USING SMALLHOLDER FARM AND HOUSEHOLD DATA FOR FERTILISER ADVISORY SERVICES

BIOMASS RESEARCH REPORT 1605

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Biomass Research
P.O. Box 247
6700 AE Wageningen

T: +31 (0) 6 520 58 537
info@biomassresearch.eu
www.biomassresearch.eu

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Bibliographical data:

J.W.A. Langeveld
P.M.F. Quist-Wessel

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Publications available from www.biomassresearch.eu

Further information on this study can be obtained from Hans Langeveld

Biomass Research
P.O. Box 247
6700 AE Wageningen

T: +31 (0) 6 520 58 537
info@biomassresearch.eu
www.biomassresearch.eu

PREFACE

Global population will reach 9 billion by 2050, increasing the demand for food by an estimated 70%. Arable land availability is expected to increase by 15%. As sufficient water is not easily accessible and the weather increasingly is becoming less predictable, a more effective and efficient food production is essential to ensure future food availability. Providing the right information at the right time to food producers like farmers, pastoralists and fishermen can help to improve and increase food production in a sustainable manner, thus ensuring food security on a global scale.

The combination of improved mobile connectivity, new satellite services and private investments offers a unique and exciting opportunity for scaling up new innovations and existing knowledge to an implementation and operation level so-far unheard of. The growing fleet of satellites encircling our planet ensures a continued global observation coverage and provision of data that are freely available.

Studies show that information from satellites and other (geo)data can be translated into agricultural advice, enabling higher crop yields and a more efficient use of seeds, water and fertilisers. Food producers can also receive early warnings for drought, flooding and/or diseases, while mobile phone technology based services providing up-to-date market prices have already been proven successful in Africa and India. Moreover, the quantity and quality of communication networks will enable millions of food producers in remote areas to benefit from relevant agricultural information allowing them to make better decisions.

The recently initiated Geodatics project has the form of a social enterprise that will deliver agronomic geodata-based information services to smallholder farmers in Western Kenya and Northern Tanzania. The project is executed by ICS Foundation, Wageningen UR (NL), Agrics Ltd. (Kenya), Manobi Ltd. (Senegal) and Biomass Research (NL).

While the project focuses on the development and implementation of advanced advisory services to smallholder farmers, it is to be expected that the impact of application of the advice will not be similar for all household types. Impacts will vary among different groups of households, depending on the amount and type of land at their disposal as well as prevailing labour availability, cash requirements and off-farm incomes. It is important to distinguish between households according to endowments and requirements, in order to make sure the products that are developed can serve their specific demands which will vary along with family size, location, soil type, climate, market conditions and social and personal preferences.

This report presents an overview of existing literature on farm size and composition, family conditions and other endowments and their relation to crop production. Specific attention is given to nutrient use, soil management and other elements of crop production in the study area. A considerable part of the available literature has been written by PPS (part of Wageningen UR and partner in the project). Insights derived from this work have been used in the development of effective crop models and other scientific tools that are applied in the current project. They will also be used in the design and implementation of the Monitoring and Evaluation (M&E) programme that is part of the Geodatics project.

The report also provides an overview of Geodatics product portfolio and data collection activities. Its contents therefore can be used to obtain a better understanding of farm household data that will be collected and used in product development, enrolment programs as well as the M&E. As the report also lists the role of farmer information services in the way crop production can be implemented effectively, it also provides insights how advisory services can be used to guarantee optimal nutrient use.

I would like to thank project partners for the provision of crucial information and useful feedback. A special "thank you" to field staff in Tanzania and Kenya and to Keiji Jindo (PPS) for providing essential data and insights in enrolment practices. Your contributions have strongly improved the quality of this report. Any errors in the report remain responsibility of Biomass Research.

Wageningen, August 2016
Hans Langeveld

SUMMARY

General objective of the NSO programme "Geodata for Agriculture and Water (G4AW)" is to improve food security in developing countries by using satellite data. The project "Geodatics" aims to serve more than 200,000 smallholder farmers in Western Kenya and Northern Tanzania, providing tailor made fertiliser advice, in-season crop management advice, farmer passports, market information and crop management support (Best Farming Practices). This ambitious range of products will help them to optimize nutrient application and increase crop production as well as farm and household income and food security. The aim of this report is to explore what farm and household data need to be collected to successfully deliver inputs and fertiliser advice to farmers to improve crop yields, food security and income.

The livelihoods of African smallholder farmers are extremely diverse as they reflect the variety of natural resources, socio-economic conditions and agricultural services available to farm families. Farmers have different production objectives and their response to products that are offered will depend to a large extent on the way in which these products address problems and limitations that farmers are meeting in their daily life and the opportunities they see in improving their situation.

Based on agro-ecological indicators three types of farm households prevail in the project area: "highland perennial farm households" in Kenya, "agro-pastoral farm households" in Tanzania and "maize mixed farm households" in both countries. These types of farm households represent the highest concentration of rural poverty, the target group of the project.

There are five main strategies to improve farming livelihoods: i) intensification of existing production patterns, ii) diversification of production and processing, iii) Expansion of farm or herd size, iv) increase off-farm income, both agricultural and non-agricultural and v) a complete exit from agricultural production within a particular farming system.

Creating a typology of farm households on the basis of common socio-economic and environmental characteristics can help to extrapolate farm-specific recommendations to other farms. Household categorisation is necessary to target agricultural innovations and to understand how the specific objectives and endowments of different household types affect resource allocation leading to soil heterogeneity. In this respect the following criteria are relevant for smallholder farm typology: land area, household size, livestock ownership, non-farm income and food availability.

Non-farm income is an important indicator for poverty reduction and the ability of households to take risks. Decreasing reliance on agriculture is part of the process of getting out of poverty. Therefore, information is needed on non-farm income sources and cash needs beyond food, clothing and housing.

Women are major food producers and a key source of agricultural production in Kenya and Tanzania, yet their land productivity is lower than that of male farmers. Women smallholders are most often found in groups with low endowments that have difficulties to access opportunities to raise their productivity and incomes. It is important to identify the female-headed households and their specific needs for intensification and diversification, to contribute to more equal and fair relations between men and women within the Geodatics project.

Within farms, fields often differ in their soil fertility conditions. This is largely due to the differences in fertiliser application dictated by (lack of) availability of nutrient resources, in particular manure. Animal manure is a key resource for nutrient management and farmers create zones of soil fertility by preferential allocation.

Project partners can use the outcomes presented in this report to decide what data to collect and how they can be used. Studies that are cited demonstrate the variation in households that exists in the project area and how this information can be used to design effective strategies to support them.

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ABBREVIATIONS

Africa RISING	Africa Research in Sustainable Intensification for the Next Generation
AGRA	Alliance for a Green Revolution in Africa
BR	Biomass Research
CAN	Calcium ammonium nitrate
CF	Community Facilitator
CRISP	Centre for Remote Imaging, Sensing and Processing
DAP	Di-ammonium phosphate
DFID	Department for International Development
FA	Food Availability
G4AW	Geodata for Agriculture and Water
GAP	Good Agricultural Practices
GPS	Global Positioning System
GSOD	Global Surface Summary of the Day
GYGA	Global Yield Gap Atlas
ICS	Investing in Children and their Societies
LGP	Length of growing period
M&E	Monitoring & Evaluation
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NL	The Netherlands
NSO	Netherlands Space Office
PPS	Plant Production System Group
QUEFTS	QUantitative Evaluation of the Fertility of Tropical Soils
RCMRD	Regional Centre for Mapping of Resources for Development
SI	Sustainable Intensification
SSA	Sub-Saharan Africa
SMS	Short Message Service
TRMM	Tropical Rainfall Measuring Mission
WUR	Wageningen University & Research Centre
YA	Achievable Yield

1. INTRODUCTION

Global population is projected to reach 9 billion by 2050, increasing the demand for food by an estimated 70%. Given limitations in availability of water and predicted implications of global climate change, a more effective and efficient food production is essential to ensure future food availability. Science and technology can help to improve food production by empowering the most important actors in the food production chain. Providing the right information at the right time to food producers like farmers and pastoralists can help to improve and increase food production in a sustainable manner, thus contributing to food security on a global scale.

The Dutch programme "Geodata for Agriculture and Water (G4AW)" aims to improve food security of smallholders in developing countries with the use of satellite data. The main aim is to help improve output of the agricultural, pastoral and fishing sector in 26 partner countries. A minimum 10% increase in sustainable food production and/or an improved financial situation of three million food producers is to be realized by providing them with relevant and timely information services. G4AW is a programme by the Dutch Ministry of Foreign Affairs, executed by the Netherlands Space Office (NSO).

In July 2015, NSO awarded the Geodatics project that aims to initiate a social enterprise that can develop and provide agronomic geodata-based services to smallholder farmers in East Africa. The project is implemented by ICS Foundation (based in the Netherlands - NL), Agrics Ltd. (based in Kenya and Tanzania), Wageningen University and Research Centre (Wageningen UR; NL), Manobi Ltd. (Senegal) and Biomass Research (NL). The project, which is focussing on Western Kenya and Tanzania, was initiated in September 2015.

Smallholder farms are producing 80% of the food consumed in Asia and sub-Saharan Africa (SSA). Smallholders are also responsible for most land cultivation in Africa. Many live in areas that are irrigated, humid or semi-humid, and which have medium to good market access (Gradl et al., 2012), but smallholders that are not in such favourable conditions need additional support in order to realise their production potential and ability to feed their families.

Production on smallholder farms in Africa is critical to the food security of the rural poor while it contributes the majority of food production at the national level. National policies and local interventions affect opportunities and constraints of poor smallholders. Policy frameworks aiming to improve food security and rural livelihoods in the developing world are however facing many uncertainties and often show low success rates (Frelat et al., 2016).

Problems encountered by smallholders in Kenyan Western Province include lack of access to markets and technical information needed to successfully dealing with traders. Linkages between researchers, extension workers and farmers are weak and insight on new innovations often is lacking. Other problems are use of uncertified seed and late planting which may be related to a lack of finance (Ali-Olubandwa et al., 2011).

Most African farmers have insufficient access to basic farm inputs which are either unavailable or unaffordable. High quality seeds, organic and mineral fertilisers (needed to replenish depleted soils) are largely beyond reach. Often, policies are needed to promote sustainable and productive agriculture and that ensure access to strong markets, extension services, and financial systems (Tegemeo Institute, 2010).

One way of reducing the food shortage among farmers is to increase their agricultural productivity within the prevailing agricultural production systems that have been developed in the region, especially given their limited access to arable lands. To attain this objective, provision of soil-related information services to the farmers such as application of inorganic fertilisers, organic manure, soil and water management and the use of improved commercial seeds.

Nambiro et al. (2010) studied the link between efficiency in maize production and access to soil-related agricultural information services in Kakamega district in Kenya. The results show that maize farmers with access to soil-related agricultural information services work more efficiently (average technical efficiency of 90%) compared to those who lack access to information (technical efficiency of 70%).

Frelat et al. (2016) developed a simple indicator of food availability (FA) using data from 17 countries covering major agro-ecologies in sub-Saharan Africa (SSA) and variation in food availability. Crop production is the major source of energy, contributing 60% of food availability. Non-farm income contribution to food availability ranged from 12% for households which lack sufficient food to 27% for households with sufficient food available.

The study showed that differences in availability of land and livestock together with household size can explain a substantial part of observed variations in food availability. This can help to develop and implement innovations that are better targeting household diversity and livelihood strategies. It is crucial to understand motivations of farmers and their families to (not) invest in agricultural inputs or technologies, seeking off-farm employment or security networks.

A farm household classification system can help policymakers and scientists to identify effective institutional and technical innovations that address the needs of specific (vulnerable) households. Results can be used to improve policy and research planning and implementation. The outcomes can also be used to add focus in the development of targeted products that can be offered to farmers and farm households.

Data on household size, number of livestock and land area can be used to predict food availability for a majority of the households, but the relationships are strongly influenced by the degree of market access. It was found that food security and poverty can be targeted through improving market access and off-farm opportunities. In many occasions, however, poor food security should be increased by focusing on agricultural production and closing yield gaps (Frelat et al., 2016).

Agrics and Geodatics address most of the challenges that are identified in literature. Agrics provides credit, inputs, as well as extension and marketing services to some 13,500 smallholder farmers in Kenya and Tanzania, reaching these farmers in a well-structured and organized way[1]. Timeliness of input availability is guaranteed for farmers enrolled in the credit scheme, allowing efficient input use and effective cropping operations.

In addition to this, Geodatics will develop a number of new services, including tailor-made fertiliser advice, mobile advisory services and additional training. An overview of the services that are being developed is given in Chapter 2.

Development of a product portfolio is a long term process involving a large number of staff members of project partners, and integrating many data sources as well as intermediate products. Data collection, integration and analysis are sometimes complex and time-consuming processes. This holds especially for the collection of farm and field information, but also frequent updates of satellite info. Additional data collection is, further, planned for the monitoring and evaluation of the project itself.

Farmers and their fields will be central in each of these processes, but the way in which their data will be treated may differ. It is important to develop an integrated concept of data collection, storage, analysis and exchange, as this will be one of the core activities of the project. At the same time, the focus should not be solely on technical issues as this may obscure the position of farmers who are to be addressed by the products.

Farmers' response to the products that are offered to them will depend to a large extent on the way in which these products address problems and limitations that farmers are confronted with in their daily life and the opportunities they see in improving their situation. It is, therefore, important to develop a vision how to keep farmers' and farming families' conditions central during the project.

The objective of the current report is to highlight which elements of farms and households are essentially determining the livelihoods and perspectives for smallholders. This will be done by presenting the main results of a few dedicated studies that have analysed the relationship between farms, fields and households in the study area.

The report is organized as follows: a short overview of Geodatics approach and products is presented in Chapter 2. An overview of existing farm household surveys, selected household indicators and their potential use for Geodatics is given in Chapter 3. Chapter 4 describes how farm data collection is organized within Geodatics. A brief discussion and conclusion section is presented in Chapter 5.

[1] For a description of Agrics activities, see the website (http://www.agrics.org/), and Langeveld and Quist-Wessel (2015)

2. GEODATICS

2.1 Introduction

The advice service that is to be developed in the project will be elaborating on existing Agrics products on credit, hybrid crop seeds, fertiliser, SMS information services and training. Agrics Kenya is operating in six regions in western Kenya: Kakamega North, Kakamega East, Busia, Butere, Bungoma and Siaya. Agrics Tanzania is operating in Northern Tanzania in Maswa, Meatu and Shinyanga rural and extending its activities to new locations in Geita and Kahama.

2.2 Products

Within the project the following four Geodatics products will be developed:

- Tailor-made fertiliser advice
- In-season crop management advice
- Farmer passport
- Good Agricultural Practices

Product I: Tailor-made fertiliser advice
The tailor-made fertiliser advice will be adjusted to local soil and climate conditions as well as farm composition and household size. It will be shared with the farmer before the start of the growing season, using satellite (Historical Normalized Difference Vegetation Index, or NDVI) data in combination with scientific data and farmer information.

The objective of the product is to allow farmers to optimise their revenues from the seed and fertiliser that are applied. This is done by advising farmers with good soils to raise fertiliser application. Farmers with less favourable soils will be advised to reduce fertiliser application levels to save money. Suggested fertiliser application levels will be calculated in an integrated science-based procedure.

The tailor-made advice is the principal product to demonstrate the potential of the Geodatics approach, which basically differs from existing advisory services providing 'blanket' advice. It will combine historical NDVI data with existing public climate and soil information using scientific models in a coherent and consistent way.

The following data are required:

- Soil and weather data, as well as indications of field location in the landscape and in relation to the farmer's house – to derive soil quality and weather conditions
- Global yield gap atlas (GYGA) output - to estimate achievable yield or YA (annual update)
- Satellite data - to adjust YA to local conditions (annual update)
- Farmer and fertilisation history data - to differentiate between good and poor fields (annual update as the plot history has to be updated after each growing season)
- Calculation rules of the QUEFTS model – to determine the fertiliser application level needed to generate the suggested yield while considering the amount of organic inputs that available on farm (annual update)

Preparations for this product are currently (July 2016) well under way. Calculation rules and routines that have been developed for data collection and exchange at this stage for the development of this product are expected to serve as a basis for the entire project.

Product II: In-season crop management advice (feedback on rainfall development)
The second Geodatics product will provide in-season feedback to farmers. It will use the most recent MODIS images to make suggestions for adjustment of top-up fertiliser applications. The images are to be collected and analysed within a few days of observing, allowing weekly updates of the advice (if needed). The product will also use latest crop growth modeling using up-to-yesterday weather information, derived from a combination of local weather stations (Global Surface Summary of the Day (GSOD) data or data from national institutes [if they are willing] and satellites (propagated NASA-power, TRMM / CRISP for rainfall).

Advice may refer to (timing of) field preparation and sowing but also to fertiliser applications. For example, if the start of the season is expected to lead to less favourable growing conditions (leading to lower yields than normally would be expected), farmers can be advised to reduce top-up N-applications. This will allow them to economize on fertiliser application, e.g. when dry spells occur after sowing.

Development of this product is expected to start in 2017. It will profit from experience gained in the development, testing and implementation of the tailor-made advice. Additional work will need to be done in order to acquire and analyse near-real time NDVI images as well as associated data exchange, storage and analysis. It is expected that the increased frequency of data analysis and advice updates will require further integration of communication and analytical routines in the project.

Product III: Farmer passport
Building on the data that have been collected for the farmer and prepared in previous activities, a passport will be developed that is to present an overview of essential information on the farm and farming household. This document will also present basic information on acquired insights on soil and weather conditions, yield potential and basic fertiliser and crop management advice.

The objective of the passport is to allow a general representation of the type of information that will be used and developed by Geodatics. The passport is to be generated once, at the start of the relation between a farmer and Agrics (or other clients) and depends on a number of questions that are to be answered by farmers during the intake. These questions may relate to family size; age of the farmer; risk attitude; size of the plot(s) included in the Agrics programme and fertilisation history of the plots.

A first draft version of the passport is currently has been distributed to Agrics staff members plus a limited number of farmers during the coming months. As it is partially depending on results of calculations for the tailor-made fertiliser advice and the in-season advice, the final contents may be expected to need some time to develop. Release and distribution of the document will be decided upon by project partners together with Agrics staff.

Product IV: Good Agricultural Practices

Essentially sound agronomic management is a prerequisite for efficient use of fertilisers and other inputs. Farmers obtaining Geodatics advice will be supported with information on good agricultural practices (GAP) which can help them to benefit better from the investments they make. In which form this information is to be shared is not yet known. It will be based on the large amount of knowledge and insights that have been accumulated by technical project partners, especially the Plant Production System Group (PPS which is part of Wageningen University and has been active in research and development activities in the continent for many decades).

Output may be linked to existing information provided by Agrics to its field staff (CF's). Some information sheets have already been prepared and distributed, covering elements of successful crop cultivation and soil management. Further output is to be decided upon; it is likely to include dedicated information sheets on weather fluctuations and gender issues.

3. FARM AND HOUSEHOLD SURVEYS

3.1 Introduction

The livelihoods of African smallholder farmers are extremely diverse as they reflect the variety of natural resources and agricultural services available to farm families. These resources include different types of farmed and fallow land as well as water resources and common property resources, including grazing areas, forest and ponds.

Farmers make decisions in resource management, developing activities in crop, livestock and tree production, as well as gathering, processing, marketing and off-farm work (Rufino et al., 2008). The functioning of an individual farm is strongly influenced by an environment of social relations, economic opportunities, market arrangement, political incentives and biophysical context. Taking a systems approach helps to capture the complexity of smallholder agriculture and household considerations for system improvement (Garrity et al., 2012).

One way to deal with farm diversity is by developing a typology which groups farms into more or less uniform clusters. Together, the clusters represent the heterogeneity within a region. This approach can help to design interventions that address the needs of different farm types. Other reasons to develop a farm typology can be (Alvarez et al., 2014):

- **Targeting**: the distinction between farming systems is aimed at identifying appropriate interventions per farming system type
- **Scaling-out**: typologies contribute to understanding how appropriate interventions can be disseminated at a large scale
- **Selection**: typologies support the selection of representative farms or the formulation of (average) prototype farms for detailed analyses
- **Scaling-up**: typologies support the extrapolation of ex-ante impact assessments to larger spatial or organizational scales

This chapter provides an overview of recent farm and household surveys and household typologies that may be relevant for the project area and project activities.

3.2 Farming systems in Sub Saharan Africa

Several studies described farm typologies to address issues of technology adoption. Dixon et al. (2001) identified strategies for reduction of poverty and food insecurity. Farms were classified using agro-ecological and socio-economic variables. The length of the growing period (LGP) was used as the primary classifier. This information was combined with data on climate, soils and landform to define so-called agro-ecological zones.

Other variables include time to reach the market, population density, crop and livestock distribution, altitude and soil type. The work by Dixon et al. (2001) has been elaborated by Garrity et al. (2012). Main farm types are presented in Annex I. In this chapter we restrict ourselves to three types prevailing in the project area: "highland perennial farming systems" and “maize mixed farming systems” (in Kenya) and “maize mixed farming systems” and “agro-pastoral farming systems” (in Tanzania).

They can be characterized as follows:

- Maize mixed farming systems are found in sub-humid and humid areas. They are dominated by maize and legume crops and located in East, Central and Southern Africa. Household income depends on maize, legumes, cassava, cattle, goats, poultry, tobacco, cotton and off-farm work

- Agro-pastoral systems are mixed crop-livestock farms with remote grazing areas, low and variable rainfall, weak markets (except for livestock), low crop yields, high population pressure, weak communities and local conflict

- Highland perennial systems have good soils and rainfall and well developed markets. Farms are small, growing traditional food and cash crops; communities are relatively strong

The highest concentration of rural poverty is found in the maize-mixed farming system, followed by the agro-pastoral and the highland perennial systems (Garrity et al., 2012). These findings are confirmed for Tanzania by Mdoe et al. (2015) and Menwa and Maliti (2010).

Factors determining a farm type’s growth potential include favourable resource endowments and access to roads and services, including markets, agricultural inputs and land tenure. There are five main strategies to improve farming livelihoods (Garrity et al., 2012):

- **Intensification** of existing production patterns
- **Diversification** of production and processing
- **Expansion** of farm or herd size
- **Increase off-farm income**, both agricultural and non-agricultural
- A **complete exit** from agricultural production within a particular farming system

According to Mdoe et al. (2015), reliance on farming activities diminishes as off-farm income increases. However, not all farming systems provide equal opportunities to increase off-farm and household income. Perspectives of poverty escape for dominant farm types in the project area are presented in Table 3.1.

Table 3.1. Perspectives of poverty escape pathways

Farm type	**Intensi-fication**	**Diversi-fication**	**Increase farm/herd size**	**Increase off-farm income**	**Exit from agriculture**
Maize mixed	Considerable potential	High potential, with resource, technology and potential markets	Some scope but land somewhat limiting	High potential with proximity to cities and mines	Some, depending on pull factors
Agro-pastoral	Some: technologies available to	Lack of local markets for different	Limited scope to increase herds, but	Some seasonal migration of	Forced emigration to other farming

	increase productivity but markets are weak	livestock or crop products	local elites control spare crop land	men to distant mines and cities	systems or cities in search of livelihoods
Highland perennial	Limited potential (yields already high)	Good scope, existing markets for a range of new high value crops, experience with production for market	Limited because of population pressure and little spare land	Plenty of jobs and opportunities in rural towns and the city	Some give up land and migrate to towns and the city – most hang on because of strong communities

Source: Garrity et al., 2012.

3.3 Kenya

A functional farm typology for western Kenya is presented in Table 3.2. Five farm types were identified using data on socio-economic conditions, type of production, household objectives and the main constraints five farm types were identified.

Table 3.2. A functional typology for household categorisation in western Kenya.

Farm type	Resource endowment[a] and production orientation	Main characteristics[b]
1	Predominantly high to medium resource endowment, mainly self-subsistence oriented	Variable age of the household head, small families, mostly constrained by land availability (lack of family labour compensated by hiring-in). Permanent sources of off-farm income (e.g. salary, pension, etc.)
2	High resource endowment, market-oriented	Older household head, numerous family (starting land subdivision), mostly constrained by labour (hired-in) due to large farm areas; cash crops and other farm produce are the main source of income
3	Medium resource endowment, self-subsistence and (low-input) market-oriented	Young to mid-aged household head, young families of variable size in expansion, mostly constrained by capital and sometimes labour, farm produce and marketable surpluses plus complementary non-farm enterprises
4	Predominantly low to medium resource endowment, self-subsistence oriented	Young to mid-aged household head, variable family size, constrained by availability of land and capital, deriving income from non-farm activities (e.g. ox-plough service, handicrafts)
5	Low resource endowment, self-subsistence oriented	Variable age of household head, variable family size, often women-headed farms constrained by land and capital, selling their labour locally for agricultural practices (thus becoming labour constrained)

Source: Tittonell et al., 2005.

[a] Assets representing wealth (i.e. land size, livestock ownership, type of homestead, etc.).

[b] Family structure (age of the household head) in relation to the position of the household in the 'farm development cycle', main constraints to agricultural production faced by the household, and main source of income.

The importance of agriculture and production varies strongly. Some rich farmer types rely mainly on off-farm earnings or remittances. Farming involved relatively small pieces of land which were mainly cultivated for home-consumption (Type 1); other farms cultivated large areas, mainly with cash crops (Type 2).

Poor farmers (Type 5) cultivate small pieces of land, deriving a large proportion of their income off-farm. This is more or less similar to (rich) Type 1 farmers but Type 5 farmers lack permanent off-farm income while their off-farm work often results in labour shortages on their own farms. Type 3 and 4 farms represent diverse strategies revolving around production of crops for home consumption and the market, including producing fodder (Napier grass) for sale to wealthier livestock owners.

Generally, input use declined from farm types 1 to 5, although large variations were found in nutrient use and land management practices (e.g. fallow).

Rich, land-constrained farms of Type 1 often apply more mineral fertilisers (ca. 50 kg/ha on average). The use of animal manure in small farms could reach levels up to 8 tonne/ha, providing net accumulation of soil organic matter and macronutrients. Small, poor, farms of Type 5 provide only low amounts of mineral and organic fertiliser inputs (0– 12 kg of mineral fertilisers and 0–0.5 tonnes of organic fertiliser per ha, respectively).

Land to labour ratios that were calculated (including hired labour) suggest that Type 1 farms are land-limited while farms of Type 5 are labour-limited. These limitations provide constraints to (improvements for) soil fertility management which may require land (for fallow), cash (to invest in increase fertiliser use) or labour (for crop management; Tittonell et al., 2005).

The relation between farm type and soil nutrient management is also elaborated by Tittonell et al. (2010). It was found that soil organic matter and nutrient contents could be explained by differences in soil management, land availability, number of livestock, labour availability and access to cash although large variations within farm types were found (especially on small farms on poor soils).

3.4 Tanzania

Rural areas in the Shinyanga District have a poor transport infrastructure which restricts trade and other business activities. Households typically engage in cropping (cotton, sorghum, millet, maize, sweet potatoes and rice), but cattle and off-farm employment (cotton harvest in Shinyanga or cotton ginneries located in the adjacent Mwanza region) are also important.

Maize production is the most important agricultural activity, supporting home consumption as well as cash earnings. Other cereals are rice, sorghum, millet and wheat. The use of inputs generally is low. World Bank supported subsidies have stimulated fertiliser use over the past years, with 40 to 50% of Tanzanian farmers currently applying artificial fertilisers. About one quart of the farmers is using draft animals (Ronner et al., 2012), the remainder depending on hand labour. Variable rainfall has a significant impact on crop production, and localized drought is not uncommon.

The project "Africa Research in Sustainable Intensification for the Next Generation - Africa RISING" aims to enhance farmers' knowledge and support intensification in maize/legume farming systems. The project is implemented in Ghana, Ethiopia, Malawi, Mali and Tanzania. The main focus is to address soil and land degradation. In Tanzania, the project is being implemented in Babati and Kongwadistricts in Manyara (northern Tanzania) and Kiteto district in Dodoma region (central Tanzania).

Africa RISING identified farm types using data on productivity, economic, environment, social, and human (Signorelli, 2016):

- <u>Female-headed households</u> (Type 1) with low educational attainment and few endowments
- <u>Young households</u> (Type 2) with medium endowments
- <u>Medium-endowed households</u> (Type 3) grow vegetables and practice intercropping
- <u>Highly endowed households</u> (Type 4) breed livestock and grow legumes

Table 3.3 summarizes their main characteristics. Figure 3.2 shows a graphic representation of the main characteristics.

Table 3.3. Matrix of performance for each Sustainable Intensification domain.

	Productivity	**Economic**	**Environ-ment**	**Social (gender)**	**Human**
Type 1: Female-headed, low educated households with low levels of endowments	Low crop production and productivity. Little livestock owned.	Low wealth, land size <2 Ha, low input use, most harvest used for home consumption rather than sales.	Little use of soil conservation practices.	High frequency of female responsibility for crops but opposite for livestock.	Female heads with low levels of literacy and education. Very low food security.
Type 2: Young medium-endowed households	Low crop production and productivity. Little livestock owned.	Low-medium wealth, land size <2 Ha, low input use, half of harvest used for own consumption, remainder is sold.	Little use of soil conservation practices.	Average gender equality.	Small households with low dependency ratio. Relatively low food security.
Type 3: Medium-endowed households growing vegetables and practicing intercropping	High crop productivity. Frequent intercropping. Vegetable and legume growers.	Medium-high wealth, high input use (fertiliser, hired labour), two thirds of is sold, remainder consumed.	Frequent use of manure but also problems of soil incrustation.	Average gender equality.	Large households with married male heads and high levels of education and literacy.

Type 4: Highly endowed households breeding livestock and growing legumes	Very high crop production and productivity. High livestock ownership. Legume growers.	Very rich, high input use, 80% of harvest going is sold. Good dwelling conditions.	Frequent use of soil conservation practices, soil erosion problems.	High frequency of female responsibility for livestock but opposite for crops.	Very large households, married male heads. Well educated and literate. Very high food security.

Source: Signorelli, 2016.

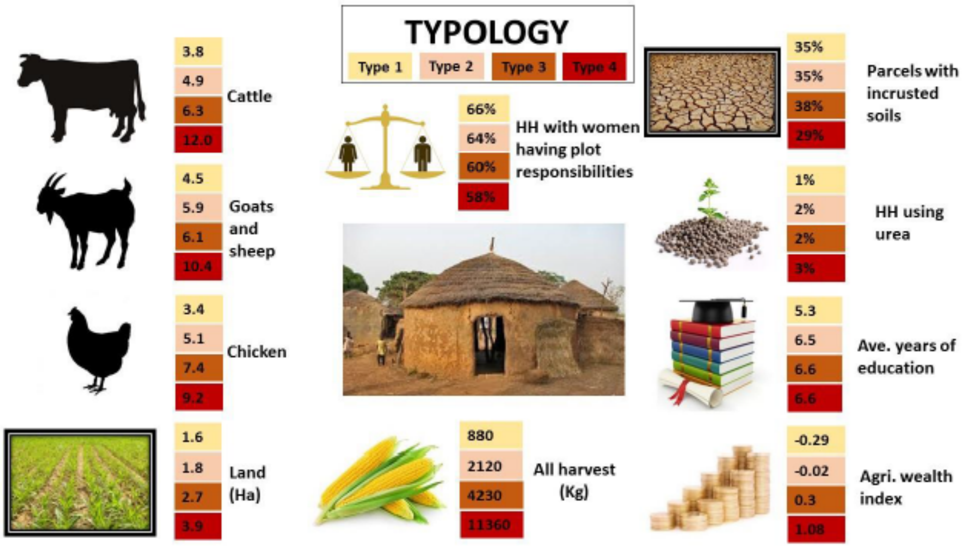

Figure 3.2. Graphic representation of four household types in Tanzania.
Source: Signorelli, 2016.

Some outcomes of this study:

- Type 3 and 4 farms are the most productive; Type 2 farms are moderately productive and Type 1 farms are lagging behind
- Type 4 farms are well endowed, the other farm types are quite close to each other be it at a lower level than Type 4 farms
- Measured by educational background, Types 2,3 and 4 are very similar; Type 1 farmers have a very low educational background
- Despite wide differences in productivity, endowment and training, farm Types 1 and 4 perform similarly in terms of soil conservation and gender equality

3.5 In-farm variability

Variations in soil quality cause large differences in response to fertiliser application within farms, even small farms. The best response is expected on fertile soils, normally found on fields nearest to the home. Home gardens usually have a high fertility and require just basic fertilisation to maintain productivity. Poor fields need long-term applications of organic matter before they can respond to nutrient inputs (Tittonell and Giller, 2013).

It is a major challenge to determine soil quality in smallholder agriculture. Three types of fields can be distinguished (Tittonell and Giller, 2013): (1) responsive, (2) non-responsive but productive, and (3) nonresponsive degraded. Soil fertility and physical conditions result from a long period of land use and crop management, but are also determined by geology, geomorphology, and resource endowment. Figure 3.2 illustrates challenges in moving from recommendations based in on-station trials to decision rules for real world farms.

Nutrient application is however not the only factor that can help to improve crop yields. According to Tittonell and Giller (2013), an important fraction of the yield gap may be reduced through proper agronomic management (planting dates, spacing, cultivars, early weeding, etc.) even when fertilisers are not applied. Sound agronomic management is a prerequisite for efficient use of fertilisers and other inputs. This will be addressed in the Geodatics project by providing good advice, focusing on Best Farming Practices alongside with fertiliser advice.

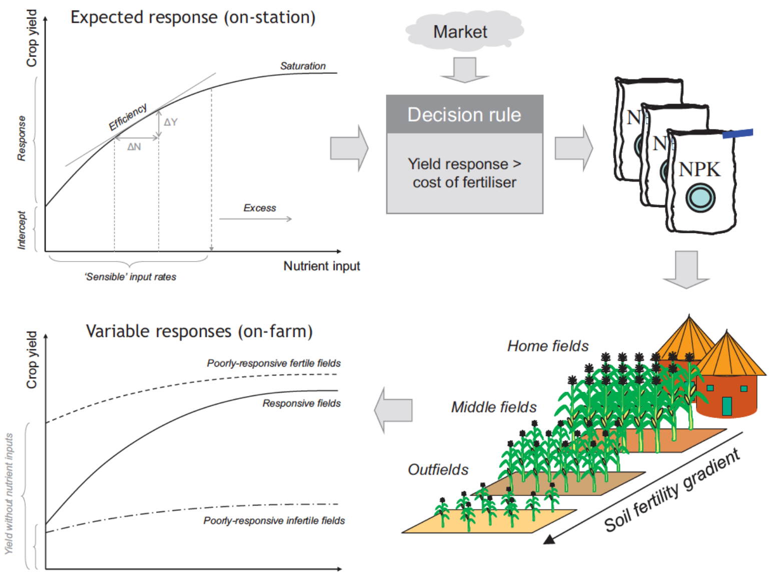

Figure 3.3. Moving from on-station fertiliser trials to real world farming decision rules. Read diagram clockwise starting from the top-left corner. Source: Tittonell and Giller, 2013.

3.6 Gender

As illustrated above, gender of the farmer can be an important factor determining wealth and crop cultivation. While women are major food producers in Sub-Saharan Africa, their productivity is below that of male farmers. Female smallholders experience great difficulties in attempts to raise productivity and incomes as they have limited access to land, credit, technology, and markets (Kroma, 2013). This is largely due to norms and underlying cultural factors emphasizing male dominance over farming resources.

The Alliance for a Green Revolution in Africa (AGRA) provides tools and opportunities to small-scale farmers to boost their productivity and profitability. AGRA commissioned a baseline study to evaluate the impact of its activities. For this study, plot, farmer and household data were collected on some 1,000 farm households, mostly located in Western Kenya; over 100 were selected in Kakamega (Tegemeo Institute, 2010).

In this section we restrict ourselves to the AGRA baseline study for Kenya and the Africa RISING baseline study for Tanzania.

The AGRA study shows significant resource gaps between women and men. Although women are active in project activities, their capacity to accumulate resources, retain income and influence decision-making bodies is low. The baseline study revealed that 17% of the households in the Western region were female-headed; the majority being widows. These households had fewer assets and earned lower incomes compared to those headed by males. They also had less access to productivity enhancing technologies - such as inorganic fertilisers and improved crop varieties (Tegemeo Institute, 2010).

This is confirmed by the Africa RISING study (Charles et al., 2016). Compared to men, female heads of households in Tanzania have less human capital, while showing more illiteracy and of lack of formal education. They live in poorer homes, built with cheaper, more traditional materials, and possess less modern furniture and equipment.

Presumably because of the uneven burden associated with home duties, or because they are more likely to be single-parent homes, female household heads are unable to spend equal amounts of time in crop cultivation, working up to 13 days less on maize and beans than male farmers. They also have fewer resources, possessing, for example, less livestock. Consequently, households are more vulnerable and more prone to food insecurity. Finally, they lack adequate representation at the local political level: only one of twenty-five communities surveyed (Chitego, in Kongwa District) had a female chairperson.

There are, however, options for future change. For example, while female participation in farmer training centres and institutions of knowledge diffusion generally is low, female membership in cooperative organizations is high. This may provide alternative channels for dissemination of new agricultural technologies. As farmers interact more frequently with friends and neighbours and lead farmers, a larger representation of women in the pool of model farmers may be another option to disseminate the knowledge. Female-headed households appear to farm an equal area under innovation programs as male-based farms.

While rural education levels have increased substantially in the past, fast development of communication technology now is bringing information much closer to small farm households. Expansion of mobile phone use, as occurring in most countries in SSA, have been reported to reduce gender inequity in access to agricultural information, including market prices and 'mobile banking' (Garrity et al., 2012).

This is confirmed by O'Donnel (2014). However, while lack of access to finance, training, and information services is limiting female farmers in day-to-day life, mobile technology could be used to bridge this gap by helping to:

- **Increase productivity and incomes** of rural women and their households
- **Empower rural women** in their households and communities and
- **Improve livelihoods** overall for underserved communities

3.7 Summary

Large variations exist between farming households, where differences in access to resources, education, inputs, off-farm income and markets determine the way they can generate food and incomes. Table 3.4 provides a summary of household types that have been presented in literature.

Table 3.4. Household typology, factors and variables identified for selected sources.

Source	Focus	Factor	Indicator
Frelat et al., 2016	Indicator of Food availability; Drivers of variation in food availability, 17 countries.	Food production Non-farm income	- Household size - Number of livestock - Land area In addition: - Market access - Non farm opportunities
Nambiro et al., 2010	Efficiency in maize production and access to soil related information. Kenya, western province.		- Access to information - Age of household head - Household size
Signorelli, S. 2016	Typology characterization of farmers in Tanzania.	- Productivity - Economic - Environment - Social - Human	- Cereal yield - Asset-based wealth index (Economic) - Soil conservation index - Gender equality index composed by female responsibility in managing certain plots and livestock - Average education in the household
Tegemeo Institute, 2010	Household baseline survey, Kenya.	- Agricultural production socio-economic, livelihood conditions and behavioral patterns.	- Agricultural production systems - Agricultural marketing - Demographic characteristics of household members - Input use and technology adoption - Access to and use of information and credit - Food security - Access to infrastructural facilities and public goods - Ownership of productive resources - Non-farm income generating activities.
Tittonell et al., 2005	Characterisation of five functional farm typologies	- Wealth class - Main constraints	Including: - Farm area - Family size

	based on: - Resource endowment - Income strategy Western Kenya.	- Position in farm cycle, family structure - Main source of income	- Age of household head - Food produced for household - Food produced for market - Cash crops - Livestock ownership - Non-farm income - Off farm labour
Tittonell et al., 2010	Functional typology of livelihood strategies. East Africa.	- Land, - Labor - Financial resources - Potential nutrient availability	- Total area - Total area farmed - Area with cash crops - Family size - Family labor - Family members working off-farm - Age of the household head - % of household income from off/non-farm activities - Production orientation (% production for the market) - Livestock ownership (local, improved oxen) - Months of food self-sufficiency

An effective programme to improve smallholder productivity, food security and incomes should specifically address typical household types. This also holds for the current project which aims to support farmers by giving them better access to inputs, training and agricultural advice.

As a first step in the development of effective inclusive services, an overview of the most relevant factors determining farm household types to be served in the project is presented in Table 3.5 (next page). They are distinguished by differences inland area, household size, livestock ownership, non-farm income and food security.

Table 3.5. Indicators for smallholder farm household typology in East Africa.

	Indicator	Source and region	Remarks
1	Land area	Frelat et al., 2016; [1]SSA Tegemeo Institute, 2010; baseline survey Kenya Tittonell et al., 2005; Western Kenya Tittonell et al., 2010; applicable for East Africa Signorelli, S. 2016; applicable for Tanzania	Also referred to as: Agricultural production systems; (total) farm area
2	Household size	Frelat et al., 2016; SSA Nambiro et al., 2010; Kenya western prov. Tegemeo Institute, 2010; baseline survey Kenya Tittonell et al., 2005; Western Kenya Tittonell et al., 2010; applicable for East Africa	Also referred to as: Demographic characteristics of household members
3	Livestock ownership	Frelat et al., 2016; SSA Tegemeo Institute, 2010; baseline survey Kenya Tittonell et al., 2005; Western Kenya Tittonell et al., 2010; applicable for East Africa Signorelli, S. 2016; applicable for Tanzania	Also referred to as: Agricultural production systems. Categorized according to animal type and use
4	Non-farm income	Frelat et al., 2016; SSA Tegemeo Institute, 2010; baseline survey Kenya Tittonell et al., 2005; Western Kenya Tittonell et al., 2010; applicable for East Africa	Also referred to as: Non-farm income generating activities; Non farm opportunities; off/non-farm activities
5	Food for household	Frelat et al., 2016; SSA Tegemeo Institute, 2010; baseline survey Kenya Tittonell et al., 2005; Western Kenya Tittonell et al., 2010; applicable for East Africa Signorelli, S. 2016; applicable for Tanzania	Also referred to as: Food security; Food availability

SSA: Sub Sahara Africa

4. GEODATICS DATA COLLECTION

Chapter 2 presented an overview of the main products to be developed along with the data that are required for implementation. Data collection in the project is to serve several activities including:

- Basic **farm and plot registration**
- **Additional data collection** and registration
- Identification and monitoring of **demoplots**
- Project impact **monitoring and evaluation**

Different types of data have to be collected in each activity. This chapter will discuss what data can be selected for specific purposes.

Agrics and Geodatics collect the following farmer and farmdata:

- **Agrics customer database**
- **Farming family data** that provide information on composition of the family, assets that they have including livestock, non-farm sources of income etc.
- **Plot information** providing information on the actual piece of land on which maize is cultivated such as the location (coordinates), altitude and slope; size; cropping and fertiliser history
- **Farming data** that refer to information on farming practices

This chapter further discusses issues of data collection and analysis. An overview of farming family data sources that are used in the Geodatics project is presented in Table 4.1.

Table 4.1. Overview of data collecting on customers and farm households.

Name	Description	Activity
Agrics customer database	Records of farmers' personal data, products and progress in repayment. (Privacy sensitive information)	Basic registration
Jotbi (Manobi data service)	An app to collect data with a mobile phone. To collect individual data from farmers on farming family, plot information and farming data.	Additional registration Demoplot
Monitoring and Evaluation	The M&E is the assessment of the accuracy and effectiveness of information provided to farmers: Geodatics products are compared to production using advice based on soil samples.	Data will be collected through farmer interviews, soil samples, yield measurements and field observations.

Basic Registration

Each farmer registering with Agrics receives an Agrics ID. Agrics keeps a customer database in which the products that are requested, credit and repayment are recorded. Record keeping is focused on loan and repayment. An overview of the information that is registered in the Agrics database is presented in Annex II.

Additional Registration

Customer and farm data that are available from the Agrics customer database will be complemented with data from the Jotbi app. To this end the existing Jotbi app that was developed for West Africa was adjusted to the purposes of the Geodatics project. A big advantage of using online data registration is that data are uploaded in a central database for analysis. Information to be collected includes photos of the farmer, the farmer's field and the soil. Use of the GPS positioning allows walking around the field taking "way points". In this way the area is measured and the coordinates of the field are available.

The questionnaire that has been developed covers the following topics:

- **Farmer ID**; this section is on personal data (for details, see Figure 4.1)
- **Farmer family**: data on size of household and family members working on the farm
- **Farmer Situation**: Since when a member of Agrics; involvement in other credit schemes; live stock (Figure 4.1c)
- **Socio-economic situation** (Figure 4.1d)
- **Plot information**: total area and area in Agrics programme
- **Crops** on the farm
- **Soil characteristics** (including photo)
- **Yield**
- **Cultural agenda + agronomic practices**; plot location

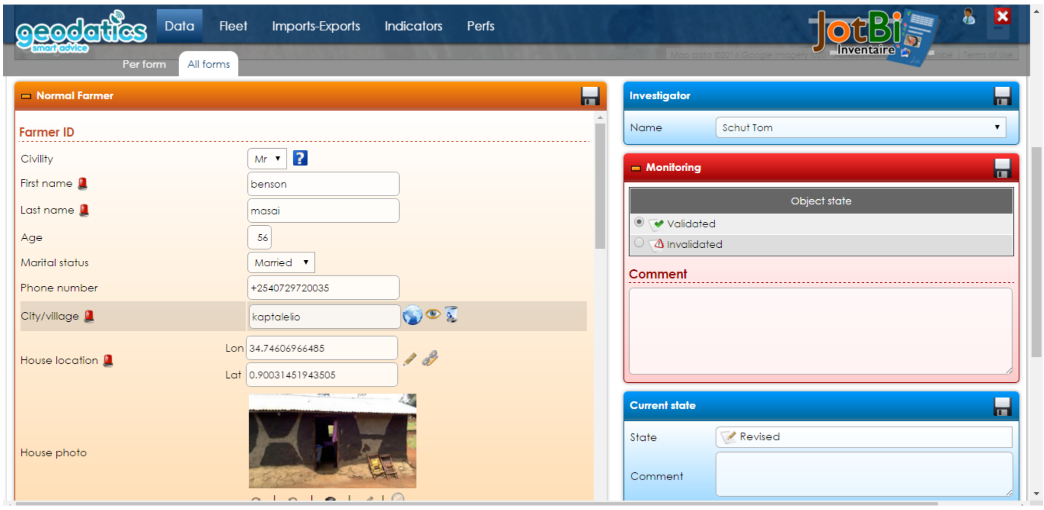

Figure 4.1. Screenshot of questionnaire for farmers. Section on farmer ID.

An online questionnaire has been developed with the adjustment of existing Jotbi applications in Kenya and Tanzania. In April 2016, 45 Community Facilitators (CFs) have been trained in Kenya in using this online questionnaire to obtain farm data. Mid July 2016, about 330 validated questionnaires have been uploaded. The training of 25 CFs in Tanzania has been scheduled for the end of July.

Monitoring of demoplots

Demonstration plots (demoplots) will be used to monitor the impact of variations in application rates of Calcium ammonium nitrate (CAN) and Di-ammonium phosphate (DAP) – the main fertiliser types in the region - on maize yields. In Kenya and Tanzania, the first demoplots are being implemented in the 2016 long rain season.

In Kenya, demoplots are established and managed by CFs. In Kenya use of fertiliser is rather common and the demoplots have the purpose of showing the effect of different fertilisation rates compared to the standard rate of Agrics. A typical demoplot is subdivided into four sub-plots with the following treatments:

- **Treatment 1**: Agrics recommendation: Hybrid seeds + CAN (50 kg/acre) + DAP (50 kg/Acre)
- **Treatment 2**: Hybrid seeds + CAN (75 kg/acre) + DAP (75 kg/Acre)
- **Treatment 3**: Hybrid seeds + CAN (100 kg/acre) + DAP (100 kg/Acre)
- **Treatment 4**: Hybrid seeds + CAN (125 kg/acre) + DAP (125 kg/Acre)

In Tanzania, many farmers are reluctant to use chemical fertiliser and the demoplots are used to show the benefits of fertiliser use in combination with hybrid seeds. The demoplots are planned in every village and they will be managed by committed farmers. Demo-plot farmers are interviewed and tailor-made fertiliser advice will be generated for the field included in the demoplot (treatment 4). A typical demonstration plot will be subdivided into five subplots; hosting the following treatments:

- **Treatment 1**: Hybrid seeds + CAN (50 kg/acre) + DAP (50 kg/Acre)
- **Treatment 2**: Hybrid seeds + CAN (50 kg/acre)
- **Treatment 3**: Hybrid seeds
- **Treatment 4**: Hybrid seeds + Geodatics: application rate of fertiliser following Geodatics tailor-made advice. It may need different products, e.g. also Muriate of Potash for K.
- **Treatment 5**: Farmer practice with land race seeds

Subplots will be monitored with an adjusted version of the Jotbi app.

Project impact monitoring and evaluation

The effectiveness of the use of the Geodatics service will be measured by means of a Monitoring and Evaluation (M&E) exercise which will use the different data sources in the project. In addition, it will carry out soil sample analyses, farmer interviews, harvest samples and field observations for farmers who use the Geodatics advice and a control group of farmers who do not use Agrics products.

Farmers using the Geodatics product will be interviewed to collect information about socio-economic and biophysical conditions and agronomic practices. This includes questions about the crop-types grown in specific fields, location of best and worst fields on the farm and also questions about family size and resource endowment, farm size, presence of animals and availability of animal manure and time of seeding and weed control (etc.).

Additionally, also farmers will be interviewed who do not use the Geodatics product. They serve as "control group". Comparisons between these two groups will be used to evaluate the success of the product. To this end, the farmers will be interviewed at the start and at the end of the season and will be queried about their experiences.

The M&E system deals with a variety of stakeholders, services, interests and evaluation criteria. As a result, it takes multiple angles of assessment and covers multiple themes:

- Food production by smallholders
- Income of smallholders

- Technical accuracy of the product
- Technical functioning of the data process
- Smallholder satisfaction with product & services
- Gender relations
- Market demand & business viability
- Project effectiveness and efficiency

The M&E survey will also provide crucial information about client satisfaction to be used by Agrics and Geodatics for continuous product development.

The overall coordination of the M&E is done by WUR, with support of all project partners. Staff of Agrics Kenya and Agrics Tanzania have specific roles in the data collection. For 2016, the M&E activities will start in September. In Kenya, in each of the six working areas (Busia, Butere, Kakamega East, Kakamega North, Bungoma and Siaya) six villages were selected based on dominant soil types. In each village three Agrics and three non-Agrics farmers will be interviewed, resulting in a total of 216 interviews (108 Agrics farmers and 108 non-Agrics farmers). In Tanzania, 25 villages have been selected in three areas Maswa (10), Meatu (10) and Shinyanga rural (5). In each village three Agrics and three non-Agrics farmers will be interviewed resulting in 150 farmer interviews (75 Agrics farmers and 75 non-Agrics farmers).

5. DISCUSSION AND CONCLUSION

General objective of the NSO programme "Geodata for Agriculture and Water (G4AW)" is to improve food security in developing countries by using satellite data. Geodatics aims to serve more than 200,000 smallholder farmers in Western Kenya and Northern Tanzania, providing tailor made fertiliser advice, in-season crop management advice, farmer passports, market information and crop management support (Best Farming Practices). This ambitious range of products will help them optimize nutrient application and increase crop production and farm and household income and food security.

Different strategies exist to improve household livelihoods. Garrity et al. (2012) identify the following:

- **Intensification** of existing production patterns
- **Diversification** of production and processing
- **Expansion** of farm or herd size
- **Increased off-farm income**, both agricultural and non-agricultural
- A **complete exit** from agricultural production within a particular farming system

So far, services provided by Agrics offered options to intensify agricultural production (higher yields with the use of hybrid seeds and fertiliser application) and diversification (vegetable crop seeds, poultry). Geodatics' main strategy so far has been to help farmers close the yield gap. This is mostly realized by showing them how fertiliser application levels can be raised economically, provided this is permitted by (weather conditions and) soil quality of the fields entered in the programme.

Occasionally, farmers may be advised to reduce fertiliser applications when soil quality is too low. This tailor-made advice considers specific conditions at both household and field levels. Successful development of this product requires efficient collection of relevant field, farm and household data. Additional data collection is planned for the development of other products (especially in-season crop management advice), while also data are needed to determine client satisfaction and project impact.

While already considerable efforts have been made to identify the type of data that are to be collected (as well as the way they are to be stored, analysed and shared within the project), it is too early to provide final lists of all types of data that will be used in the project. This holds especially for data to be collected and treated in the development of the in-season advice and the M&E programme.

The aim of this report has been to explore experiences of data collection for successful interventions aimed at the delivery of advice and fertilisers to farmers in order to allow them to improve crop yields, food security and income. The outcomes presented in earlier chapters can be used by project partners to reflect on what data are to be collected and how they can be used. Studies that have been cited demonstrated what variation in households exists in the project area and how this information can be used to design effective strategies to support them.

One of the most common strategies to address poverty reduction in Africa's rural context, is to group household based on their endowments such as land size, livestock ownership and type of housing (e.g. studies by Tittonell et al., 2005; Charles et al., 2016; Rufino et al., 2008).

In the context of this project, we aim at increased crop yields through enhanced fertiliser use. One important element of soil management and crop nutrition may easily be overlooked in the context of existing fertiliser types that are applied in the region as these almost exclusively contain two elements: nitrogen and phosphorus. Consequently, other sources of (micro-)nutrients need to be considered as well. In this light, it is highly relevant to have information on livestock ownership as it is known that there is a positive interaction between fertiliser and manure and the benefits of manure applications in conditions of decreasing soil fertility as is often the case in SSA has been widely demonstrated (Castellanos-Navarette et al. 2015; Rufino et al., 2007; Zingore, 2011).

According to Vanlauwe et al. (2015) the combined application of fertiliser and organic inputs made sense since as (i) both fertiliser and organic inputs are often in short supply in smallholder farming systems due to limited affordability and/or accessibility; (ii) both inputs contain varying combinations of nutrients and/or carbon, thus addressing different soil fertility-related constraints; and (iii) extra crop produce can often be observed due to positive direct or indirect interactions between fertiliser and organic inputs.

The importance of manure of source of micronutrients is addressed by Kihara et al. 2016; while use of manure for maintaining soil organic matter is addressed by studies of Tittonell et al. 2005; Tittonell and Giller, 2013.

For poverty reduction and the ability of households to take risks, the studies that have been reviewed show that non-farm income is an important indicator. Decreasing reliance on agriculture is part of the process of getting out of poverty. Therefore, information is needed on non-farm income sources and cash needs beyond food, clothing and housing.

Women are major food producers and a key source of agricultural production in Kenya and Tanzania, yet their land productivity is lower than that of male farmers. Women smallholders are most often found in the groups with low endowments and experience great difficulties accessing opportunities to raise their productivity and incomes. In order to reach the goal of Geodatics of contributing to more equal and fair relations between men and women within the Geodatics project it is important to identify the female house holds and their specific needs for intensification and diversification.

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ANNEX I FARMING IN THE STUDY AREA

Table I.1. Description of the main farming and livelihood systems.

Farming Systems	Market access	Main livelihood source	Defining characteristics
Maize Mixed	Medium	Maize, tobacco, cotton, cattle, goats, poultry, off-farm work	Sub-humid and humid areas, dominated by maize with legumes
Agro-Pastoral	Medium-high	Sorghum, pearl millet, pulses, sesame, cattle, sheep, goats, poultry, off-farm work	Semi-arid areas, mixed sorghum/millet and livestock systems
Highland Perennial	Medium-high	Banana, plantain, enset, coffee, cassava, sweet potato, beans, cereals, livestock, poultry, off-farm work	Moist highland areas with a dominant perennial crop either banana (often with coffee) or enset in Ethiopia
Root and Tuber Crop	Medium	Yams, cassava, legumes, off-farm work	Lowlands, dominated by roots and tubers with no major tree crop, LGP
Cereal-Root Crop Mixed	Medium-high	Maize, sorghum, millet, cassava, yams, legumes, cattle, off-farm work	Two starchy staples alongside roots and tubers
Highland Mixed	Medium	Wheat barley, teff, peas, lentils, broad beans, rape, potatoes, sheep, goats, livestock, poultry, off-farm work	Above 1700 m; LGP, temperate cereals because of altitude
Humid Lowland Tree Crop	High	Cocoa, coffee, oil palm, rubber, citrus, yams, cassava, maize, off-farm work	Where tree crops replaced forest; > 25% source of cash income; Oil palm has local market
Pastoral	Medium	Cattle, camels, sheep, goats, remittances	LGP. Extensive livestock dominant.
Fish-Based	High	Fish, coconuts, cashew, banana, yams, fruit, goats, poultry, off-farm work	Proximity to sea or lake; fish is significant livelihood source
Forest-Based	Low	Subsistence food crops including cassava, maize, beans, coco yam and taro, and off-farm work.	LGP, humid lowland heavily forested areas
Irrigated	High	Rice, cotton, vegetables, rainfed crops, cattle, poultry	Large scale irrigation scheme; mappable; absence of rainfed agriculture
Perennial Mixed	High	Deciduous fruits, tree plantations, sugarcane	High production intensity and commercial orientation
Arid Pastoral and Oasis	Very low	Date palms, cattle, small ruminants and off-farm work, with some scattered irrigated crops and vegetables	LGP, strong hydrological and livestock connection between oases and arid surroundings
Urban-Based	High	Fruit, vegetables, dairy, cattle, goats, poultry, off-farm work	Centre or fringes of cities, population density

Source: Garrity et al., 2012.

ANNEX II AGRICS DATABASE

See below, an overview of the type of data that is registered the Agrics database.

Client ID
Client name
Season ID (type of season/ year)
Group ID
Group name
District
Site (location such as Kakamega)
New Member
Facilitator
Land Size (only related to the amount of inputs bought, eg maize seeds for 0,5 an acre)
Input Seed Choice
Input ID
Input1Qty
Input2Qty
Input3Qty
..
Repayment1Amount
Repayment2Amount
Repayment3Amount
...
Repayment1Date
Repayment2Date
Repayment3Date
...
Dropped (out of the Agrics program)
Dropped Date
Repayments Refunded
Maize input Seed Choice
Solar Light (ordered yes or no and the nr)
Bean Top-up (ordered yes or no and the nr)
KUKU Top-up (ordered yes or no and the nr)
Traction (ordered yes or no and the nr)
Solar Delivery Date