UAV operator Jacob Petersen from Danoffice IT shows CRS staff Thierry Yabi (on his left) and cashew farmers how to fly a UAV in Benin. CRS and NetHope, 2017.

Unmanned Aerial Vehicles (UAVs):

WALKING VS. FLYING – *A COMPARISON*

CRS CATHOLIC RELIEF SERVICES

BACKGROUND

A pilot for using Unmanned Aerial Vehicles (UAVs) in agricultural programming was conducted February 20 – 23, 2017. The pilot was a collaboration between NetHope, DanOfficeIT, and CRS Benin for a project that addresses cashew productivity. Twelve farmers' fields were flown. The imagery was then shown to partners to reflect on how it can be used in future programming.

CRS and NetHope performed agricultural analysis in some parts of Benin using a drone. The software that processed the imagery also allowed for counting the number of trees, detecting crop stress and weeds, distinguishing where there had been forest fires, and determining where there was planting space.

Hypothesis

UAVs could collect farmer boundaries faster than traditional methods which are accurate enough for daily operations. It is also possible to automate some agricultural practice indicators with software analysis.

Ultimately, the pilot served as a learning experience. The following lessons were learned:

- Standardizing logistical processes;
- Finding the best software for imagery processing;
- Identifying what indicators could be collected automatically;
- Mapping boundaries;
- Comparing the use of a fixed wing vs. a quad copter.

These learning experiences provided a basis for forming UAV capabilities at CRS, which is crucial to helping future programs that want to use them.

Walking the Line

When the farm boundaries were walked on foot, it was done using ESRI's ArcGIS Collector software on smart phones. When comparing walked boundaries to drawn boundaries, there was a standard deviation of .05 hectares per plot for drawing outwards, while the standard deviation for drawing inwards was .1 hectares per plot. This error could be further reduced with practice and repetition.

Below is an image that compares the walked lines to the boundaries that the farmers drew on top of the UAV scanned images.

The pilot project mapped 12 plots in total. The yellow lines signify the walked lines while the blue lines represent the hand drawn plot lines.

Walking farmers plots takes a substantial amount of time. A single plot took about 30 minutes to walk and it took even more time to find a farmer who knew the boundary. Not to mention, the amount of time it took the farmer to get to the farm! Walking each and every border of a farmer's plot, depending on the project, requires a lot of CRS staff and a lot of mobile devices for data collection. This is time and money *not* well spent.

For example, if a project targets 32,000 farmers, and CRS calculates a minimum of 30 minutes of mapping per farm, it would take 2000 days to complete. If we have 100 data collectors and 100 devices, it would take 20 days to map out all of the farmers' plots. Considering the cost of a CRS recommended mobile device is in the $300 price range, the cost of data collection would be $30,000 for the equipment alone; and, that is not including staff compensation or vehicle and fuel costs.

COMPARING BOTH APPROACHES

A *quadcopter* UAV costs $1,500 - $30,000 depending on need, while the software for piloting and image analysis can cost $83 for a monthly license or $4,990 for an unlimited license. Onsite training typically costs $6,000 in addition to airfare and accommodations. The optional multispectral sensors can cost anywhere from $1,300 - $7,000 depending on one's needs. Finally, a laptop to process the imagery (if the online option is not viable) can cost up to $3,000.

A *fixed wing* (plane) UAV costs $5,000 - $35,000, with the same software and onsite training expenses as the quadcopter. A fixed wing can fly up to 200 hectares per flight compared to the 50 hectares of a quadcopter. The multispectral sensors can cost $3,000 - $7,000 depending on need; however, the more expensive fixed wings will include these. Finally, a laptop is also required to process the imagery – if the online option is not viable.

According to a study done by the **CTA**, UAVs are able to reduce field time by 50% or more. Their study reduced the field office days from 52 to 4.6, resulting in cost savings of over $2,716.

Table 8. Comparison of labour cost: conventional versus UAV/SfM technique

	Field person days	Field rate	Field labour costs	Office person days	Office rate	Office labour costs	Total labour costs
Conventional method	52	$60	$3,120	3	$30	$90	$3,210
UAV/SfM	4.62	$60	$277.20	7.2	$30	$216	$493.20
		Total savings in labour costs:					**US$2,716.80**

From CTA Working Paper 17/07, W. Volkmann, 2017, p. 26.

The next graph illustrates the change in methodology that occurs to a project using a UAV compared to projects using traditional methods.

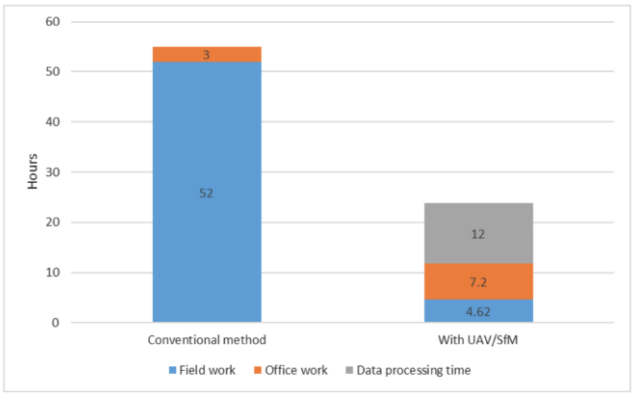

Figure 18. Comparison of the completed work infield and office person hours, plus time devoted to automated data processing

From CTA Working Paper 17/07, W. Volkmann, 2017, p. 25.

An interesting shift happens regarding labor when using a UAV. For instance, the huge chunk of time required for field work is reduced, office work is increased, and a new category of 'Data processing time' is introduced. Considering that data processing can be completed during offline hours (after work) and the biggest expense is field work, it becomes evident that using UAVs (particularly for delineation) results in enormous cost savings.

	Farmers	Days needed	Workers / days	Hardware + software cost	Labor cost
Traditional	32,000	16,960	100 workers / 160 days	$37,000	$419,200
UAV	32,000	1201	2 workers / 10 days	$30,000	$138,971
Savings		15759		$7,000	$280,228

The typical cost to hire a UAV operator – the more common path for CRS – is *extremely* country specific with varying prices between them.

For both of these types of UAVs, Pix4D software is recommended to help with avoiding patches of land that have already been flown. Software that requires an internet connection to retrieve this information from the UAV has proven to be problematic because of the high bandwidth that is required but can be a cheaper option for locations with good connectivity.

Once the UAV captures the imagery, staff must travel back to the office to process it and turn it in to a functional map. Turning the images captured by the UAV into a single map is time consuming and we recommend processing it overnight.

After the image is processed, it must be printed, and a meeting time should be set up with the farmers whose plots of land appear on the newly created map. The data collector works with them to identify the farm boundaries using landmarks they are familiar with, as most farmers have never seen an aerial view of their property.

Finally, once the farmers have finished marking their farms' borders on the maps – they are taken back to the office and digitized with ESRI software.

Conclusion:

Preliminary results show that flying farmers' boundaries with a UAV is recommended when multiple fields are close together. Furthermore, staff need limited training with a quadcopter compared to a fixed wing UAV. Quadcopters are less expensive and usually have less regulations than fixed wing drones. This operational pilot could be strengthened by looking at the accuracy of drawn boundaries vs. walked boundaries of more fields.

Also, some farms are impossible to walk – as the terrain makes it unfeasible. If farms are close together and the farmers are easy to coordinate, UAVs have the potential to offer tremendous time saved that would otherwise be spent mapping farmers' plot boundaries.

In order to make this a reality, we suggest knowing the flight areas prior to arriving to the field.

Advantages of Using UAVs Instead of Walking

- UAVs can take a fraction of the time to collect the imagery needed compared to walking.
- Working with the farmers to draw on top of the imagery has the added benefit of familiarizing farmers with their own land and establishing a closer working relationship with them.
- UAVs can be used in areas of high risk where it would be dangerous to send someone.
- UAV imagery can give you survey-grade topographic maps, allowing you to work with farmers to better plan the slope of their plots. This helps with landslide preparedness, irrigation, and land erosion.
- UAV multispectral imagery can let you see things that the human eye cannot perceive:
    - Over/under fertilization of cereal crops and rapeseed oil;
    - Some diseases and weeds;
    - General plant stress;
    - Leveling issues.
- UAVs can offer a very high return on investment.
- Repeated flights over the same area can show improvements/degradation over time.
- UAVs can provide timely and informed decisions about farming practices.

Please keep these things in mind when considering purchasing or renting a UAV: laws and regulations in your country; distance between farms; total size of farm groups; taxes; and, what can and cannot be done using a UAV. UAVs in agriculture need to be paired with actionable intel for their use to be relevant to a small holder farmer.