SIANI
Swedish International Agricultural Network Initiative

SLU Global

SUSTAINABLE AGRICULTURAL PRODUCTION & FOOD SECURITY

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Variations in productivity - Causes and effects on food security and on sustainability of cropping systems.

Summary

A workshop was conducted in a region of Uganda to explore productivity differences between and within households in order to identify their causes and their effects on food security and the sustainability of cropping systems. The approach used combined tools and information derived from socio-economic sciences, natural sciences and remote sensing technology. The potential of this approach to link investigations on different geographical scales was evaluated. Representatives of socio-economic and natural science disciplines and working within research, agricultural extension services and village development were invited to the workshop, which included two phases: an on-campus phase at Makerere University, Kampala, where the approach was developed, and a field phase in the Mbale sub-region, where it was tested. The field work included interviews, field observations and collection of aerial images. A post-workshop section included further data processing to link the high-resolution imagery with satellite imagery and an evaluation of the approach.

The preliminary results showed that the spatial resolution of unmanned aerial systems (UAS) is sufficient for our research needs, including possibilities to visually distinguish individual crops. The equipment needs some adaptation to create a truly robust system, but the technology for this is available. It proved possible to derive normalised difference vegetation index (NDVI) data from the UAS tested here, but more work is needed to link NDVI between different sensors. The flyovers and interviews were positively received in the villages. The conclusion from the workshop was thus that the suggested remote sensing framework is feasible and could soon become operational.

Contents

Background	1
Workshop aim	2
Workshop programme and approach	2
Description of tools used within social and natural sciences	2
Interviews	2
Field observations and experiments, samplings and determinations	2
Remote sensing systems	3
Crop yield and yield gap estimation	3
Test of strategy during the workshop	4
Description of the field area	4
Interviews	5
Field observations, samplings and measurements	5
Unmanned aerial systems (UAS)	5
Linking the imagery at different scales and with interviews and biophysical data	6
Conclusions	6
References	7
Appendices	8
Appendix 1 Workshop programme 'Variations in productivity - causes and effects on food security and on the sustainability of cropping systems'.	8
Appendix 2 List of participants	8

Background

Global demand for food, animal feed and fibre is projected to increase in response to population and income growth. In order to meet this and also improve the food security of poor populations, the agricultural sector needs to increase production dramatically without compromising environmental sustainability. The link between farm production and food security at the household level is quite direct and obvious for the smallholder farmers that make up the majority of the population of sub-Saharan Africa (SSA). For these households, many of which have few opportunities to expand their farms, an increase in agricultural productivity – areal productivity as well as labour productivity – carries the potential to substantially reduce food insecurity, which is currently affecting approximately some 35% of the total population in SSA (Boussard, Daviron et al. 2006).

Ironically, recent research reports provide evidence of stagnating crop yields and regionally very variable crop yield patterns all around the globe (Grassini, Thorburn et al. 2011). It is well documented that the productivity can vary considerably between households under similar agro-ecological conditions within a village. Even more so, there is often variation in productivity between fields and plots managed by the same household (Tittonell, Vanlauwe et al. 2007).

This is partly caused by large variations in e.g. soil type and status and rainfall patterns, but also past farm management and highly variable socio-economic conditions, such as access to inputs and markets where farmers can sell their produce. Smallholder farmers in SSA are therefore often unable to benefit from the potential yields offered by e.g. improved crop varieties. In particular, continued cropping requires inputs of nutrients and organic matter (e.g. Dahlin and Rusinamhodzi 2014 (in press)) to avoid soil degradation. Poor or sub-optimal practices in other agronomic aspects, such as planting time, weed and insect pest management, also severely limit the scope to exploit the potential of improved varieties (Tittonell and Giller 2013). This situation is often due to limitations in labour availability and access to advisory services and inputs. This illustrates that issues of a social, economic and institutional nature are difficult to disentangle from aspects of agro-ecology and geophysical limitations, particularly in relation to agricultural development. A major challenge is thus to find ways to adjust already known principles and practices for intensification of agricultural production to the great variability which exists, starting by identifying key causes of poor productivity at the local and higher levels.

To do so, there is a need to combine knowledge from the socio-economic and natural science disciplines, take longer-term changes and trends into account, and find ways to address different spatial scales so that we can advance from site-specific studies and draw more general conclusions.

(Photo: Sigrun Dahlin)

Figure 1. Many stakeholders participated in the field part of the workshop.

Workshop aim

The workshop aimed to explore productivity differences between and within households in order to identify their causes and their effects on food security and on the sustainability of cropping systems. The approach used combined tools and information derived from socio-economic sciences, natural sciences and remote sensing technology.

Workshop programme and approach

To achieve the workshop aim, representatives of complementary disciplines and working within research, agricultural extension services and village development were invited to the workshop. The point of departure was existing geographical and agronomic data on the Mbale sub-region in Uganda, which were made available by Makerere University. In the first phase of the workshop, meetings were held at Makerere University, Kampala, in order to introduce the approach of combining disciplines to the workshop members and to a wider circle of university staff (Appendix 1). After transportation to Mbale, where the pilot field study was to be carried out, a seminar was held where presentations were made on the socio-economic, geological and agronomic conditions of the area and the technology and possibilities of unmanned aerial systems (UAS) were introduced. The following discussions ascertained that all participants had a common understanding of the anticipated strengths and weaknesses of the proposed approach, a common vocabulary and a basic understanding of the study area, irrespective of their background in research or extension, social science or natural science or whether they came from Uganda or other countries. Knowledge gaps and requirements for complementary socio-economic and biophysical data were identified. This was followed by joint production of a questionnaire pertaining to the area and its agricultural production, which was needed to test the approach.

The approach was then tested in four villages in collaboration with an extension officer, a representative of Tabu Integrated Women's Group Bulambuli (the local village development group) and a number of farmers. UAS data were collected for individual farms and paired with interviews and discussions with the respective farm operator (i.e. the person carrying out most of the work on each farm). Discussions were also held with additional farmers in each village (Appendix 2).

Description of tools used within social and natural sciences

Interviews

The interview has become the main data collection procedure in many studies and is closely associated with qualitative social science research. It is often a one-to-one discussion between an interviewer and an individual, intended to gather information on a specific set of topics. Interviews differ from surveys, another commonly used tool for data collection in social science research, by the level of structure placed on the interaction. In seeking a very complete response, interviews are most likely to provide the depth of information that might be useful. They are also the best method to resolve seemingly conflicting or contradictory information. The use of both qualitative and quantitative techniques is becoming increasingly common and the approach is referred to as mixed methods.

Field observations and experiments, samplings and determinations

One approach to understanding yield variation is to carry out field experiments according to scientific standards. If well designed, these provide reliable information on the effects of e.g. different farm management options, but high costs may prevent plot maintenance in the long term and thus the study of long-term effects. Another approach is to collect biophysical site and landscape data from farms and villages through observations of slope, current and historical erosion and measurements of soil parameters. Measurements to date generally comprise chemical analyses, although spectrometric determinations are increasingly being used at different scales ranging from analysis of individual samples to remote sensing covering large areas. The biophysical data are generally combined with investigations of farm flows such as harvest outputs, fertilizer and manure inputs and crop residue use, as a means of explaining observed differences in soil fertility. Such data can be confirmed through visual triangulation during transect walks at farm and village level. Meteorological data and observations of crop appearance at critical stages are also used to explain yield figures.

Linking these approaches can provide opportunities to combine information that is site-specific with more generalised information that is applicable to larger geographical areas. More specifically, one route to improve the capability for large-area assessments with a resolution relevant to smallholder agriculture may be to combine field spectrometric measurements (calibrated against a subset of samples analysed by chemical analysis) with remote sensing data, geo-referenced ground surveys and new spatial statistical methods.

Remote sensing systems

Remote sensing is the analysis of objects from a distance. There are numerous applications of this technology, but here we refer to remote sensing as a system with any kind of detector mounted on an aerial vehicle. In the workshop, we explored the full range of remote sensing data from satellite-derived imagery to imagery collected with small unmanned aerial crafts. Typical remote sensing applications include e.g. vegetation mapping and monitoring and can replace costly and slow data collection on the ground, thus permitting large-scale data collection not feasible with other technologies.

The contribution of remote sensing to the study of yield gaps is relatively small but constantly growing. Existing examples suggest that remote sensing can help to overcome some of the inherent spatial and temporal scaling issues associated with field-based approaches and thereby provide for large-area assessments.

There is clear evidence that crop yield in mono-cropped stands can be estimated with good accuracy using remote sensing. The most conceptually simple and practically sound method to estimate crop yields is to establish empirical relationships between ground-based yield measures and vegetation indices (e.g. normalised difference vegetation index (NDVI) or enhanced vegetation index (EVI)). However, there are several potential sources of error in crop yield estimations with remote sensing. These are (mainly) a function of satellite sensor properties (spatial, temporal and spectral resolution) and landscape complexity. With sufficiently high resolution, it is possible to distinguish different crop types, but misclassification of crop types is problematic in regions that grow multiple crops with similar phenologies, or in regions with intercropped fields (Lobell 2013). The mixed cropping systems found throughout Africa are probably the most challenging in the world.

Acquiring data with sufficiently high spatial resolution to delineate individual fields and data with sufficiently high temporal resolution to obtain cloud-free observations during the growing season is difficult, particularly in the African context. The main source of high temporal resolution is the MODIS sensor, but it has low spatial resolution. Landsat, on the other hand, has a footprint of 30 metres but low temporal resolution, decreasing the chances of acquiring cloud-free images. An emerging interesting alternative is UAS with sensors mounted on and the capacity to record images below and independent of the cloud cover. Previous experiences with UAS have primarily been to inform precision agriculture applications (Yand, Everitt et al. 2001). The temporal resolution of UAS is variable and can be harmonized or fine-tuned with, for example, fine temporal data from MODIS or knowledge of crop development. UAS can solve the long-lasting dilemma with the scale mismatch between household surveys and remote sensing data (Hall 2010).

Crop yield and yield gap estimation

There are generally two approaches that are considered viable for crop yield estimation. The first, and the simplest, of these is to establish empirical relationships between ground-based yield measures and vegetation indices measured on a single date or integrated over the growing season (e.g. Lobell 2003). The second relies on estimates of photosynthetically active radiation (PAR) over the course of the growing season, radiation use efficiency (RUE) and harvest index (HI):

$$Yield = \left(\sum_{t=1}^{n} PAR_t \cdot fPAR_t\right) \cdot RUE \cdot HI$$

PAR and fPAR are extracted from MODIS. The time step in the equation can either be coarsened to match MODIS 16-day data or interpolated (Myneni, Hoffman et al. 2002; Nightingale, Morisette et al. 2009). The two final factors are RUE and HI, usually assumed constant. They can either be derived from field data or calibrated to reported statistics.

Remote sensing can only provide estimates of actual yield. For calculations of yield gaps, additional information on potential yield is needed. One approach to derive potential yield is to pair independent estimates on potential yield, e.g. from modelling or field trials, with estimates of actual yield from remote sensing. An alternative is to use the maximum yield, or variations thereof, estimated within the remotely sensed area. This approach has been tested in some cases (Bastiaanssen and Ali 2003; Lobell, Cassman et al. 2009). A hybrid approach is suggested by Lobell (2013).

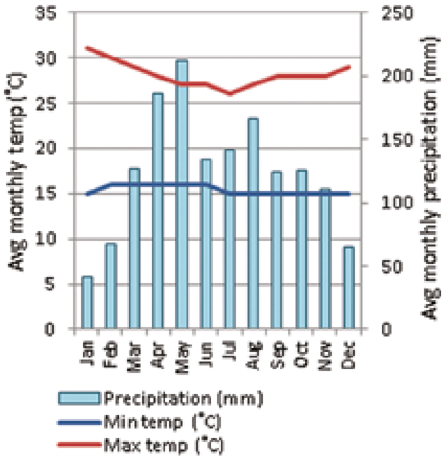
Mapping of yield gaps from remote sensing data (see above) can be compared with other data that are believed to control crop yields. Explanatory variables are then statistically analyzed to derive the relative importance of each variable in driving crop yields. There are several examples of this approach reported in the literature (e.g. Lobell, Ortiz-Monasterio et al. 2005, Lobell 2013). Another approach is to examine the spatial distribution of average yields over varying lengths of time. The basic idea is that averages calculated over longer periods will show less spatial variation than averages for shorter periods, since factors that are less persistent tend to cancel out across years. This approach has been used extensively by Lobell at various study sites (e.g. Lobell and Burke 2010). Furthermore, by extracting some key statistics from the yield map distribution, yield gap curves can be constructed. Among several things, the steepness of these curves can provide insights into the persistence of spatial yield differences through the study period. This can then be related to other persistent factors (soil quality, farmer skill, etc.).

Figure 2. A) Map of Uganda showing Mbale in the east (Google maps).

Test of strategy during the workshop

Description of the field area

The concept/approach was tested in the Mbale region near Mt Elgon, a caldera volcano in eastern Uganda (Fig. 2A). The area is densely populated (586 persons km^{-2}; UBOS, 2002) with 90% living in rural areas and dependent on agricultural activities. The landscape is mainly mountainous, but with some low and level land. The climate shows an approximately bimodal pattern of rainfall, with mean annual rainfall ranging from 1500 to 2000 mm and with the wettest months occurring in April and October (Mugagga, Kakembo et al. 2012). Mean annual temperature ranges from 15 ˚C (night) to 28 ˚C (day) (Fig. 2B).



▶ **Figure 2.B) 20-year average monthly minimum and maximum temperature and monthly precipitation.**

Figure 3. A) Soil map of the Mt Elgon area with Mbale and the study area situated west of the mountain peak (Jones, Breuning-Madsen et al. 2013).

- Nitisols: deep red soils with a well-developed structure,
- Vertisols: soils with shrinking and swelling clays,
- Phaeozems: slightly acid soils with a thick, dark-coloured surface layer,
- Umbrisols: acid soils showing early development,
- Plinthosols: soils with accumulation of iron that hardens irreversibly when exposed to air and sunlight,
- Ferralsols: strongly weathered soils with low nutrient levels,
- Luvisols: soils with clay accumulation in subsoil.

The mountain slopes are dominated by relatively fertile, calcium-sodium-potassium rich loams (Fig. 3A), although these are physically unstable (Mugagga, Kakembo et al. 2012). The rapidly growing population in the area has led to forests and woodland being continuously replaced by agricultural fields. Agricultural activities are also extending onto critically steep and fragile slopes of the mountain. A sense amongst the local population of their right to access and exploitation has underpinned this development and has also led to logging within the protected forest on the steep mountain slopes at higher elevation. The agricultural activities have triggered landslides, the most fatal of which killed more than 300 people. The negative effects of agricultural activities are partly attributed to the low level of literacy and training among community members, especially women, who also lack the right to own land, yet carry out a large share of the farm work. There is thus an urgent need to sustainably intensify agricultural production on the more suitable soils on the lower slopes and level land at the foot of the mountain and implement protective measures on the higher slopes.

Farming in the region is mostly of a subsistence nature, with 80% of the area devoted to cereal crops and usually two crops grown per year (Buyinza and Mugagga 2010). Manure produced by farm animals makes up the largest nutrient input to these cereals. Other inputs are used in minor amounts and erosion control practices only to some extent, and there is a lack of knowledge of farm technologies to address novel challenges such as Striga infection of cereal crops (Fig. 3B). To date, there has been little agricultural advisory work in the region, but Eco Development Foundation is currently extending its activities to the area (represented during the workshop by advisor William Nambafo).

(Photo: Sigrun Dahlin)

B) Maize crop infected with Striga hermonthica, a parasitic weed attacking multiple cereal crops, frequently causing yield losses of more than 50% and contributing to the low and decreasing areal yields in sub-Saharan Africa (Kanampiu, Ransom et al. 2002).

A development organization that has been active in the area for some time, CBO - Tabu Integrated Women's Group Bulambuli, was represented during the workshop by its chairman, Florence Gibutayi.

Interviews

Four study farms were selected based on presence of a maize crop (pure stand or mixture) despite the fact that the workshop was held during the driest time of the year (Fig. 2B). A first test of the draft questionnaire (and UAS) was carried out on one farm and the questionnaire was subsequently complemented with a few further questions. On three other farms, an interview based on the questionnaire was held with the family member that had the main responsibility and spent most time working on the particular maize field, i.e. the operator. Whenever possible, the interview was carried out in English to enable direct communication between the overseas participants and the respondents. However, a Ugandan participant acted as translator when needed.
The interviews showed large differences in resource availability, educational level and work partitioning within the household. All three operators interviewed were female. Their work was complemented by that of family members, and in one case by hiring labour for weeding. Soils had been under cultivation for between a couple of years and generations. Livestock manure was used on all the current maize fields, but the use of other household wastes/by-products differed between farms. These were in some cases (e.g. household ash and human urine) only applied to certain crops such as mangoes or bananas, and not to maize. Purchased inorganic fertilizers were used on two of the farms. Weeding was a major task and due to labour shortage was sometimes not conducted according to plan. This severely impaired crop development and yield (Fig. 4). The main pests (apart from weeds) in the maize fields were mosaic virus and (probably) maize stemborer, but no specific crop management practice was implemented to target these pests.

Field observations, samplings and measurements

There was only time to conduct field observations during the workshop, although a need for complementary measurements was identified. The observations obtained indicated that nutrient supply was a major limiting factor for yields, confirming that questions regarding nutrient inputs and field history should be included in the questionnaire. They also confirmed that crop colour variation, as detected by aerial imagery, has the potential to explain yield differences. Striga infection was new in the area and knowledge about control measures was lacking. Weed control was a general challenge that could be expected to significantly affect yields (Fig. 4). Some farmers in the area had the possibility to irrigate to a limited extent, which could help overcome dry spells or extend the growing season. This option was not much used, but is possibly increasing.

Unmanned aerial systems (UAS)

The background maps used for determining the UAS flight routes were downloaded from open access sources online and proved to be of sufficient quality. The initial flights also supplied photographic data of a quality that permitted identification of individual maize plants and allowed maize plants to be distinguished from weeds and other crop plants in mixed crops. It was also possible to directly process the data and compare them with satellite imagery data. However, the team encountered some technical problems with the airplane which could only be partly solved during the workshop. The field sites tested, with their intimate mixture of annual and perennial crops, trees and bushes, also provided difficult conditions for landing the airplane. This highlights the need for robust and well-adapted systems and adequate access to service and infrastructure.

Figure 5. A) Assembling the unmanned aerial system.

B) Airplane in the air is followed with interest.

(Photos: Sigrun Dahlin)

Figure 4. Timeliness of weeding is crucial for crop development. This whole field received the same amount of manure and fertilizer, but the part to the right of the picture was weeded according to plan, whereas the part to the left was not weeded at the right time.

Linking the imagery at different scales, and with interviews and biophysical data

Our primary results suggest that UAS of the type used here can produce data at a sufficient level of detail. It proved possible to distinguish individual fields from each other, which from a conventional remote sensing perspective is problematic for most SSA smallholder regions. Furthermore, it proved possible to identify individual crops even within complicated mixed crop fields. This is promising as we now have the tools to produce, at least, village level land cover maps that could be used as the basis for interviews, data collection and the foundation of a spatial database.

Using a modified ordinary camera, we also tested whether NDVI could be calculated. As this index is dimensionless, it holds promise as the link between different spatial scales. We found that NDVI could be calculated easily from our UAS (Fig. 6C). Thus we have the tools to estimate crop yields even at this detailed level. However, there are still several issues that need to be addressed before the methodology is fully complete.

The examples above required substantial amounts of data and pre-processing. The main obstacle was to find series of cloud-free observations. The two approaches above can also be combined. For regions with few cloud-free images, a single year analysis with or without ancillary data can be performed. Studies of subsequent years can be used to study the persistence of identified factors. This type of map can also guide fieldwork sampling schemes.

The approach requires collaboration between different research fields, researchers, extension officers and farmers. This was made possible during the workshop through the previously established contacts and introductory seminars during the first phase of workshop. Another factor that facilitated implementation was the relatively high level of education among the interviewed stakeholders, which meant that direct communication was possible between the Ugandan and foreign participants. This may have implications for the future applicability of the approach.

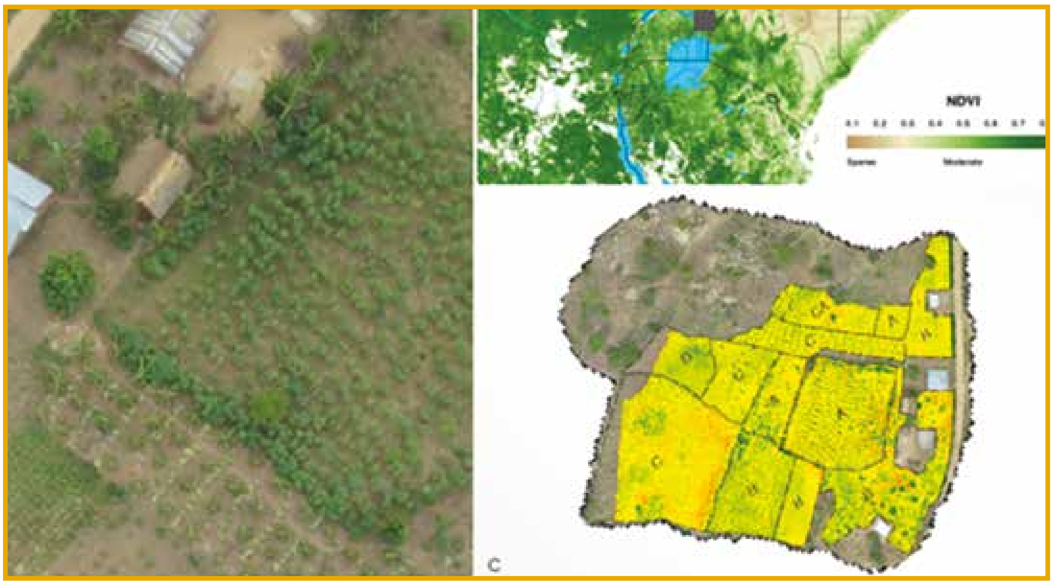


Figure 6. Example of the remotely sensed data from the workshop and derivatives thereof.
A) The field study area with MODIS NDVI data. The potential is large coverage (global), high temporal resolution (weekly) and great detail (250 m).
B) RGB imagery from the UAS flight over Wokiri village (Imagery: Niklas Adolfsson, JTI). The potential is great detail and a way to resolve the issue of mixed cropping pattern.
C) NDVI calculated from UAS data for parts of village, overlaid on imagery from same craft (Imagery: Ola Hall).

Conclusions

The approach tested here is promising, although it requires more data than could be collected during the workshop. The equipment also needs refinement to create a truly robust system, but the technology needed for this is already available. The flyovers and interviews were positively received in the villages we visited. The conclusion from the workshop was therefore that the suggested remote sensing framework is feasible and could soon become operational. The next step would be to perform a study over larger areas and over at least two seasons.

Acknowledgements

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Appendices

Appendix 1 Workshop programme

'Variations in productivity - causes and effects on food security and on sustainability of cropping systems'.

Thursday 2014.01.30

Arrival Kampala

Friday 2014.01.31

09.00-10:30	Introductory meeting with workshop participants Briefing by Magnus Jirström
11:00-17:00	Meetings at College of Agriculture, Makerere University

Saturday 2014.02.01

09:00-15:00	Travel to Mbale
15:00-19:00	Arrangements for field trips, joint development of questionnaire

Sunday 2014.02.02

09:00-11:30	Seminar; Presentations of soils, crops and socio-economic conditions in Mbale region, William Nambafo, Frank Mugagga, David Kiirya Unmanned Aerial Systems (UAS) – potential use in farming systems analysis Niklas Adolfsson Discussion: Moderator Paul Mukweya
13:30-18:00	Field visit to Wokukiri village with testing of UAS and questionnaire
19:00 -	Evaluation of field visit and planning

Monday 2014.02.03

9:00-18:00	Field visit to Buwebele village with field mapping using UAS and interviews
19:00 -	Summing up

Tuesday 2014.02.04

9:00-18:00	Field visit to Bubuyela village with field mapping using UAS and interviews
19:00 -	Summing up

Wednesday 2014.02.05

9:00-18:00	Field visit to additional village within Bukhalu sub-county with field mapping using UAS and interviews
19:00- 21:00	Evaluation of methodology and summing up

Thursday 2014.02.06

Return to Kampala and meeting at Makerere University
Return to Sweden and Ghana

Appendix 2 List of participants

31 January 2014

Meeting 9:30

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University; Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU

Meeting 11:00

Frederick Tumwine, Makerere University
Rerocatus Tunwomuhangi, Makerere University
Yazidhi Mabutaze, Makerere University
Wasswa Hannington, Makerere University
Alex Nimusiima, Makerere University
Daniel Kisitu, Makerere University
Catherine Mulinde, Makerere University
Faridah Nalwayoa, Makerere University
Paul Musali, Makerere University
Edward Mwavu, Makerere University
Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU

Saturday 1 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU

Sunday 2 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU
William Nambafo, local extension officer, Mt Elgon region
Yese Mayena, farmer in Wokukiri Village
Around 35 other respondents in Wokukiri Village

Monday 3 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU
William Nambafo, local extension officer, Mt Elgon region
Florence Gibutayi, chairman CBO - Tabu Integrated Women's Group Bulambuli
Lea Wanyenya, farmer in Buwebele Village
Yelusa Kleisa, farmer in Busabulo Village
Around 15 other respondents in Busabulo Village

Tuesday 4 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
David Kiirya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU
William Nambafo, local extension officer, Mt Elgon region
Florence Gibutayi, chairman CBO - Tabu Integrated Women's Group Bulambuli
Lea Wanyenya, farmer in Buwebele Village
Around 20 other respondents in Buwebele Village

Wednesday 5 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
Fred Dzanku, Legon University, Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU
William Nambafo, local extension officer, Mt Elgon region
Florence Gibutayi, chairman CBO - Tabu Integrated Women's Group Bulambuli
Lea Wanyenya, farmer in Buwebele Village
Carol Mutonyi, farmer in Bubuyela Village
Eight other respondents in Bubuyela Village

Thursday 6 February

Frank Mugagga, Makerere University
Paul Maukwaya, Makerere University
Fred Dzanku, Legon University; Ghana
Magnus Jirström, Lund University
Niklas Adolfsson, JTI
Håkan Marstorp, SLU
Sigrun Dahlin, SLU

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The views presented are solely the author's.