

Thesis in geographical information technology no. 18

# Mapping in Agricultural Development

Introducing GIS at a Smallholder Farmers'  
Cooperative in Malawi

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# Mapping in Agricultural Development

## Introducing GIS at a Smallholder Farmers' Cooperative in Malawi

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## **Abstract**

Malawi is a country in southern Africa and considered to be one of the poorest countries in the world. The main part of the population lives in rural areas and is completely depending on farming for their livelihood. There are, however, no records of land registration or tenure for the smallholder farmer.

The use of geographical information systems, GIS, is increasing around the world. At a smallholder farmers' cooperative in Malawi, NASFAM, there is a desire to map size and location of all fields and houses of member farmers. This data are expected to improve planning and evaluations of NASFAM's operations hence improve the living conditions of the farmers.

As a way of testing the possibilities with GIS at NASFAM, a pilot study in the project was implemented. In this phase different methods for education and measurements have been tested in order to evaluate their feasibility to be included in recommendations for continued work.

To introduce GIS in the organisation, trainings were held with field staff. Trainings were also held with the people who were assigned to collect the requested points. To investigate the opinions on this project among field staff, interviews were conducted with staff representing districts in various parts of Malawi. When the necessary data had been collected they were compiled and analysed.

Results observed after the study lead to conclusions about continuous work. One issue that has to be solved is how measurement of locations should be performed. In the pilot study people with a low level of education were taught how to collect points with a GPS-receiver because they were farmers themselves and had the local knowledge how to find the farmers. Errors in the measurements could be seen, for example an insufficient amount of measurement points. This was due to lack of basic understanding of the methodology and purpose of the assignment.

To map all farmers in NASFAM is extremely time-consuming and the measurements might have to be redone every year due to change of field alignments and usages. If a project like this is to be performed on a large scale, it is important that NASFAM views it as a long term commitment and that all staff have understanding of the purpose and benefits but also possible problems.

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## Sammanfattning

Malawi är ett land i södra Afrika och betraktas som ett av de fattigaste länderna i världen. Befolkningen lever framför allt på landsbygden och är helt beroende av jordbruk för att överleva. Det finns dock inga register och ingen säkerställd rättighet över marken de brukar.

Användandet av geografiska informationssystem, GIS, ökar runt om i världen. Hos ett jordbrukskooperativ i Malawi, NASFAM, finns en ambition att kartlägga var alla dess medlemmar bor och hur mycket mark var och en brukar. Denna information förväntas sedan kunna förbättra planering och utvärdering av projekt och på så sätt förbättra levnadsvillkoren för lantbrukarna.

För att undersöka förutsättningarna för GIS inom NASFAM har en pilotstudie för projektet gjorts. I pilotstudien har olika metoder för undervisning och datainsamling testats och utvärderats för att kunna dra slutsatser om och hur de bör tas med i rekommendationer för hur projektet ska fortsätta.

Utbildning hölls för fältpersonal för att introducera GIS i organisationen. Det hölls också utbildning för de som fått i uppdrag att samla in de efterfrågade punkterna. För att undersöka åsikterna kring projektet bland anställda hölls intervjuer med personal från de olika distrikten. När tillräcklig data hade samlats in kunde de sammanställas och analyseras.

Resultaten som kunde observeras efter studien ledde till slutsatser om hur arbetet kan fortsätta. Ett problem som måste beaktas är hur datainsamling ska genomföras. I pilotstudien instruerades personer med en relativt låg utbildningsnivå i att samla in begärda data med GPS-mottagare eftersom de själva är lantbrukare med lokalkännedom och vet var de eftersökta lantbrukarna bor. Det kunde dock konstateras vissa felaktigheter med mätningarna, som exempelvis ett otillräckligt antal punkter. Detta kan bero på bristfällig förståelse för uppgiften, metoden och syftet.

Att kartlägga alla lantbrukare inom NASFAM är mycket tidskrävande och mätningarna behöver eventuellt upprepas varje år, allt eftersom lantbrukare byter fält med varandra. Om ett sådant projekt ska genomföras i någon större skala krävs det att organisationen betraktar det som ett långsiktigt engagemang och att alla anställda har en grundläggande förståelse för syftet och de fördelar som kan uppnås med användandet men också insikt om möjliga problem.

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## Acknowledgements

With this thesis I complete a year of challenges, adventures and renewed knowledge about the world and about myself.

The journey started with my acceptance to We Effect's internship programme and has, apart from spending five months in Malawi, also included thorough preparations and rehabilitation.

I would like to thank all my colleagues at NASFAM for trusting me with your time and energy and thereby making this project come true. I want to send a special thanks to my co-worker and friend, Mr. Ken Chilingulo, for your company and high ambition. Never before have I seen an organisation so determined to try harder and better in spite of the constant struggle against the system.

The NASFAM motto is as true in rural Malawi as it is in Sweden:

*The future belongs to the organised.*

Lund, May 29<sup>th</sup> 2015

Ellen Walleij

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## **Abbreviations**

**ABM** – Association Business Manager

**AFO** – Association Field Officer

**DEO** – Data Entry Officer

**GAC** – Group Action Committee

**GIS** – Geographical Information System

**IPC** – Innovative Productive Centre

**M&E** – Monitoring and Evaluation

**NASFAM** – National Smallholder Farmers' Association of Malawi

**NTS** – NASFAM Tracking System

**Sida** – Swedish International Development Cooperation Agency

**UTM** – Universal Transverse Mercator

**WGS** – World Geodetic System

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## Definitions

**Association** – An association of smallholder farmers, consisting of several GACs.

**Association Business Manager (ABM)** – NASFAM staff, the head manager at every IPC.

**Association Field Officer (AFO)** – NASFAM staff, placed in every Association, works directly with the farmers.

**Club** – A group of 10-15 smallholder farmers. The smallest unit in the NASFAM organisation, used primarily for study circles.

**Data Management Officer** – Responsible for all data at the NASFAM head office and co-worker with the author in the GIS project.

**Data Entry Officer** – Staff at every IPC office, responsible for entering the data from the NTS-forms into the NTS.

**Development Director** – Responsible for all development work at NASFAM.

**Extreme poverty** – People living at or below \$1.25 a day (World Bank Poverty 2015).

**Farmer Trainer** – A leading farmer responsible for study circles and for being a role model when it comes to farming methods.

**Group Action Committee (GAC)** – Formed by several Clubs and the key points for dissemination of information to members

**Innovation Productive Centre (IPC)** – Provides management and operational support to the Associations in terms of production, marketing and community development.

**NASFAM Tracking System (NTS)** – A MySQL-based database for NASFAM membership data.

**Smallholder Agribusiness Development Project** – A USAID-funded project which is the origin of NASFAM.

**Smallholder farmer** – A farmer with limited resource endowments relative to other farmers in the sector (FAO 2015).

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# 1. Introduction

## 1.1. Background

The voice of smallholder farmers can easily be overlooked if they stand alone but if they are organised, governments have to listen. Therefore, farmers form associations and cooperatives to make an impact on conditions for farming, facilitate seed distribution and to create a fair market for their crops.

A major issue for farmers in Malawi, together with many other countries in the world, is the land management system. If there is no registers on property boundaries or ownership, a farmer cannot use the property for mortgage security nor can they hold it with an assurance that it cannot be taken from them without an equivalent compensation.

National Smallholder Farmer's Association of Malawi, NASFAM, has nearly 150,000 farmer members (NASFAM 2014). The average member supports a family of six people by farming less than 1 hectare of land (NASFAM 2015a). However, no one knows for sure how much land each farmer has since there are little or no registers of land tenure in rural Malawi. Without knowing the actual sizes of the farmers' fields it is difficult to estimate which annual yield can be expected, something that is important for planning and evaluation of different farming methods. It is also problematic when it comes to seed distribution since the quantities are proportioned to the area of cultivated fields. In addition to the limited information about field sizes, NASFAM also encounter challenges with knowing the members whereabouts. The staffs in the district offices rely on other members and the word of mouth to give directions if they need to find a certain member. As a result, farmers often "disappear" without any trace after getting a micro-finance loan or other capital assistance (Chilingulo 2015).

Therefore, the Monitoring and Evaluation unit at NASFAM, M&E, intends to map fields and houses for all member farmers with GPS and GIS technology. An updated GIS map could be used for planning purposes at central NASFAM level but also be spread to district offices as a tool in their planning and day-to-day activities.

We Effect (formerly known as Swedish Cooperative Centre) is a cooperative development organisation focusing on long term aid. The principal is "help to self-help", to improve livelihoods through rural development and by focusing on gender, housing and access to land (We Effect 2015). As a part of We Effect's internship programme, financed by Sida, the author was positioned with the M&E unit at NASFAM at their head office in Lilongwe to kick-off the project and contribute to their knowledge of GPS-measuring and GIS-mapping. During the stay in Malawi, the author investigated the possibilities for GIS within the organisation and initiated GPS trainings of members and staff in one of the districts.

This thesis describes the pilot phase of introducing GIS as a tool for planning, monitoring and evaluation at NASFAM. It describes the practical work, in the field and in the office, and shows the successful parts as well as the challenges and obstacles encountered. Thoughts and evaluations of this project are summarised to work as guidelines for the continuation of GIS at NASFAM and can possibly be used as guidelines for similar projects in the future.

## **1.2. Purpose**

The purpose of this project is to investigate the possibilities with using GIS as a tool at NASFAM to improve the monitoring of NASFAM members and agriculture development. The purpose is also to inform about how this technology can be used in relation to working conditions in Malawi, for example when it comes to electricity, economy and education.

The objectives are:

- To collect geographical data about member farmers. The data should capture the location and size of fields and the location of the farmers' houses.
- To make an evaluation whether the trainings with GPS were successful.
- To gather opinions on this project among field staff.
- To specify guidelines on how to continue this project.

## **1.3. Limitations**

This is a pilot study and in order to make it manageable during a limited period of time the GPS trainings were limited to one district, Mulanje Association. Possibly, the results of the training in this area could differ from results in other areas due to other conditions such as longer or shorter distances between farmers or different methods of communication in the communities and organisation.

## **2. Related work**

### **2.1. Access to Land**

Land is not a commodity like any other on the market. It affects the lives of especially farmers by representing economy and food security as well as basic human rights. With no legal access to land, a farmer is contained in their work and possibility to evolve (Gregow, Hermele, Johansson, Nhampossa, Wolpher 2012). If there is no registers of land ownership, the farmer is incapable to use the land for security in loans (Sida 2013). They are also more exposed for land grabbing issues (Gregow et al. 2012).

Botswana in southern Africa has had issues with land and property management. Before the 1970s, the village chief divided the land but since then no official land registration has been maintained. With no registrations of land ownership, the land cannot be used as mortgage security and land transactions are insecure (Sida 2013a).

The Swedish National Land Survey therefore collaborated with the Botswana National Land Survey to develop systems for an efficient management of land information in the country. The project went on for five years and constituted a long-term strategy for land ownership procedures. Apart from the strategies and management systems, three new courses in land administrations have been implemented at the University of Botswana to secure the demand for future skills. Simultaneously as the land management collaboration, a new comprehensive land reform was carried through (Sida 2013b).

Before the project initiation, the Government of Botswana had identified an operating land administration as a fundamental condition for economic development. Former changes in land administration had focused on the solution of separate needs at the time. The new land administration project therefore aimed to take an overall look at the management issues in Botswana (Malatsi, Finnström 2011).

### **2.2. GIS in Development Work**

GIS projects in organisations around the world are often completed without a clear plan on what comes next or without an understanding of the benefits and possibilities (Somers 1998 see Taleai, Mansourian & Sharifi 2009). It has been shown that for long-term results, the GIS system has to be integrated with other systems in an organisation. Instead of focusing on GIS as an independent unit, it must be part of the main strategic plan of the organisation and adapted depending on the basic conditions and resources (Taleai et al. 2009).



### 3. Malawi

#### 3.1. History and Economics

The current border of Malawi originates from the British protectorate of Nyasaland which was established in 1891 (CIA 2015). After independence in 1964 the country was ruled by President Hastings Kamuzu Banda until the first multiparty elections in 1994 (UNDP 2015a). In 2014 the current president, Prof. Arthur Peter Mutharika who represents the Democratic Progressive Party, was elected (Utrikespolitiska Institutet 2015).



Figure 3.1. Southern Africa with Malawi marked with red (Google 2015).

In 2013, Malawi had more than 16 million people (World Bank 2015), half of them were below the age of 15 (CIA 2015). The area of Malawi is approximately 118,000 square kilometres (UNDP 2015a) and the high population density is substantially affecting access to land and every year cultivated land is increasing its proportion of the total land area. Forests are exploited for firewood and charcoal production and the deforestation leads to increased erosion, with damages to infrastructure, soils and fishery as a consequence (World Bank 2015). With a rank of 174 out of 187 countries in the Human Development Index (UNDP 2015b), Malawi is considered to be one of the poorest countries in the world with 34 % of the population in extreme poverty

(World Bank 2015). More than half of the households in rural Malawi are estimated to be affected by HIV/AIDS which often leads to loss in labour (NASFAM 2015b).

Approximately 80% of the population lives in rural areas and agriculture dominates the export economy with 90%. The Burley tobacco stands alone for more than half the exports and is vital to the country's growth (CIA 2015). To secure the economy towards changes in international market prices, Malawi is encouraged by the UNDP to a diversification of crops. In addition to tobacco the country has potential to develop the production of sugar, tea, legumes, cotton, pepper and coffee. However, problems with insufficient infrastructure obstruct transports of the commodities (UNDP 2015c). Malawi's economy is extensively depending on support from the International Monetary Fund, IMF, the World Bank and individual nations (CIA 2015).

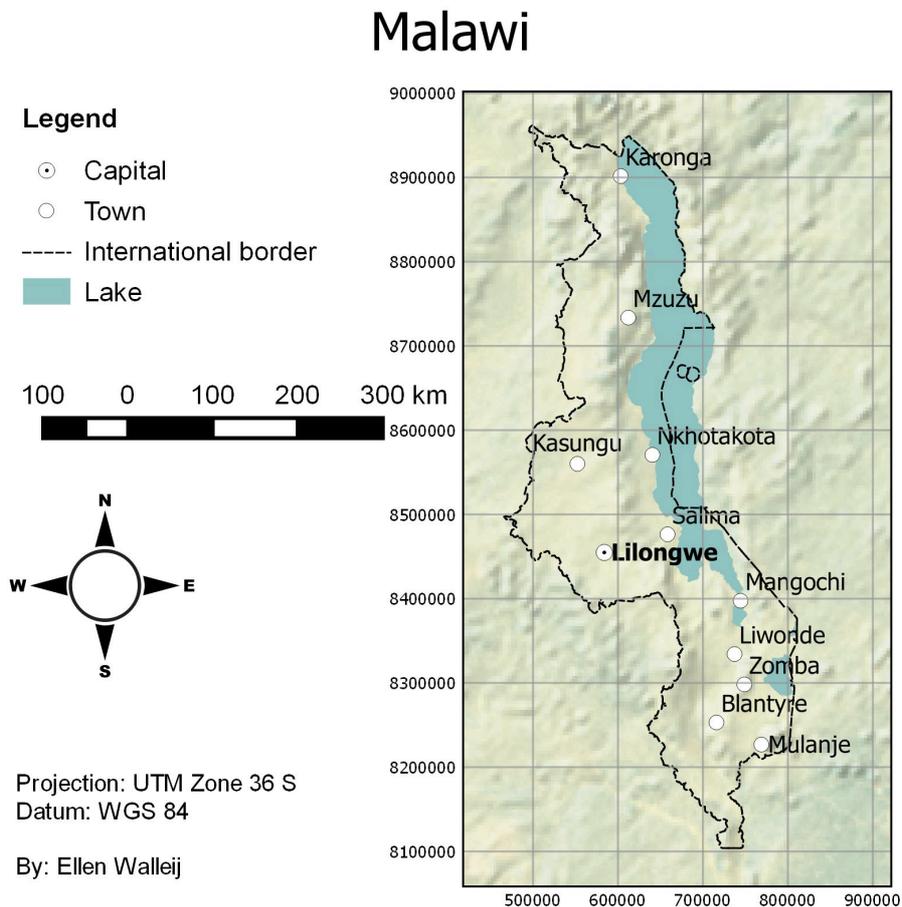


Figure 3.2. Map of Malawi showing major towns (MASDAP 2015).

Malawi is a landlocked country (MNLP 2002), situated in south eastern Africa with borders to Zambia, Mozambique and Tanzania. One significant feature of Malawi is the lake, which also is named after the country. Lake Malawi is the most southern of the great lakes of the East African Rift Valley and famous for the Malawi cichlids. The lake is also an important source of income for inhabitants along the shores, originally due to fishing but in recent years also due to increasing tourism (Malawi Tourism 2015).

### **3.2. Land Tenure**

The land tenure in Malawi is profoundly influenced by the colonial era. The colonial land policy aimed to appropriate all land to the British sovereign whereby the settlers received private access to the land and the native's rights were redefined as occupation rights. As a British protectorate Malawi obeyed English property law between 1902 and the independence in 1964 (MNLP 2002).

After independence, land was redefined as public, private or customary; however the laws were not entirely straightforward. Customary land, which is most land in rural Malawi, functioned as a kind of public land which made the rural citizens mere tenants on the land they farmed. Malawi has lacked a comprehensive legal framework for land ownership and therefore the Malawi National Land Policy was developed in 2002 with the purpose to clarify and formalize customary tenure. It was also needed to illuminate property rights and property transactions and to form a foundation for the development of a new land law (USAID 2015).

The lack of a comprehensive land policy has contributed, although indirectly, to poverty, food insecurity and injustices in access to cultivatable land. White farmers still hold some of the most fertile lands while smallholder farmers crowd less desirable lands.

The National Land Policy defines land into different categories:

*Government land* is privately owned by the government and can host functions such as government building, schools and hospitals.

*Public land* is held in trust by the government or traditional authorities such as national parks and historic and cultural sites. In the past there have been problems with the distinction between government land and public land. The concept of public land was then used to expropriate customary land with no compensation to the communities which is the source to many of Malawi's land problems.

*Customary land* is land within the authority of recognized traditional authorities. It is then granted to a person or a group under customary law: rules based on customs that are applicable to particular communities. Customary tenure is central to cultural identity in Malawi and the core of the traditional authorities. The tenure is not based

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on documentary evidence guaranteed by the government but only recognized as legitimate by the community.

*Private land* is all land that is owned exclusively, held or occupied under freehold tenure and customary land allocated to a clearly defined community, for example a corporation, institution, clan, family or individual (MNLP 2002).

## 4. NASFAM

### 4.1. Background

The National Smallholder Farmers' Association of Malawi, NASFAM, was founded in 1997 (NASFAM 2015c) and is the largest independent smallholder-owned membership organisation in Malawi (NASFAM 2015d). NASFAM originated from the USAID-funded Smallholder Agribusiness Development Project, SADP, founded to support smallholder agribusiness (NASFAM 2015c).

### 4.2. Organisation Structure

NASFAM members in rural areas form Clubs consisting of approximately 10 members. The Clubs are part of a Group Action Committee, GAC, which form the Associations. The NASFAM Associations are legally registered entities, managed by the farmers. Depending on their geographical location, the Association belongs to one of 14 Innovation Productive Centres, IPCs, which provide support to the Associations when it comes to marketing and community development (NASFAM 2015d).

#### Association Structure

#### Corporate structure

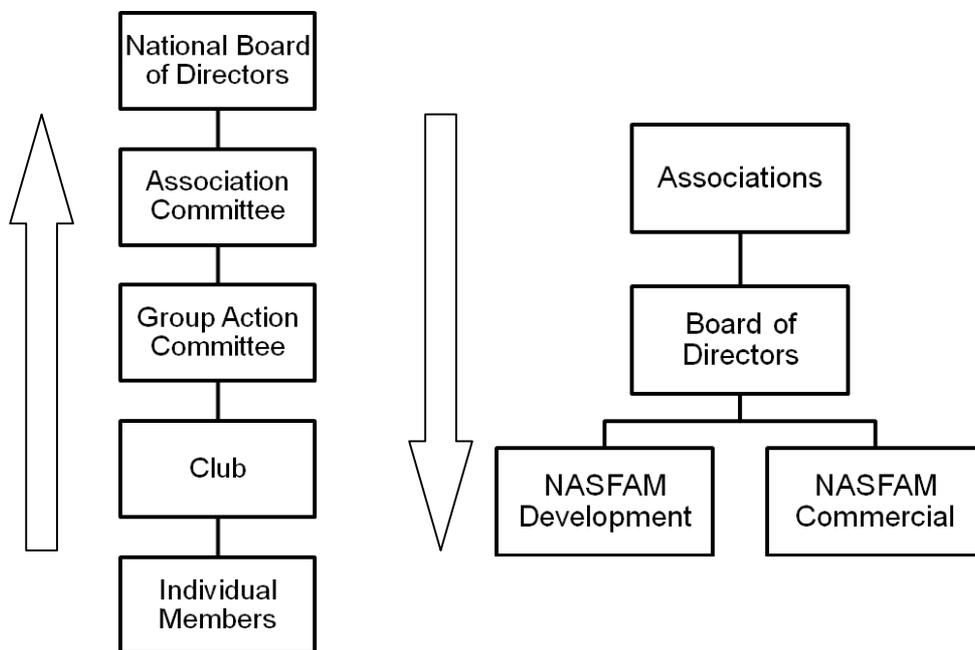


Figure 4.1. Organisational chart of NASFAM. The arrows describe the working process.

The NASFAM Head Office is located in Lilongwe and support the IPCs in specific projects and trainings. NASFAM owns two subsidiary companies, NASFAM Commercial and NASFAM Development, and both are governed by a Farmer Board representing the Associations. NASFAM Development is responsible for trainings and policies regarding the community development and also inputs such as seeds. NASFAM Commercial is responsible for marketing and buys the produced cash crops from farmers (NASFAM 2015d).

### **4.3. Operations**

Through farmer groups in rural areas, i.e. the Clubs, farmers meet to discuss farming methods, gender and HIV. The aim is also to change their approach to farming, from seeing it merely as a way to feed the family towards regarding it as a business (NASFAM 2015a).

Most smallholder farmers in Malawi mainly grow food crops, primarily maize, which make them easily affected the years when the yield is insufficient. To improve food security among the members, NASFAM encourages planting more cash crops as a complement to maize and also crop diversification, irrigation farming etcetera (NASFAM 2015b).

To improve the conditions for the smallholder farmers NASFAM also has a policy unit which speaks for the farmers in politics and research. The policy unit also work to create a market with fair prices for the farmers' cash crops (NASFAM 2015e).

### **4.4. Monitoring and Evaluation Unit**

The main purpose of the Monitoring and Evaluation Unit, M&E, is to collect membership data and present it upon request from other departments. To collect information about members in every club the M&E Unit uses the MySQL-based NASFAM Tracking System, NTS. Every club annually fills a sheet of paper, called the NTS-form, and the Data Entry Officer in the concerned districts enters the information to the database. However, every district has its own database and if information is needed at the head office the M&E Unit has to call and request that particular information from the districts. Due to regular electricity blackouts it is common that the M&E must wait several days for the requested information.

One main issue for the M&E Unit is to receive the correct information. Problems with illiteracy and understanding of the NTS-forms among members result in them sharing the wrong information.

## **5. Methodology**

### **5.1. Background**

Together with the Monitoring and Evaluation Coordinator and the Data Management Officer, a work plan was developed for the pilot study of introducing GIS at NASFAM (Appendix 1). The project is referred to as a pilot study since it takes place in a limited area and during a limited time.

The initial idea was to implement the project in two Innovation Productive Centres, IPCs, South Mzimba and Zikometso. After discussions with the Data Management Officer it was agreed that it was better to focus on a smaller area to make sure that the work could be finished during the given time frame of approximately 4 months. It was therefore decided only to focus on Mulanje Association in the IPC Zikometso since the Data Entry Officer there already had entered information from many of the farmers into the membership database, NTS, which was not the case in South Mzimba. Information about the farmers needed to be entered into the NTS so that the accurate personal details about them were accessible and also to make sure that they had paid the membership fee for the following year. On 18th November 2014 the Association had 252 members registered in the database which seemed manageable for this project. The 252 members belonged to three Group Action Committees, GACs: Nansongole, Nkhonya and Nansomba.

The time frame and exterior conditions such as road availability resulted in a methodology as shown below in figure 5.1. The meaning of each section is described in the following paragraphs.

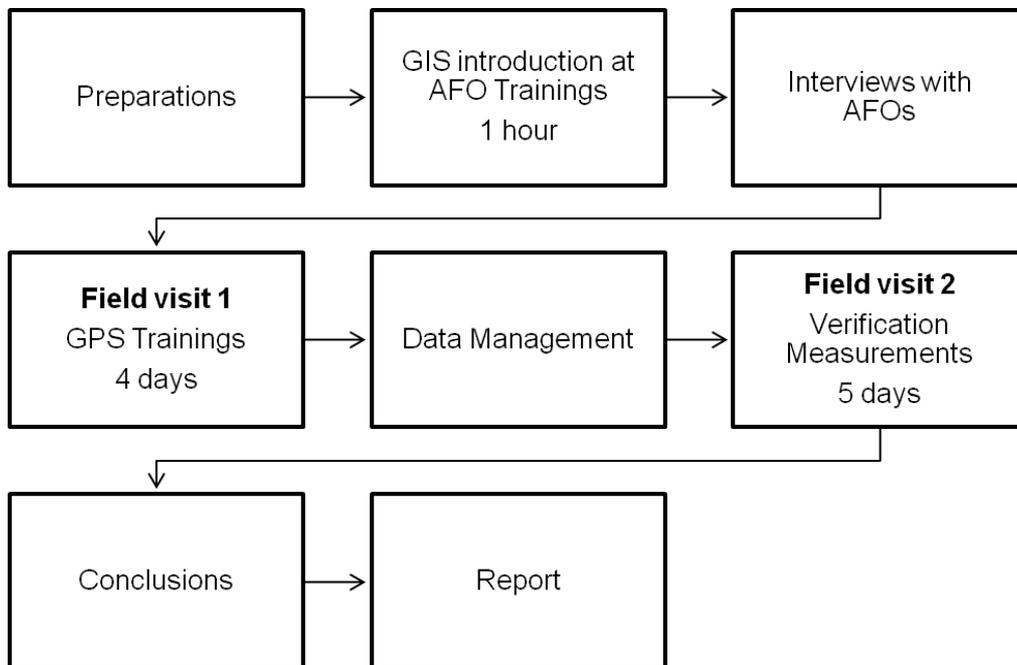


Figure 5.1. Flowchart of the GIS pilot phase. For further details see following paragraphs.

## 5.2. Introductions to GIS for Field Staff

To raise awareness among NASFAM field staff about the GIS project and to introduce the terminology, presentations were held during trainings for Association Field Officers, AFOs. The AFO trainings are held one week in every quarter of a year and consist of trainings in a variety of subjects. There are three different occasions of trainings at three different locations every quarter and the AFOs attend the training located closest to the region they represent. During these trainings, the GIS project was given one hour per group. The purpose of the presentation was to show the possibilities with GIS and how it can be useful to the M&E unit and to the AFOs in their work but also to prepare and inform them of activities that might take place in the future.

In the presentations, the concept of GIS was limited to vector-GIS as it is the most useful in NASFAM monitoring since the main interests are areas and distances.

All presentations introduced the terminology of GIS and GPS and included examples of what GIS can do, for example visualizing where the members live and calculating the area of their fields. The presentations were held at three different occasions and with three different audiences and at every occasion the content changed slightly.

At the first presentation, a Power Point presentation had been prepared to show important headlines and to illustrate the theory behind GPS measurements. It was a

technical presentation which explained how the data is collected using GPS satellites and how different layers are stored in geographical databases. It also included information about geodetic datum and map projections such as WGS 84 and UTM. The inclusion of a rather technical background was a request from the Data Management Officer.

The second presentation was also based on a Power Point and focused more on the difference between GIS and GPS and how the tools are used together and only briefly mentioned WGS 84 and UTM as expressions the AFOs would encounter when they were collecting data using the GPS.

The last presentation emphasized almost entirely on how GIS could be used in their work, and only contained brief definitions of GIS and GPS. A paper road map of Malawi was used to show that the map is fixed and static; it cannot be changed after it has been printed, and that they cannot receive more information from the map than what is already shown. This was used as a contrast to GIS, which can be updated at any time and which can also store more information than what is shown to the eye. To visualize this, a basic GIS map of Mulanje had been prepared in QGIS, showing land usage and roads, and could illustrate how layers are stored on top of each other and how information can be stored in attribute tables.

At the first presentation, the AFOs were also given the opportunity to try the GPS after brief instructions. They were encouraged to walk the border of an imaginary field and then use the Garmin Tracking function to calculate the area. The GPS receivers were not available during the second and third training opportunity.

### **5.3. Interviews with Field Staff**

In order to investigate the opinions and thoughts among field staff, 10 interviews were conducted with the AFOs. The interviews took place at different times and locations with AFOs representing different parts of Malawi and different NASFAM districts but all interviews were held before the first field visit. The open-ended questions asked were:

- Which difficulties/challenges do you experience in your work today?
- How could these difficulties/challenges be prevented?
- Do you think that mapping the farmers could help you in your work? How?
- What do you think of the implementation of the GIS/mapping project? How should it be done? Do you have any concerns?

### **5.4. Collecting GPS Points**

#### **5.4.1. Background**

To carry through the field work in Mulanje Association, and eventually possibly for all of NASFAMs 150,000 members, it is not possible for a few people to reach all farmers themselves, and because collecting the data is very time consuming, it was

decided to take assistance from the Farmer Trainers in the district since they know how to find the members and their fields. Evaluation of this method will also allow guidance if the work is to be continued in the rest of the country. For the field visit, 11 GPS-receivers of the model Garmin GPS 60 were available. The GPS-receivers used the technique of absolute measurements to collect the data.

#### **5.4.2. Preparations**

Four days were spent in the town of Mulanje to conduct the GPS trainings. The first day consisted of meetings with the Association Business Manager, ABM, and the AFO to agree on guidelines for the upcoming training. As planned, it was decided to focus only on one Association in Zikometso IPC, Mulanje.

It was decided that all 22 Farmer Trainers in Mulanje Association should participate in the training so that they could continue the project in their respective area once the data had been entered in the NTS. Many of the Farmer Trainers had to travel long distances by bike so they were given one day notice for the first day of training.

The GPS receivers were prepared for the training by making sure they were emptied of all previously stored data and by changing the settings to be uniformed for all devices. The reference system was set to WGS 84 and the coordinate system was set to decimal degrees. This was to allow transformations in QGIS instead of in the GPS receiver to avoid possible miscalculations and errors in accuracy.

#### **5.4.3. Trainings**

The trainings began with introduction of the mapping project and the purpose of this training. Since the Farmer Trainers had very limited skills in English every part of the trainings were held in the local tongue, Chichewa. After the introductions the Data Management Officer explained how to capture a point and store it with a given name. The Data Management Officer also emphasizes the importance of the accuracy to be 5 metres or less before they capture the point. The Farmer Trainers were encouraged to divide themselves into pairs and practice in the yard.

Soon after the initial exercise, the trainings moved from the office yard to the nearest Club. The Data Management Officer, the AFO and the author split up to accompany three different groups in the measuring of actual fields. Field by field the Farmer Trainers were instructed which points to capture and how to store the points with the given registration number. After the first day of training the collected points were transferred to a computer to see if the intention of the points could be interpreted in order to decide the best way to continue the training the following two days.

During the training the following day, strips of paper were handed to the Farmer Trainers with the names and registration number of which member's farms to be measured so that they could collect the data more independently. Again, the importance of storing the points with the correct reference number was emphasized.



*Figure 5.2. Amos Dulani from the village Zuzuma in Mulanje captures a point.*

#### **5.4.4. Importing the Points**

The Association Business Manager was taught how to transfer the collected data from the GPS receivers, how to store them in GPS Exchange Format and send them to the head office in Lilongwe by e-mail.

#### **5.4.5. Accuracy**

The requested accuracy was determined to be 5 meters in standard deviation for each collected point which was reasonable due to the quality of the GPS receivers available. The accuracy was shown in the display of the used GPS devices and to simplify the trainings it was determined to trust this information.

The initial idea, suggested by the Data Management Officer, was to use the Garmin Tracking function to calculate the area of the field. After several tests with the tracker it was discovered that the calculated field area did not have the accurateness needed. The tracker did not follow the exact path of the user but made rough generalizations. The generalizations were discovered by comparing the track to points collected on the same area. Even though it is not always certain that the points are more accurate than the tracks, the accurateness is always known when collecting the points while for the tracker it is always unknown, using these devices.

Therefore, the data collection was done by taking point registrations at the field breaking points and one point registration in the centre of the field. The field mid-point should be stored by using a unique reference number for each farmer while the

other points were numbers in an increasing order. A point should also be collected at the farmer's house.

## 5.5. Data Management

### 5.5.1 General

The data in GPS Exchange Format (.gpx) was imported to QGIS at the head office. By using the ID of the collected points, new layers for the field border (line) and field (polygon) were created to visualize the data. New layers for house location (point) and field midpoint (point) were also added to the map. Every added object was given the attributes first name, last name, registration number, club name, GAC and gender according to the NASFAM Tracking System. See table 1.

FNAME	LNAME	REGNO	CLUBNAME	GAC	GENDER
Mary	Sitolo	057-06	Vision	Nkhonya	1
Beatrice	Watson	057-09	Vision	Nkhonya	1
Edina	Choo	060-11	Talandira	Nkhonya	1
Memberson	Njaidi	059-09	Kachere	Nkhonya	0
Lignet	Bwanali	059-06	Kachere	Nkhonya	1

*Table 5.1. Extract from attribute table of the file field.shp.*

### 5.5.2. Software

The initial plan was to use ArcGIS for the GIS analysis. The reason for this was that the people involved had previous experiences of this software. However, since it was complications with accessing ArcGIS hence also installing it on the computers other possibilities were investigated and QGIS proved to be a reasonable substitute. QGIS is freely available open source GIS software (QGIS 2015).

## 5.6. Verification

To ensure that the collected data were accurate and trustworthy verification of some of the collected points was needed. Verification was also necessary to be able to evaluate the conducted trainings and how NASFAM could continue their work with GIS as a tool for monitoring. The possible errors that were suspected were that fields located next to each other could be overlapping or that it would be difficult to interpret the collected points.

As a preparation for the second field visit a list of fields in need of verification was created. These were chosen due to characteristics like very irregular shapes, overlapping, difficulties to interpret names, that the field midpoint was located outside the field borders or because the tracks from the GPS receiver were not accordant to the collected points.

With assistance from one Farmer Trainer the members in the list could be found and their fields measured once more.

### **5.7. Presentations**

A presentation for staff at the head office was held explaining the purpose, work and results of this project. They were given recommendations on how to continue after the pilot study.



## **6. Results**

### **6.1. Introductions of GIS to Field Staff**

Approximately 30 Association Field Officers, AFOs, participated at each training opportunity. Due to power outages, the Power Point presentation could not be used during the first presentation so a flip chart was used instead to illustrate important parts. The listeners seemed distant and only asked a few questions which were all demands of repetitions on things already explained. The GPS exercise held after the first presentation was appreciated as a way of understanding which type of work could be expected though time limitations during the exercise made any real understanding difficult.

The second presentation was held at the head office which ensured electricity availability due to generators. The questions after this presentation were also demands of repetition and further explanations, mostly regarding the technical parts.

The last presentation, which explained the theory behind GIS briefly and mainly focused on the use the AFOs can have of it, seemed most successful considering the general opinion afterwards and also considering the type of questions asked by the listeners. The questions after the last presentation concerned, unlike the first two, issues on how this project could be done practically.

### **6.2. Collecting the GPS Points**

The education level of the Farmer Trainers varies. Although all are smallholder farmers, some have had previous work experiences, for example as teachers, while others only have a few years of education. To be a Farmer Trainer, however, the farmer must be able to read and write. Only a few of the 22 Farmer Trainers were able to work independently after three days of GPS training.

During the GPS trainings it was discovered to be better to name all points with the reference number instead of just the mid-point and the house. The reason for this was that the author experienced confusion among the participants about the point capture procedure. The level of understanding was easier if they could capture all points according to the same pattern. The points should be stored with the farmer's reference number followed by an abbreviation of the point type and a number. For example 059-02F1C3 means the third corner (C3) of the first field (F1) of the farmer Lexa Kachemwe (059-02).

### **6.3. Data Management**

When all collected data had been entered it showed that some fields were overlapping more than the accepted 5 meters. Points belonging to some of the fields were also not harmonizing with the tracks from the same GPS receiver. In other fields there were uncertainty concerning the ownership since some of the collected points were named differently from the others.

197 of the 252 targeted members had their fields measured during the period of the pilot phase. According to the Farmer Trainer A. Dulani, 13 of the 55 missing farmers refused to have their fields measured since they had not received seed loans from the Association because of not repaying the loan from the previous year.

Some of the GPS Exchange Format files had a layer showing the tracks of the GPS receiver although this was not planned for during the preparations. Even though the tracks were of no substantial use for mapping the fields, the tracks could help interpreting the points in files in which the names were insufficient. However, in some files the tracker layer differed from the collected points which led to confusion about the data interpretation.

### **6.4. Verification**

Because of severe flooding in the area the week before the verification some fields could not be measured as planned.

The verification showed that for some fields, the number of points collected was not enough, and that measurements were missing at breaking points of the field border. Points were always collected in the major corners but not always at less significant change of directions. Since even a minor change of the field border direction can affect the field size significantly it is important that points are collected also at these places. The tracks from the GPS receiver suggested for which fields this was a possible problem and the verification often proved it to be true. See figure 4.

## Tracks and accuracy

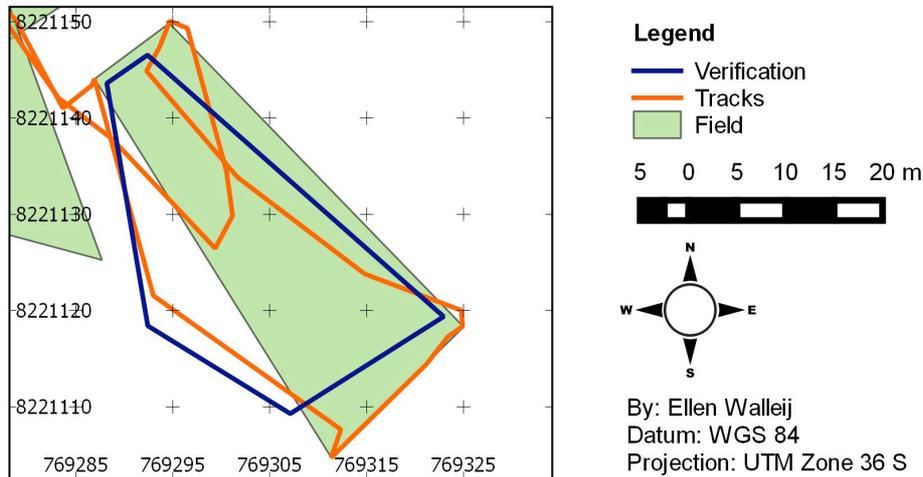


Figure 6.1. The green polygon, Field, shows the field shape according to the originally measured points, collected by the Farmer Trainers. The orange line, Tracks, shows the tracks collected at the same time and by the same GPS receiver. The blue line, Verification, shows the field shape according to the verification measurements.

### 6.5. Interviews with Field Staff

Almost all of the AFOs experience challenges in their work today with insufficient resources, particularly lack of fuel for their motorbikes. According to some of the interviewees this means they cannot reach all farmers as often as they see appropriate.

One general concern about the GIS project that appears in half of the interviews is if the AFOs will have sufficient training before implementation and if they will receive the necessary support if they encounter problems.

A majority of the AFOs (7/10) believe that mapping the farmers can be of use in their work. Some explain that maps will allow them to locate the farmers on their own without relying on the Farmer Trainers to give them directions. One of the AFOs says that this way they can receive the correct information directly from the source and not second hand information as of today. Others say that mapping will help the farmers to know the sizes of their fields. If they know the size they can calculate how much yield to expect and how much equipment and seed they need.

One of the AFOs does not believe that mapping the farmers' fields can be of any help for them. This AFO believes that the farmers will not see the point of it and that it will not be of any advantage to them. Another AFO explains how difficult it is to

reach the farmers since they are very scattered and is of the opinion that it is easier to ask for directions than to use a map.

Some also raised a question if they will be able to use the system and maps themselves after the data has been collected or if it will only be people from head office who can use it. One of the AFOs points out that not all offices have computers and therefore will not be able to use the system.

One worry that was raised is that the project will fail before it is accomplished due to lack of funding. One of the AFOs explains that NASFAM has a good structure but not enough resources. Another considers that NASFAM has too many projects, both local and nation-wide, that are competing with each other.

For a full review of the interviews, see Appendix 2.

## **6.6. Presentation**

Approximately 30 people from NASFAM head office attended the presentation, including the Chief Executive Officer and the Development Director. The presentation was opened by explaining the purpose of the project and basic GIS technology.

The approached methodology was explained by showing pictures from field visits and examples from the data management. The problems and challenges encountered, such as communication, collaboration with the district offices and the detected faults from the verification measurements were also raised.

The presentation was completed by sharing recommendations on how to continue the work with GIS as a tool for monitoring and evaluation and an exhortation to discuss this thoroughly and thereafter aim for reachable goals.

During the presentation the listeners were active and often paused the presentation by asking questions, adding general information or discussing ideas with each other.

## **7. Discussion**

### **7.1. Sources of Error**

Malawi is a hierarchic country and it is possible that the interviewed field staffs were not completely honest when it comes to which problems they see in their work because of unease about superiors' opinions.

The collected data could be inaccurate due to the fact that the collectors did not fully master the technique or that the hand-held GPS receivers were of insufficient accuracy.

Generalizations of conclusions after this project can be wrong due to differences between districts, people and time but should not be so wrong that it would affect the conclusions.

### **7.2. Challenges**

During the GPS trainings with the Farmer Trainers, language was a substantial challenge. Since most of the Farmer Trainers could not communicate in English the trainings took more time than expected as the collection of every point had to be explained by showing them how to do it, one by one, several times per person. Even with the assistance of an interpreter the important message could be difficult to address.

Most Farmer Trainers had little or no experience of mobile phones or similar equipment which makes the understanding of the GPS receiver much more complicated. Since they had no experience with computers either it was also difficult to awake a general understanding of the purpose of the collected points. During the verification it was discovered that often not enough points around the fields had been collected which resulted in incorrect field shapes and areas.

Batteries were not distributed from the district office to the Farmer Trainers as requested which made it impossible for them to fulfil their task.

External conditions, such as regular black outs and severe flooding have affected the project by delaying assignments or preventing availability.

### **7.3. Measurements**

Measuring the fields in the way that was done in the pilot phase is extremely time-consuming. To expand this work to the rest of the 150 000 NASFAM members would be an enormous project hence very expensive. The measured fields often had faults such as scarcity of corners. This may be explained by the in general low level of

education among the farmer trainers. If fewer but more educated people were targeted for the measurements they could be performed in a more effective way. Alternatively, instead of measuring every field every year (due to change of field borders in the villages) the Association Field Officers, AFOs, could be taught how to use the GPS receivers and thereafter measure the fields whenever they are needed for development work. However, this way a geographical database would never be completely updated and available for further analyses.

For all future measurements it is essential to give emphasis to the importance of collecting enough points around the fields. This might be experienced easier if the means of collecting points is quicker, for example by using a simplified way of storing them. This cannot, however, be allowed to affect the understanding of the data management afterwards.

### **7.4. Mapping**

It was suggested by the Data Management Officer that maps for printing should be produced and distributed to the concerned offices. However, after processing the data in QGIS it was discovered that the fields were too small compared to the area covered by every Group Action Committee to be of any use even with a paper size of A0. Possibly, maps could be printed in smaller sizes for every farmer and made into a booklet but that would mean that more than 150 000 pages would be printed every year. Therefore, maps for printing do not seem like a feasible alternative.

Collected field data could be combined with for example soil maps as a way of determining which crop is suitable to plant in which area (Appendix 3). The same data together with yield information could also be used to evaluate results in different areas with soil or other conditions as possible explanations.

Even with physical maps available it is not certain that Farmer Trainers and AFOs know how to read and use them since maps in general are not available to the public in Malawi.

### **7.5. Data Management**

The NASFAM Tracking System, NTS, is a MySQL based software and could possibly be linked to QGIS. This way all information about each farmer could be stored in the NTS while the shape and size is stored in QGIS. This combination may in the future make the system more users friendly if no GIS knowledge is necessary to access information about field size directly in the NTS. This might allow the Data Entry Officers to access the information themselves.

Even if the GIS and NTS is not linked it could be time efficient to only store the geographical data with the farmers registration number, and not all information shown in table 1, to avoid the work of entering all the additional information already available in the NTS. On the other hand this method would not allow an analysis of

for example field sizes and gender unless other ways of importing the additional information are found.

## **7.6. Interviews**

In the interviews with the AFOs many of them raised the issue of insufficient funds for fuel. With the necessary information in the GIS database, for example Club meeting points and roads in the area, a network analysis could be done to determine the distances they travel and thus how much fuel they would need. This way the AFOs would always have enough fuel to accomplish their task and the head office would know that the fuel is used for work related journeys only.

## **7.7. Continuation**

To map all of NASFAMs members is time-consuming, especially since some farmers change their fields from year to year. If that is the case, NASFAM needs to find out which farmers have new fields so that measurements can be made again. If the system is not updated, it quickly loses its reliability and if all NASFAM units should be encouraged to use it, it must be reliable. If NASFAM is to have effective use of GIS it requires that all units are aware of the existence of the database, what kind of data it consists of and an initial idea about what it can do. That way all units could make use of it to assist them in their specific tasks.

It requires consideration to determine how best to collect the required points. Since so many of the Farmer Trainers that were trained in Mulanje had great difficulties with the GPS receivers it is questionable if the work is best assigned to them or if it should be done by someone else. Since experiences of mobile phones or computers makes it considerably easier to collect the points it might be good to teach people with a higher level of education. The work will probably be carried through better if fewer people in every district are involved so that the training can be more focused. It is very important that the AFOs know how to use the GPS so that they can assist and adjust common encountered problems without help from the head office. During trainings with the GPS it is necessary to emphasize the importance of collecting many points, every time the field border changes its direction and not just in four corners. Otherwise the size will be wrong. The tracker-function can be activated as guidance to the mapping but should not be trusted as actual borders.

If lack of funding is an issue it might be advisable to teach the AFOs in how to collect points and let them collect points from fields belonging to a certain farmer or Club whenever it is needed for a specific purpose. This method saves time and will not have to be redone every year. Instead points could only be collected at the farmers' houses or at Club meeting points to easily locate them.

Since connection through the 3G network is becoming more and more common through Malawi it might be possible to connect mobile phones to an updated GIS database and access the information wireless. That way they would have further more

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use of the system. The AFOs could find the members houses on their own by merely using their phones.

## 8. Conclusions

The GPS Trainings would have been more successful if the participants had a higher level of education and thereby a greater basic knowledge of computers and data management. The interviews with field staff announced issues with the current conditions such as lack of resources and training. If a new project is to be introduced it is necessary to have qualified staff and a reasonable budget from start.

GIS is a tool which can be adapted depending on the needs and the resources. Even though the vision might be to know exactly how big every farmer's fields are it could be better to start with objectives easier to reach, for example houses or meeting points. Supplementing data could therefore be collected when it is needed.

It is important that all concerned units of the organisation discuss if it is an interesting way to develop the work of a smallholder farmers' organisation and also how all units believe they can have use of the system so that the right data is collected. It is also important that someone is responsible for GIS and that the work is viewed as a long-term and continuous part of the monitoring and evaluation work.

To root this project in the organisation as well as the society it is crucial to emphasize the benefit it will have for both staff and members. Without a general understanding of the purpose and possibilities with geographical information, the system will not be used and updated and thus impracticable.

The underlying issue is the lack of comprehensive land law in Malawi with clearly defined land tenure. Mapping NASFAM farmers in a greater extent does not seem reasonable in a long-term perspective due to the required time and resources. For permanent results a governmentally lead land management reform, similar to what has been conducted in Botswana, is necessary as a way to secure farmers' right to the land they farm. This would gain not only farmers' organisations such as NASFAM but the whole Malawian economy. Until that day, agricultural organisations are doing what they can to assist their members but it is an uphill struggle. It is admirable to observe their power of initiative and ambitious vision.



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## Appendix 1. NASFAM Work Plan

### GIS at NASFAM - Pilot Phase

Period: October 28, 2014 – March 6, 2015

#### Objectives

- Actual location of farmer's dwelling house.
- Actual size of the farmer's fields.
- Type of soil in the area

#### Methodology

Zikometso IPC will be piloted. The Association Field Officers and Farmer Trainers will be trained with the GPS during field visits in collecting the coordinates of fields and houses. The collected data will be mapped using ArcGIS/QGIS.

**Resources:** Funds, Vehicle, Man power, Laptop for keeping the data.

**Tools:** GPS Receivers, ArcGIS/QGIS software, Shapefiles (Map of Malawi, Extension Planning Areas (EPA), Traditional Authorities (TAs), Soil type).

**Target:** Paid up members as at 30<sup>th</sup> October 2014 in Zikometso IPC.

Taking in consideration the great number of members we have decided to do the pilot in the Association Mulanje (1000 members).

IPC	Association	AFO	FT	Members	Members
Zikometso	Mulanje	1	25	1000	2700
	Phalombe	1	40	1000	
	Thyolo	1	20	700	

#### Work plan specification

Code	Result	Data type	Time period
A	GPS coordinates from Mulanje	Field breaking-points, field mid-points, house point	November/December
B	Maps in ArcGIS/QGIS	Shape files with the attributes; field size, name	January/February

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		of farmer, club membership, etc	
C	Linking GIS data to NTS	Membership data	February
D	End of internship report	Report	February/March

**A: GPS Exercise**

Responsible: Ellen and Ken

Participants: Association Field Officers and Farmer Trainers

- Collecting points from a made up field with an irregular shape.
- Collecting field mid-point and saving it with a name.
- Collecting point of house location
- Importing data from Garmin GPS to MapSource and save it as .gpx-file.  
(Before saving: make sure the settings are **WGS 84** reference system and **UTM**-projection).

**B: Mapping in ArcGIS/QGIS**

Responsible: Ellen (while Ken is learning the process)

- Import GPS data to ArcGIS/QGIS
- Create polygon layers of fields
- Import appropriate background data (vegetation, water, altitude etc.)
- Create maps for demonstration use

**C: Linking GIS data to NTS**

Responsible: Ellen and Ken

- Investigating if there is a way of connecting the GIS data to the existing NTS data.
- Linking/validating the membership data from the NTS and ArcGIS/QGIS.

**D: Report**

Responsible: Ellen

- Writing a report of the pilot phase.

## **Appendix 2. Interviews**

### **Interviews with Association Field Officers**

#### **Questions**

Full name

Date and location

Year of birth

Sex

Background

1. Which difficulties/challenges do you experience in your work today?
2. How could these difficulties/challenges be prevented?
3. Do you think that mapping the farmers could help you in your work? How?
4. What do you think of the implementation of the GIS/mapping project? How should it be done? Do you have any concerns?

#### **Elia Msasa (1)**

Lilongwe, 2014-10-30

Born 1986, male

Background: Diploma in Agriculture, AFO in Ntchisi

1. Not enough training, not enough information
2. More training of AFOs. Clear guidelines.
3. Yes. Identifying places for farmers will be good for visitors and also for AFOs so that we can find them ourselves without relying on Lead Farmers.
4. Will we get enough training? Will we have enough time/be given extra compensation?

#### **Joanne Chigwede (2)**

Liwonde 2014-10-31

Born 1993, female

Background: Diploma in Natural Resources, AFO in Machinga

1. Adoption rates for the farmers. They don't do what you train them to do.
2. Have a model farmer that does everything as you're supposed to do that the other farmers can learn from.

3. Yes.
4. We would need help and support. The AFO can be responsible but will need practical help with the technicalities and also help with communication.

### **Patrick Chapitapita (3)**

Liwonde 2014-10-31

Born 1989, male

Background: Diploma in Irrigation Agriculture, AFO in Liwonde

1. Limited resources: fuel, Can't attend all the beneficiaries.
2. More resources.
3. Yes. Investing in the farmers motivates them. They get motivated whenever you visit them or show interest for them and their work.
4. No.

### **Charles Zawanda (4)**

Kasungu 2014-11-04

Born 1978, male

Background: Agriculture Certificate, AFO in Kasungu

1. Insufficient resources. The motorbikes are old and do not always work which leads to that I can't reach all the farmers.  
Complications with other organisations. People come and go from different organisations so we have to train new members all the time.  
Climate change, it is not raining as expected so the yields are smaller and we are blocked as a business.  
HIV/AIDS is affecting the work. A lot of members are dying so they can't deliver as expected. This also means that we have to train the same topics instead of moving forward.
2. We should collaborate with other stakeholders and grow more sustainable crops.  
When it comes to HIV/AIDS we should focus more on information to the whole association. We should also provide better food for the sick.  
NASFAM should be more strategic, focus on fewer subjects. They should find out what the farmers want.
3. Mapping the farmers would mean that all can find the farmers. This way we could get the correct information from the source instead of having bridge information like today.

4. Will we be provided with the necessary gadgets at the office so that we can find the farmers when we need too? If we're using this technology we should also collaborate with other stakeholders so that we together have a functioning system.

### **Owen Mapeto (5)**

Rumphi, 2014-11-07

Born 1987, male

Background: Certificate of Agriculture, AFO in Rumphi

1. There are long distances within the association, it covers 3 EPAs and the motorbike is not in a good condition, it breaks down occasionally
2. Support from head office to buy a new motorbike.
3. Yes, because the farmers don't know the size of their land. If we knew the size we could know how much equipment and seed they need.
4. We must have the possibility to practice with the GPS so that we know how to collect the data. Someone must help and train us so they we know how it's done.

### **Patterson Botha (6)**

Rumphi, 2014-11-07

Born 1958, male

Background: Certificate in Agriculture, Ministry of Agriculture, AFO in Kasitu (Rumphi)

1. It is too much work, too much programmes implemented at the same time. We have to meet many farmers the same day but sometimes they don't turn up so other people are kept waiting.
2. We have to change the mindset of farmers, dissemination of information to the farmers. Increase number of staff, we need more AFOs. The Association is very big, much larger than other associations in the country.
3. No, it will not be advantage to farmers – why bring it to farmers? They will not see the point of it.
4. We must be sure to have enough education to AFOs. The training should be 4-5 days and it should only focus on GPS training.

### **Patience Hara (7)**

Karonga 2014-11-10

Born 1987-06-16, female

Background: NASFAM since 2007, Diploma in agriculture (natural resources management). AFO in Karonga.

1. The goals are too high; the farmers we're supposed to reach are too many which affects the quality of our work. There's also a waste of programmes; several programmes, both local and from head office, that are competing with each other. Nasfam as an organisation has too many departments. Many orders from higher levels reach the AFOs and it's confusing.
2. Timing of the programmes, there should be one training of AFOs per quarter so that we won't be disturbed during the other months. There should be a more open discussion and agreement of an appropriate target, not more than 1000 members per AFO.
3. Yes, crop estimates. Then we know how much land the farmers have and what the right information is – how much seed they really need.
4. We need real training, several days and then assistance during the work. Farmer trainers should be able to collect the GPS points.

### **Alfonso Chindungwa (8)**

Mponela 2014-11-12

Born: 1988, male

Background: MSc in Irrigation Technology, AFO in Ntchisi. Part of the Fumento project.

1. The salary is not as high as expected. Not possible to pay school fees. Its far between the farmers and the bike we use today is not enough. We need motorbikes to reach the farmers.
2. We have to raise the issue to the donors; it doesn't work just to talk to our own bosses.
3. I don't know.
4. We don't know how to use the facilities in the GPS, we have not learned how to use the system ourselves, only how to collect the points and the size of the fields. NASFAM has a good structure but not enough resources. I'm worried that the project won't be accomplished in the whole country. We also don't know what the mile stone is.

### **Cedric January (9)**

Mponela, 2014-11-12

Born: 1988, male

Background: Diploma in Agriculture, AFO in Ntchisi. Part of the Fumento project

1. Transport is a big problem, I need a motorbike.
2. We are often overlooked; the planning process is not good enough. With good planning they (the bosses) would know the distances to the farmers and realize that bikes are not enough.
3. It's not easy to get to the farmers anyway. The farmers are so scattered. Better to ask someone than use a map.
4. NASFAM may not have enough resources to implement the project. I'm afraid that it will fail. Not all offices have computers so they won't be able to use the maps themselves.

### **Wilfred Munta (10)**

Mulanje, 2014-11-18

Born: 1984, male

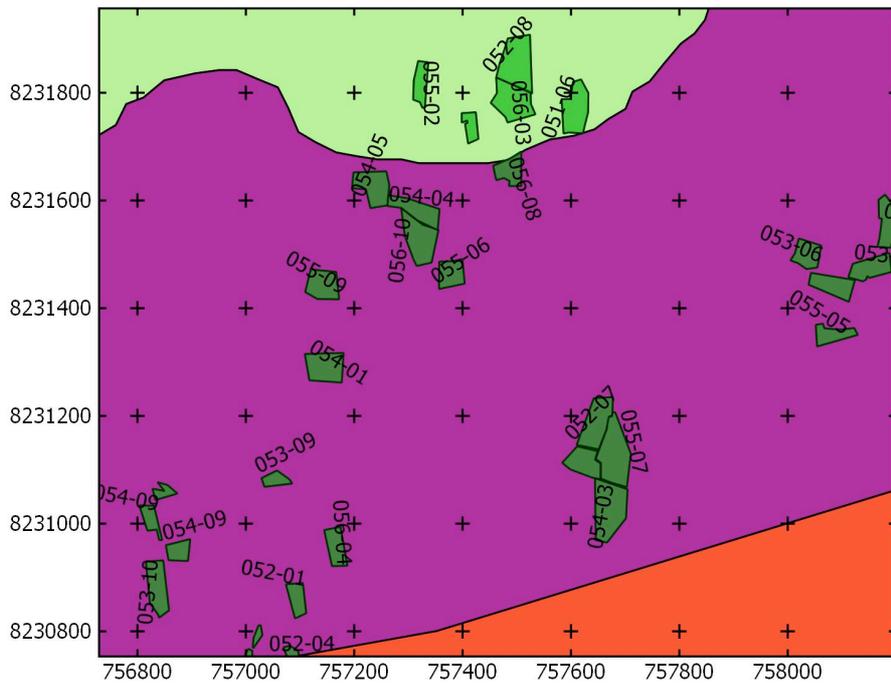
Background: Natural resources scholar - Diploma in agriculture

1. There are very limited resources and because of that we fail to meet the expectations. Because of the lack of fuel I can't reach all farmers on my own. I also have to travel far without possibility to eat lunch.
2. We can be better at using available resources due to good planning. However, most problems can't be solved without more resources. I try to involve the Lead Farmers (Farmer2Farmers) and depend on them to help with minor assignments to minimize the problems.
3. The focus of NASFAM should be to develop farming as a business. To make profit we need to know the size of the fields so that we know how much yield we can expect and also for crop estimating and gross marginal analysis.
4. No problem, mapping will assist the farmers in their work. It's important that the training exercises are both practical and theoretic. Each and every Lead Farmer (Farmer2Farmers) should get personal training. If we hear something, we forget, if we see we remember, if we do we understand.

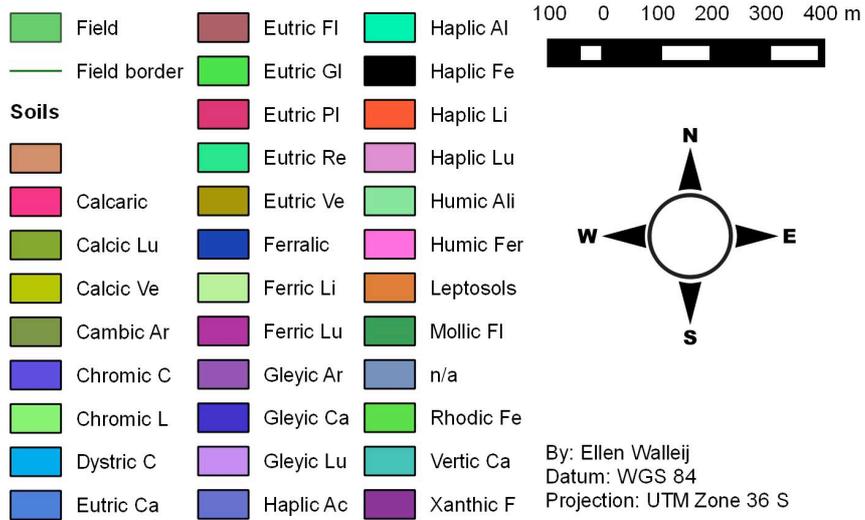


## Appendix 3. Example of Soil Map

### Mulanje Soils



#### Legend





**Institutionen av naturgeografi och ekosystemvetenskap, Lunds  
Universitet.**

Student examensarbete (Seminarieuppsatser) i geografisk informationsteknik. Uppsatserna finns tillgängliga på institutionens geobibliotek, Sölvegatan 12, 223 62 LUND. Serien startade 2010. Hela listan och själva uppsatserna är även tillgängliga på LUP student papers och via Geobiblioteket ([www.geobib.lu.se](http://www.geobib.lu.se))

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- En pilotstudie i Kristianstad kommun
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- 11 *Alexander Quist* (2013) Undersökning och utveckling av ett mobilt GIS-system för kommunal verksamhet
- 12 *Nariman Emamian* (2014) Visning av geotekniska provborringar i en

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