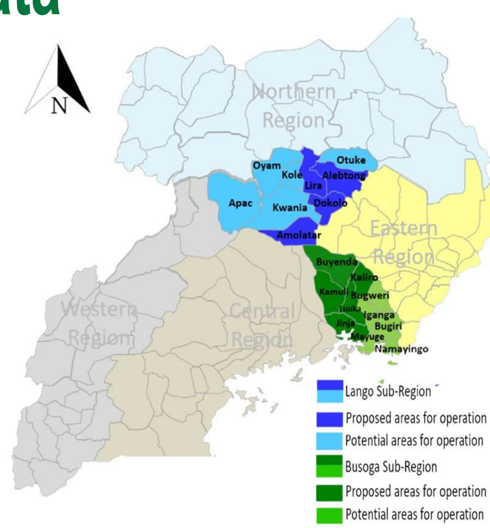
INSPIRE

INTEGRATED AND SUSTAINABLE PRODUCTION FOR INCLUSIVE RESILIENT ECONOMIES IN BUSOGA AND LANGO SUB-REGION

Farming System Analysis and main baseline data

GOAL IN PARTNERSHIP WITH
WAGENINGEN ENVIRONMENTAL RESEARCH (WENR)

Technical partners
Agriterra & Resilience BV



May 2025

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List of Acronyms

CSA	Climate Smart Agriculture
CSO	Civil Society Organisation
EKN	Embassy of the Kingdom of the Netherlands
FO	Farmer Organisation
GAP	Good Agricultural Practices
GESI	Gender Equality and Social Inclusion Analyses
HH	Households
INSPIRE	Integrated & Sustainable Production for Inclusive and Resilient Economies
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
IWRM	Integrated Water Resource Management
PEA	Political Economy Analysis
PIP	Participatory Integrated Planning
PMEL	Planning, Monitoring, Evaluation & Learning
PHH	Post Harvest Handling
PHL	Post Harvest Losses
PSA	Private Sector Actor(s)
R4S	Resilience for Social Systems
SACCO	Savings & Credit Cooperative Organisation
SHF	Smallholder Farmers
SLU	Sustainable Land Use
SWR	Stichting Wageningen Research
ToC	Theory of Change
VSLA	Village Savings & Loan Association
WENR	Wageningen Environmental Research

1. Introduction

1.1. INSPIRE

INSPIRE is a five year (2024- 2029) smallholder agricultural development project funded by EKN and implemented by a consortium of GOAL and WUR, with two international partners (Resilience BV and Agriterra) and three local partners (A2N, VEDCO and FINASP).

The overall project objective is: *Resilient and inclusive economic development of rural lowland communities*. The planned impact is: *SHFs achieve increased income and resilient livelihoods to climate change and market deficiencies*.

The project works through four pathways:

- **Pathway 1: Participatory Integrated Planning (PIP)** – inclusive community and household decision-making and action planning, with a focus on soil and water management and integrated farming practice.
- **Pathway 2: Extension via Farmers Learning Groups** - enabling farmers to learn about and adopt new production practices and technologies that increase yields and incomes in an environmentally sustainable way.
- **Pathway 3: Private sector development** – in which farmers and firms are encouraged to cooperate in a way that empowers smallholders so they can integrate in commercial value chains in a fair and sustainable way.
- **Pathway 4: Strengthening farmers' organisations** – so that they improve their services to their members (access to inputs, finance and markets) and enhance their voice in strategy and policy discussions.

1.2. Objectives

Rural livelihoods in the INSPIRE project area are fundamentally grounded in the farming systems. Sustainable and more productive farming systems are therefore a critical pre-condition for more resilient and inclusive livelihoods. In this context the first objective of this study is to identify and analyse the farming systems in the project area.

A closely related objective is to present and discuss the main baseline data collected during a survey among 1,100 households in the project area. These data cover a wide range of issues: from access to resource (land, labor), production & productivity (crops & livestock), farming practices, chain integration (input, markets), access to skills and finance, socio-political issues (PEA, gender, social capital) to final outcomes like household income, food security and resilience. These data make it possible to provide a rich and in-depth under-standing of the farming systems and livelihoods, that can serve as a benchmark for both designing program interventions and for measuring program impact in 2029.

INSPIRE is based on the Participatory Integrated Planning (PIP) approach, which empowers communities and households to design action plans at community, household and plot levels for sustainable livelihoods. The approach uses training materials originally developed for a highland context. As erosion is the main challenge to sustainable land management in mountainous areas, the training materials focus primarily on physical soil and water management practices. This leads to the second objective of this study: to identify the main constraints in the lowland farming systems and recommend adjustments to the PIP approach and materials to suit this context.

1.3. Method

This Farming System Analysis is based on four steps:

1. A quick scan of agricultural activities through two surveys: one on production practices (N=138) and one on production and sales (N= 259), covering a total of 397 households.
2. A literature review, focusing on soils, climate, and integrated soil fertility management.
3. Validation of findings from steps 1 and 2 through separate FGDs with farmers and experts in all nine INSPIRE districts.
4. Identification of three farming systems, based on steps 1-3, which then served as the basis for a baseline survey among 1,100 households. The outcomes of this survey were used to generate a more in-depth understanding of the farming systems.

From these steps, three distinct farming systems were identified within the project area:

- Perennial Integrated Farming System (PI-FS) in South Busoga
- Annual Legumes Farming System (AL-FS) in North Busoga
- Annual Oilseed Farming System (AO-FS) in Lango

Using these farming systems as a framework, a baseline survey was designed employing a quasi-experimental research design. It combined quantitative and qualitative methods and included interviews with 1,100 households: 846 in the treatment group and 254 in the control group. The control group was drawn from sub-counties where INSPIRE will not operate and where no other EKN-funded initiatives are present. Of the total sample, 366 households were in South Busoga, 364 in North Busoga, and 370 in Lango. Among the respondents, 227 HHs (25%) were female-headed.

Given the impracticality of collecting detailed data on all ten major crops and livestock for each household, a selection of five crops was made for each farming system. Three crops—maize, beans and cassava—were included across all systems, with two additional crops selected to reflect the distinct characteristics of each system. The table below outlines the specific crops chosen.

Table 1 Selected crops per farming system in the baseline survey

	Perennial South Busoga	Annual Legumes North Busoga	Annual Oilseed Lango
Maize	X	X	X
Beans			X
Cassava	X	X	X
Banana	X		
Coffee	X		
Groundnuts		X	
Soy beans		X	
Sunflower			X
Simsim			X
Vegetables	X	X	X

An important initial finding was that there were no significant differences between the treatment and control groups. This allows the combined dataset to be used in the analysis of farming systems presented in this report. Most data in this report come from the baseline survey. Some tables are based on the quick scans; this is indicated by the number of households interviewed (N=397 for the quick scan and N=1,100 for the baseline survey). In the former case, the data refer to differences between regions; in the latter, to differences between farming systems.

1.4. Structure of the report

Chapter 1 introduces the study—outlining INSPIRE, the objectives, the method, and this structure note. Chapter 2 profiles the agro-ecology of the project area, covering soils, climate, and population. Chapter 3 characterises the farming systems, detailing the cropping and livestock systems, the pressures they face, farmer-reported challenges, pathways of intensification, and a short conclusion. Chapter 4 analyses production and productivity: farm size (crops and livestock), integrated farming practices, and access to inputs, knowledge and skills, finance, and markets; it also examines labor, crop gross margins, off-farm income, social capital, and household incomes. Chapter 5 presents the conclusions—findings at the farming-system level and adjustments to the PIP approach for lowland contexts.

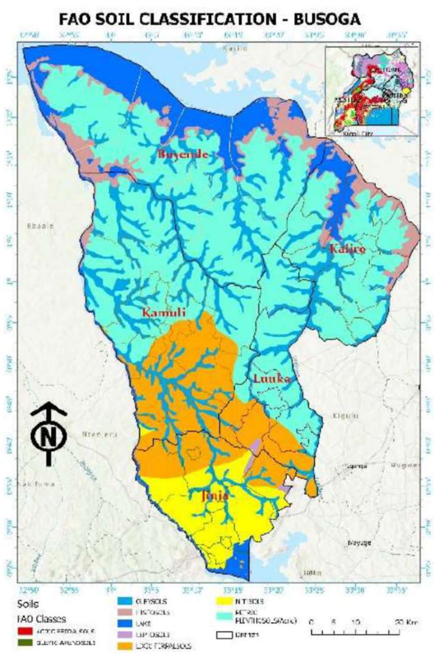
Annex I explores the key issue of Integrated Soil Fertility Management (ISFM). It also serves as the starting point for the work of a Task Force that will advise the project on how to engage with smallholders on the complex issues of IPM and IFSM.

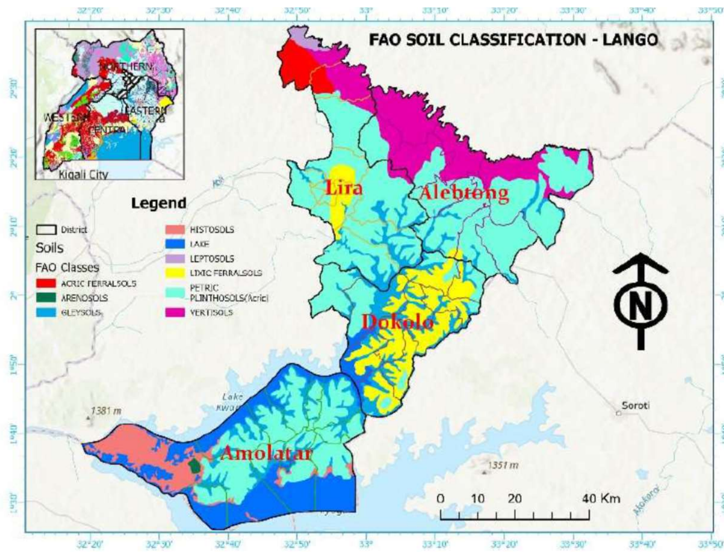
2. Agro-ecology

2.1. Soils

The land is the foundation of any farming system, both literally and practically. Figure 1 shows the FAO soil maps of Busoga and Lango.

Figure 1: Soil maps of Busoga and Lango





Plinthosols (light blue) cover more than half of the project area, dominating most of Lango, Buyende, Kaliro, and parts of Kamuli and Luuka. These deeply weathered soils have poor natural fertility, are prone to waterlogging in bottomlands and drought in shallow areas, and often develop an irreversible ironstone layer, common in iron-rich soil in warmer climates due to fluctuations in the groundwater table. While this layer restricts root development, the topsoil also has low organic matter and poor nutrient retention. Globally, such soils are mainly used for grazing.

South of the Plinthosols lies a strip of Ferralsols (orange), covering about 15% of the area (notably Kamuli and Luuka, and a small area in northern Lira). These are deeply weathered red or yellow soils typical of the semi-humid tropics. Although their natural fertility is very low, their good structure and nutrient retention allow productive use if fully fertilised, including liming. They tend to fix phosphorus fertilisers, a problem that can be managed with rock-P or localised applications of Super-P applied around the roots of the crops.

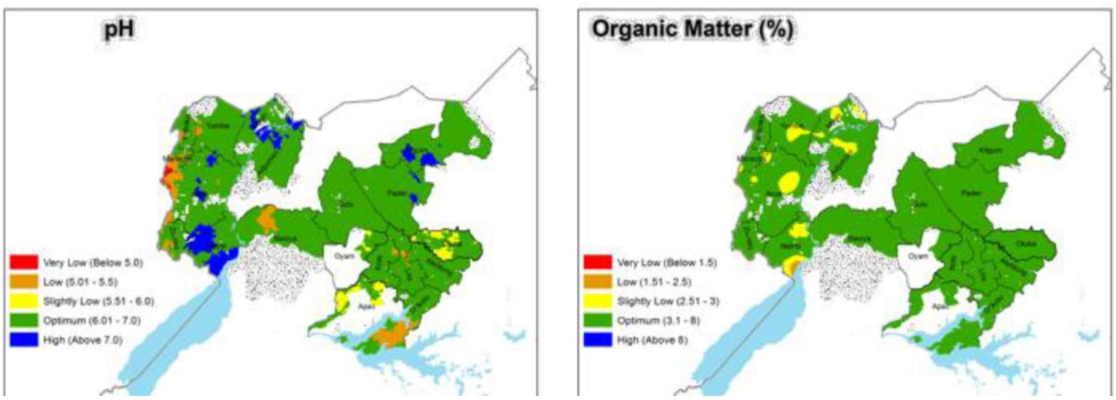
Both Plinthosols and Ferralsols are inherently poor. In their natural state most nutrients are held in vegetation, with the limited nutrients in the soil concentrated in the topsoil. Removal of vegetation accelerates degradation through erosion and via a hardening of plinthite layers into ironstone (Plinthosols), and a rapid loss of fertility (Ferralsols). While both soil types are considered poor, the impact on soil health differs. Research in East Africa shows that without fertiliser, maize yields on Plinthosols are only half of those on Ferralsols.

Nitisols (yellow) are found in the southern project area (Jinja rural and parts of Luuka) and around the towns of Lira and Dokolo, covering about 15%. These soils are generally fertile, well-structured, deep and stable. They are suitable for a wide range of crops, being well-drained but also able to retain water and nutrients. Their low capacity to deliver phosphorus can be addressed through combined fertilisation schemes (e.g. rock- or superphosphate).

Along streams and swamps there are Gleysols (dark blue). These soils are associated with wetlands and develop under anaerobic conditions. They have a characteristic blue-grey appearance when waterlogged, turning brown or reddish when drained. Gleysols are generally fertile, due to a combination of high soil organic matter and clay content, which gives them a strong capacity to retain and release nutrients. They are commonly used to grow rice and vegetables. In the extreme north of Alebtong there are vertisols as well. These are fertile but are hardly utilised, as the area is frequently flooded and has a low population density. Together, Gleysols and Vertisols cover about 10% of the project area.

Unfortunately, no maps of actual soil fertility in Uganda were found. The most relevant data on Lango can be seen on the following graphs of soil pH and organic matter.

Figure 2 Soil Organic Matter and pH in Lango



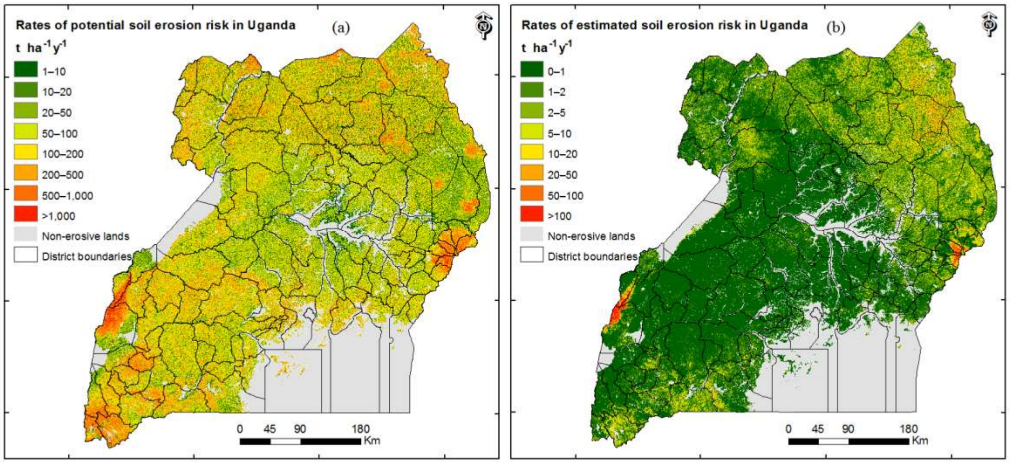
Source: Data from the Catalist project in ÍFDC (2018) Assessment of Fertiliser Distribution Systems and Opportunities for Developing Fertiliser Blends, UGANDA.

In Lango, soil organic matter is not (yet) a major constraint, but pH levels are low (5.0–5.5). Data from FINASP on over 100 soils amples in our project area showed that 78% of soils are low in nitrogen, while phosphorus is somewhat better and potassium is generally adequate. In Busoga, data from 17 soil samples in Buyende[1] show a less favorable situation, with average pH at 5.4 and organic matter and nitrogen levels less than half of desirable values (1.2% and 0.08% respectively). These sandy loams therefore have a low Structural Stability Index, indicating structural degradation or a high risk of degradation.

Land degradation is the combined result of soil characteristics, landscape position (slope catchment), vegetation and climate. The graphs show the potential and the actual erosion risks in Uganda.

[1] Odongo. R.I. et al. (2023) Evaluation of soil fertility status in the Kyoga Basin of Uganda: A physio-chemical study in Buyende and Serere districts. African Journal of Agricultural Research. Vol. 19 (10)

Figure 3 Potential (left) and estimated erosion risk in Uganda



Source: Karamage F., C. Zhang, T. Liu A. Maganda and A. Isabwe. 2014 Soil Erosion Risk Assessment in Uganda In: Forests. 2017.

The potential erosion in the project area is among the lowest in the country. District level estimates of actual erosion in the same publication show the project area to be indeed among the least affected in the country. Annual soil losses are around 1–2 MT/ha in Jinja and Alebtong, and about 0.5 MT/ha in the other seven districts. On average the erosion can be estimated at 800 kg/ha of cropland per year (see the Annex for some more details).

2.2. Climate

Rainfall and water balance

The first requirement for agricultural production is adequate rainfall. Table 2 presents the average annual rainfall distribution in the project area.

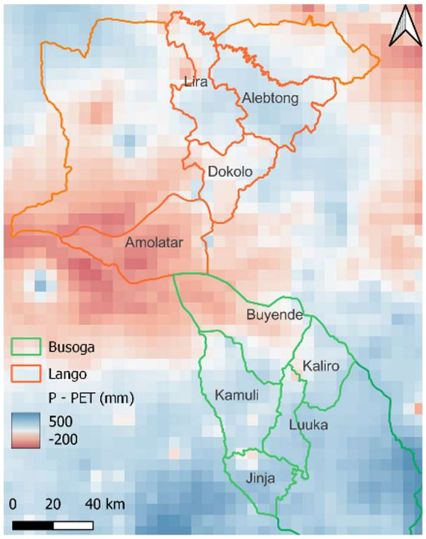
Table 2 Rainfall patterns in Busoga and Lango (mm per month)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Busoga	78	64	142	212	166	96	79	109	145	195	142	95	**1.520**
Lango	29	34	84	158	172	116	137	184	154	186	97	46	**1.395**

While total annual rainfall in Busoga is only about 10% higher than in Lango, the distribution patterns are markedly different. If 100 mm per month is taken as the minimum requirement for crop growth, Busoga experiences two short dry seasons (June–July and December–February) that are mild enough for perennial crops to withstand. By contrast, Lango faces a prolonged five-month dry season (November–March), which poses a serious constraint on the productivity of perennial crops.

Figure 5 presents the net annual water balance of the project districts: total rainfall minus total evaporation.

Figure 4 Annual water balance for the project area



The relatively small difference of 200 mm in annual rainfall is now transformed into a gap of more than 600 mm between Jinja and Amolatar. South Busoga has a clear water surplus of about 500 mm, while the northern half of Busoga and the southern part of Lango experience a deficit of around 200 mm. In Lira and Alebtong the balance is close to zero.

The combination of lower rainfall and poorer soils in Lango means that crops there suffer more from water and heat stress. Decomposition of organic matter is also more difficult, as several months each year have insufficient soil moisture for microbes to break down crop residues, manure and other biomass.

Climate change

A climate impact study by WENR showed that ongoing global climate change will also affect the farming systems in Busoga and Lango. Several climate models were used to assess changes expected over the 30-year period from 2009 to 2040 and the resulting impact on the potential yields of maize and beans.

The graphs show the projected changes in temperature and rainfall in the March-May season.

Figure 5 Projected changes in temperature (2009-2040) in the March May season

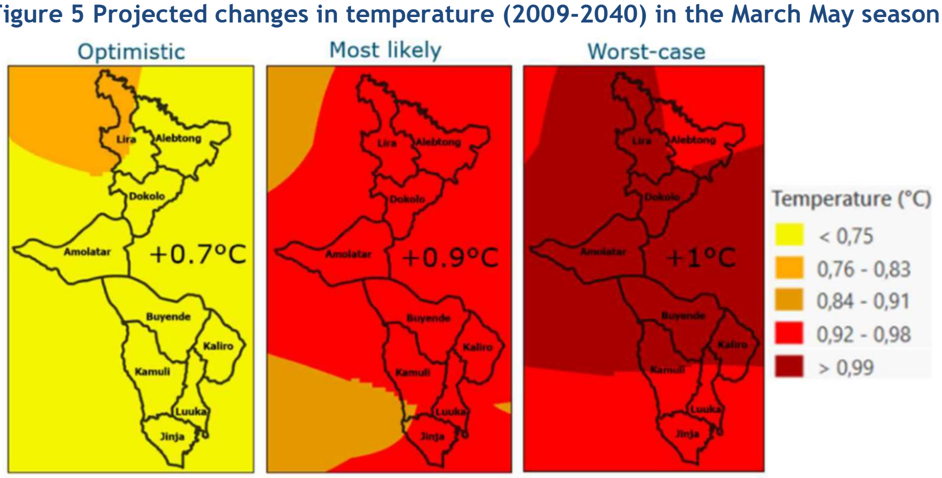
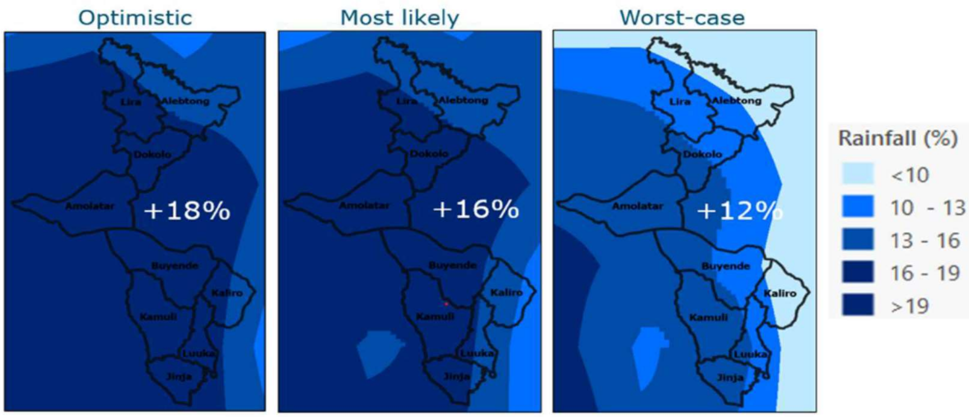


Figure 6 Projected change in rainfall (2009-2040) in the March - May season



While rainfall data show an improvement, higher temperatures increase evaporation as well, which can reduce water-use efficiency and lead to heat stress on crops.

A critical factor is the length of the rainy season, more particularly the onset of the rains, and the length of dry spells during the season. The outcomes of the climate models in this respect are complex. The WENR report explains that the number of consecutive wet days is expected to decrease (by up to 6 days), particularly under the worst-case scenario. Based on historical climate projections (1961-2005), the onset of rainfall in the Busoga-Lango region ranges between 21 March and 20 April. The recent climate assessments also indicate that an early onset of rain (3 - 6 days) can be expected in the 2030s. (2030-2040). In the 2050s (2040-2069), however, the onset of rainfall is expected to be early in some areas (by up to 4 days), while a delay of up to 6 days is projected in other areas.

The table gives the details on the overall projected impact on yields of maize and beans in the MAM season.

Table 3 Projected impact of climate change on potential yields of maize and beans in MAM season

	Maize			Beans		
Region	Optimistic	Likely	Worse	Optimistic	Likely	Worse
Bosuga	-2%	-2%	-8%	-9%	-14%	-14%
Lango	+2%	+2%	-13%	-8%	-12%	-15%

The impact on maize is limited, unless the worse-case scenario would unfold. In Busoga the optimum plantings date (remains) the first half of March. In Lango the second half of March is optimal. For beans a yield reduction of over 10% in three decades is likely. The models show the potential yields increase substantially when planting is shifted from the start of March to the start of May. In Busoga the increase is one around one third; in Lango it is even much higher as the yields from planting March are much lower. The difference in impact between maize and beans suggest (underlines) that heat stress is the main challenge.

The report concludes that farmers can minimise these impacts by adjusting planting times and using more short-maturing varieties. This is already happening as farmers adopt earlier-maturing crops. Plant breeders are also responding, although yields of such varieties tend to be lower. Improved soil and water management – through mulching, organic materials, and physical measures such as contours and micro-catchments – is also essential to mitigate the negative effects.

An important disclaimer on these data is that they refer to *potential* yields. These are yields that are only limited by water and warmth. In the case of maize this goes up to ten MT/ha, or more than ten times the actual yields of smallholders. As we will see below, these yields are severely limited by pests and diseases, weeds, low soil fertility and poor agronomic practices the final impact of climate change is hard to project. In the case of beans farmers already complain that beans yields are going down, and they think that this is due to a decline in soil fertility. Maybe the higher temperatures plays a role as well.

Addressing climate impacts requires not only adjustments in agronomic practices but also complementary strategies such as tree planting, producing high-value crops under irrigation, and shifting towards small livestock.

When farmers are asked about climate change, their perceptions are not uniform. While 59% believe rainfall has decreased, 31% feel it has increased. Most, however, agree that the onset of rains is delayed. There is stronger consensus on temperature: 75% of respondents report that it has risen. These align closely with the Climate Impact Study.

When people were asked about their experiences with natural disaster in the past 5 years, 91% confirmed to have been impacted by climate-related natural disasters, with minimal variation across the farming systems. Droughts were mentioned by 94% of households. Due to the ongoing siltation of Lake Kyoga, waterlogging is a challenge in Buyende (19%) and Amolatar (25%). Storms are more prevalent in Northern Busoga, with Buyende at 39 % and Kaliro at 33 %. When asked how they coped with the immediate impact of these hazards, 79% did not take any action, either because they did not feel the need, or lacked the capacity to do so.

Another question related to the measure people take to become less vulnerable to climate change. The table shows the responses.

Table 4 Mitigation measures to climate change (N = 1,100)

Measure	Perennial system	Legume system	Oilseed system
Farm diversification	29%	20%	17%
Agroforestry	23%	20%	5%
Change crops / season	5%	9%	15%
Change variety / seeds	4%	1%	5%
Income diversification	4%	1%	13%
Soil / water conservation	3%	2%	2%
Irrigation	7%	2%	0%
No action	**64%**	**65%**	**58%**

The main responses are diversification of farm income planting trees (agroforestry) in Busoga. Focus group discussions suggest the diversification involves investing in small stock (pigs, chicken, goats) that are less susceptible to climate change and can generate more steady income throughout the year. In Lango households look for income diversification and change of crops (see Section 3.3 how this is also linked to a decline in soil fertility). Very few HHs are responding by working on soil and water conservation. Irrigation is not seen as an option, except in the perennial system.

2.3. Population

Table 3 presents the population density in the project districts, based on the 2024 census.

Table 5 Population density per district (based on 2024 census)

Districts	Inh/km^2	Districts	Inh/km^2
Buyende	293	Alebtong	185
Kaliro	368	Amolatar	162
Kamuli	357	Dokolo	215
Luuka	459	Lira Rural	232
Jinja Rural	563		
BUSOGA	**408**	**LANGO**	**199**

Source www.geo-ref.net/ph/uga.htm

Population density in Busoga is more than twice that of Lango. Within Busoga, the southern districts again have densities about 50% higher than those in the north. There is a clear relationship between population density and soil fertility: on Plinthosols, population density is about half that found on Ferralsols. This reflects wider research in East Africa[2] showing that maize yields on Plinthosols without fertiliser are half those on Ferralsols.

Population growth has averaged close to 3% per year over recent decades. As a result, the number of inhabitants per km^2 has tripled in the last forty years, placing enormous pressure on land use and natural resource management.

[2] Kiwia A., D. Kimani, R. Harawa, B. Jama and G.W. Sileshi (2022). Fertiliser use efficiency, production risks and profitability of maize on smallholder farms in East Africa. In: Experimental Agriculture (2022), vol. 58., page 1–16.

3. Farming systems

Any farming system is the logical outcome of its geographical context. Soil and climate determine what can be produced competitively, while markets determine what can be sold. Population pressure shapes the balance between livestock (especially cattle) and crops. It also determines farm size and, therefore, the balance between food and cash crops.

In this chapter, we first examine the two main pillars of the farming systems: the cropping system and the livestock system (particularly cattle). The current systems are then placed in historical perspective: identifying the main trends of the past few decades and, on that basis, the most likely trajectories in the coming decades.

This chapter highlights the main elements of the farming systems, while the next chapter explores actual production and productivity within these systems, which must be understood in the context of the overall system.

3.1. Cropping system

Farming systems are most easily characterised by the dominant crops cultivated. The table below shows the crops identified as most important by farmers in the nine project districts, based on the initial quick scan of 397 households.

Table 6 The most important crops per district (N= 397)

	Banana / Coffee				Maiza/ Cassava / Legumes			Maize/ Cassava / Oilseeds				
	Jinja	Luuka	Kamuli	Av.	Kaliro	Buye.	Av.	Lira	Dokolo	Alebt.	Amol.	Av.
Staples												
Maize	31%	15%	24%	23%	16%	22%	19%	24%	29%	20%	22%	24%
Cassava	9%	12%	3%	8%	14%	24%	19%	20%	22%	28%	8%	20%
TOTAL	40%	27%	26%	31%	29%	46%	38%	44%	51%	49%	30%	43%
Perennials												
Matooke	16%	11%	9%	12%	5%	1%	3%	0%	0%	0%	0%	0%
Coffee	4%	17%	41%	21%	2%	2%	2%	0%	0%	0%	0%	0%
TOTAL	20%	28%	50%	33%	11%	4%	7%	0%	0%	0%	0%	0%
Legumes												
Beans	24%	3%	3%	10%	17%	5%	11%	8%	9%	6%	8%	8%
Groundnuts	0%	5%	3%	3%	14%	19%	16%	0%	7%	13%	0%	5%
Soya	4%	1%	0%	2%	13%	12%	12%	11%	7%	9%	3%	7%
TOTAL	29%	9%	6%	14%	44%	35%	39%	18%	24%	27%	11%	20%
Oilseeds												
Simsim	0%	0%	0%	0%	1%	0%	1%	3%	9%	10%	42%	16%
Sunflower	0%	1%	0%	0%	0%	0%	0%	11%	4%	1%	4%	5%
TOTAL	0%	1%	0%	0%	1%	0%	1%	14%	13%	11%	47%	21%

Note: Blue and green cells indicate that at least 10% of HHs mentioned the crop among their three most important—blue at district level and green at farming system level. Brown cells highlight the group of crops that characterise a farming system.

Maize and cassava are dominant across all areas, except for cassava in South Busoga. Perennial crops are concentrated in South Busoga, where soils are well-structured and deep, and rainfall is sufficient. Fieldwork suggests that the towns of Kamuli and Kaliro mark the northern boundary of this system. Further north, soils are poorer (Plinthosols) and the dry season is more pronounced, favoring annual crops in the cropping pattern.

Market access is the main factor distinguishing the two sub-systems in Busoga. Legumes dominate in North Busoga, where they have a comparative advantage, while oilseed crops are concentrated in Lango, where they have a ready market.

This clustering of crops across neighboring districts led to the distinction of three cropping systems:

A. Banana/coffee perennial system in South Busoga
B. Maize/ cassava/ legumes system in North Busoga
C. Maize / cassava / oilseeds in Lango.

This classification formed the foundation for dividing the INSPIRE project area into three farming systems, and it provided the basis for sampling in the baseline survey.

3.2. Livestock system

While most rural households keep a mix of livestock (poultry, pigs, and goats), the number and type of cattle are the defining factor, as they are closely linked to the overall land use system. In fact, cattle numbers both influence land use and are influenced by it. Cattle thus represent the second pillar of traditional African smallholder farming systems. The table below presents the basic baseline data on cattle.

Table 7 Number of HHs with meat and dairy cattle (N = 11,00)

Type of cattle	Perennial system	Legume system	Oilseed system
Meat cattle			
% of HHs	13%	43%	37%
Av. # of animals	1.94	3.23	4.29
# of cattle/cap.	0.03	0.20	0.27
Dairy cows			
% of HHs	13%	8%	2%
Av. # of animals	2.9	4.4	4.8
# of cattle/cap.	0.05	0.05	0.01
Total of meat and dairy			
% of HHs	26%	51%	39%
Cows/capita	0.08	0.25	0.28
Share dairy cows	60%	20%	5%
Cattle/km^2	31	81	57

Note. The average number of animals refers only to households that own cattle.

A quarter of the households in the perennial system keep cattle. Half of these raise dairy cows, while the other half rear traditional East African Shorthorn Zebu for meet. Because households with cows for milk tend to own larger herds, 60% of all animals are dairy cows. Overall herd density is limited to 31 head/km^2.

In the legumes system, about half of the households own cattle, with the vast majority (80%) being meat animals (incl. a few Long Horn Ankole). These herds are, on average, 50% larger than in the perennial system, resulting in a per capita cattle population roughly three times higher. The 81 head/km^2 recorded here exert considerable pressure on land use.

In the oilseed system, herd size is larger than in the legumes system but the number of dairy cows is very small. Since fewer households keep cattle (39%), the number of animals per capita is similar to that in the legumes system. As population density is lower the number of cattle per km^2 is also lower.

As the level of exotic blood in the animals varies a lot it is difficult to distinguish between more local cows and crossbreds. Only 49 cows were classified as ‘real crossbred’; they produced a 5-10 liters per day at their peak (with an average of 6.5) which generated 1.2 million UGX of gross income per head of cattle (incl. none-productive animals). With 3.5 heads this is nearly 50% of their average total annual income of 8.8 million UGX.

Households reporting to keep cows for milk with low levels if exotic blood, get 2-4 liter per day at peak, generating 800,000 UGX per head per year. Here the average herd of 3.5 heads generates 60% of their average income of 4.5 million UGX.

Management practices are poor across the board. Just as an illustration: only 64% of the cows kept for milk in the perennial system are vaccinated and 26% are housed separately. In other areas this is much less. Section 4.1 provides more details on livestock management.

3.3. Farming systems under stress

To understand the production and productivity of a farming system, it is essential to consider the underlying trend that shapes and transforms it: population growth. Over the last four decades, population density in Busoga and Lango has tripled. As noted earlier, this has resulted in well over 400 inhabitants/km^2 in South Busoga, with about half that density in other areas.

This rapid population growth has had a profound impact on both natural resource management and production across all farming systems. In this section, we examine the main changes over recent decades in vegetation (trees and grazing areas), wetlands, livestock, and crops. These changes are interconnected, with developments in one dimension often reinforcing shifts in others.

Vegetation

Overexploitation of trees for firewood, charcoal, bricks, and timber – combined with expanding cropland – has accelerated land degradation and erosion of hills, wetlands, and cropland itself. The micro-climate has also deteriorated, with reduced rainfall and increased heat, evaporation, and dry spells.

Wetlands

Encroachment (and sometimes privatization) of wetlands has led to active water management (drainage and irrigation) for sugarcane, rice, and vegetables. Trees have been cleared, and opportunities for grazing and watering livestock are severely reduced. Land degradation in upstream areas (Mt Elgon) leads to the siltation of Lake Kyoga and Lake Kwania which causes wetland shores to become frequently inundated, leading to the loss of high-value cropland and grazing areas. In case of heavy rainfall this leads to serious floodings causing (e.g. in Alebtong in Aug. 2025). Serious conservation measures of the government means that traditional fishing communities along the shores of the lakes lost their livelihood; this had a particular deep impact on the peninsular of Amolatar.

Crops

Soil fertility and yields have declined dramatically. In focus group discussions, farmers reported yields being halved - from 8–10 to 4–6 bags per acre – due to less manure, minimal or no fallowing, and nearly continuous double cropping. Soil mining continues at an alarming rate. Ever-smaller farm sizes force households to prioritise food production (to avoid buying food), making maize and cassava the dominant crops across the area. In North Busoga and Lango, crops that require good soil fertility are disappearing—such as cotton, finger millet, and pigeon pea—while beans are significantly reduced.

External factors add to these challenges. Local and global climate change has led to higher temperatures and less reliable rainfall patterns. Slowly improving local infrastructure has eased access to inputs and markets, yet poverty means demand for markets grows faster than access to inputs. Improved national and international roads have also increased competition with frontier areas such as southwest Tanzania, driving down prices for crops like maize, which in turn makes farmers less willing to invest in inputs.

Livestock

Population growth would normally increase demand for livestock, yet as crop production is more efficient (both in terms of food and income) than cattle, extensive livestock keeping is being displaced by crops. Only in Amolatar some free grazing remains. Herd sizes dropped dramatically—from around a dozen cattle to half a dozen or fewer per household, mostly used for ploughing.

Historical data illustrate this trend[3]. In 1965, the oilseed system had between 1 and 2.5 animals per capita; today it has only 0.3 heads per capita—an 80% decline. In the legume system, cattle numbers fell from 0.5–1.0 heads per capita to 0.3 (a 60% decline). In the perennial system, Jinja had fewer than 0.1 heads per capita in 1965, and Kamuli had up to 0.5; today the average is just 0.04 heads per capita—less than half the previous level. However, today 60% of these animals are dairy cows, a clear indication of system change.

3.4. Challenges experienced by farmers

The following table presents the main challenges reported by households when asked to identify the most important problems in crop production.

Table 8 Challenges in the crop production and marketing system (N= 1.100)

	Perennial	Legumes	Oilseed	TOTAL
Production challenges				
Pests and diseases	63%	79%	69%	**70%**
Water shortage / droughts	58%	70%	72%	**67%**
Low soil fertility	52%	61%	28%	**47%**
Weeds	53%	56%	40%	**50%**
Water accumulation / heavy rainfall	9%	13%	8%	**10%**
Soil erosion/soil degradation	1%	11%	3%	**5%**
Challenges with inputs				
High cost of inputs	29%	35%	66%	**43%**
Poor quality seeds	21%	24%	27%	**24%**
Fake inputs	10%	7%	12%	**10%**
Challenges with marketing				
Lack of markets for produce	3%	16%	36%	**19%**
Low prices for farm produce	9%	19%	54%	**27%**
Post-Harvest Losses	5%	13%	30%	**16%**
Challenges with resource base				
Land shortage	26%	28%	24%	**26%**
Labor shortage	3%	10%	24%	**13%**

The production challenges are considerable. Pests, drought, weeds, and low soil fertility affect all three farming systems. These issues are interrelated: declining soil fertility contributes to higher incidence of pests and diseases, as well as greater vulnerability to heat stress and drought. In the oilseed system, relatively larger farm sizes mean that soil fertility and weed pressure are (still) less acute challenges.

Climate change further compounds these problems: dry spells reduce yields, while heavy rains—reported by around 10% of households—cause flooding, crop lodging, and post-harvest losses. Erosion affects about 10% of households in the legume system, reflecting the low soil pH and limited soil organic matter (see Section 2.1), combined with a high cattle density (81 cattle/km^2).

[3] Baker P.R. 1968. *The distribution of cattle in Uganda*. East Africa. Geographical Review. No.6. April 1968, pp 63-73.

In terms of value chain integration, input supply tends to be a greater challenge than marketing. In Lango, high input prices pose a particular barrier, while limited market access results in low farm-gate prices and post-harvest losses, especially for crops such as simsim and sunflower

3.5. Intensification of the farming systems

This section examines the overall process of intensification within the farming systems, as a direct result of growing population pressure.

Banana/coffee system
This system is found in South Busoga, particularly in Jinja Rural and Luuka districts, as well as the southern half of Kamuli and Kaliro. With favorable soils and rainfall, virtually any crop can be grown, and farmers benefit from relatively good access to markets. Population pressure, however, is very high, with 72% of HHs cultivating less than two acres of land.

In terms of natural resource management, most original vegetation has been cleared for firewood, charcoal, timber, and brick production, though some private forests and on-farm tree planting remain. Private nurseries are also common, particularly near towns. Over the past 15 years, virtually all wetlands have been converted to sugarcane production following the establishment of new factories responding to rising global sugar prices. While the direct environmental impacts appear limited, there may be negative consequences for downstream communities.

Production is centered on intercropping banana and coffee – bananas providing food security and coffee generating cash income – supplemented by a variety of other crops such as maize, cassava, beans, and soya. The livestock system is well into transition, with free grazing virtually absent. Some households are adopting fodder planting (including shrubs like Calliandra) and cut-and-carry practices. Over half of the cattle are now crossbreeds.

Favorable agro-ecological conditions support a well-integrated farming system in which nutrients are effectively recycled through manure and crop residues. Banana groves, especially those near homesteads, accumulate nutrients as organic matter decomposes rapidly and nutrient removal through harvest remains limited, resulting in higher yields. A considerable number of (larger) farmers also apply inorganic fertilisers, particularly on coffee, rice, and maize.

These favorable conditions facilitated an early penetration of the capitalist mode of production. Investments in sugarcane and cotton historically drove improvements in infrastructure, education, urbanisation, and cottage industries. Today, the area is relatively well connected, with several large towns. Farmers, including smallholders, enjoy better access to inputs, services, finance, and markets, which enables engagement in higher-value activities such as vegetable production, poultry, piggery and dairy. Around half of farmers use some form of irrigation, almost exclusively with simple tools such as watering cans.

Maize / Cassava/ legumes system
This system is predominant in North Busoga, with Buyende district at its core and extending into the northern parts of Kamuli and Kaliro. Poor soils and lower rainfall make perennial crops unviable, forcing farmers to focus on rainfed annual crops (typically two seasons per year) and cassava. Interestingly, only two decades ago the area was still described as a banana/cotton system, but both crops have disappeared from smallholder farming due to declining soil fertility and climate change.

In terms of natural resources, there was until recently some "unused land," and the area was known for exporting charcoal by truckloads. Today, tree resources are depleted, prompting farmers to begin small-scale tree planting, often in agroforestry configurations. Unlike South Busoga, there are no private nurseries and very few private forests. Wetlands remain partially intact; in some, rice is cultivated, and in a few cases, sugarcane. With a new sugar factory planned in the district, wetland conversion to cane production is expected to increase significantly.

Traditionally part of the cattle corridor, the area once supported extensive grazing. Today, about half of households keep cattle, but herd sizes are much smaller than in the past, leaving the number of animals per capita at less than half of historical levels. Nonetheless, cattle density remains high at 81 heads per km^2, enhancing the risk of soil erosion. A minority of farmers keep crossbred dairy cows, but these are managed in the same way as local breeds—tethered on common land—yielding little milk and income. There is little sign of intensification, such as fodder production or grass strips.

Cropping has narrowed to a minimum. Limited farm sizes and poverty force most HHs to allocate land primarily to maize and cassava for food security. Maize, the dominant crop, leads to heavy soil mining. Cassava, by contrast, serves as a "semi-fallow" crop: its canopy covers the soil for an extended period, and its leaf fall contributes organic matter. Legumes – including beans, soy, and groundnuts—play a dual role: they support soil fertility through nitrogen fixation and provide a cash source, with groundnuts as the leading cash crop. While markets exist, they are strongest at harvest. Fertiliser use is minimal, and irrigation is virtually absent.

The farming system remains poorly integrated, with weak nutrient recycling. Only one-fifth of farmers apply manure to their fields. Others even sell manure to (urban) buyers for nurseries and vegetable production. Composting is not economically viable, and although mulching is practiced after the first rainy season (when moisture allows partial decomposition), residues left in the long dry season tend simply to dry out. Small amounts of mineral fertiliser are applied occasionally, mostly on maize and groundnuts.

Labor bottlenecks further constrain production. Weeding peaks twice a year, creating the paradox that even in densely populated areas, farms face labor shortages. Poorer farmers often hire themselves out to weed the fields of better-off households to earn daily food, leaving their own fields under-weeded and perpetuating cycles of poverty.

Maize / Cassava / Oilseeds
This system is found in Lango. It resembles the maize/cassava/legumes system of North Busoga, but oilseeds have taken the place of legumes due to strong local markets. Poor soils and low rainfall limit options to rainfed annual crops (two per year) alongside cassava.

With respect to natural resources, some "unused land" remains in districts such as Amolatar. In general, tree cover is scarcer than in Busoga, and signs of intensification are limited, occurring mainly in Lira and Dokolo where better Ferralsols are found. While commercial woodlots exist, farmers do not typically plant trees, even in agroforestry configurations. Private nurseries are rare and appear only near towns.

Wetland encroachment is less extensive than in Busoga. Where wetlands are used, it is mostly by young farmers producing rice and vegetables. Ongoing population growth suggests future competition over wetland control. Only a few formal irrigation schemes exist, based on small dams, while communities around Lake Kyoga face rising water levels caused by upstream land degradation, which has already reduced valuable cropland and grazing areas.

Lango, like Busoga, was historically part of the cattle corridor. Today, free grazing has declined, though larger herds remain in Amolatar. A notable development is the replacement of short-horn Zebu with the more productive Ankole breed, reflecting a modest form of intensification in beef production. Nearly 40% of households still keep cattle, but herd sizes are small, and animals are primarily used for ploughing. Broader signs of intensification, such as fodder production or grass strips, are absent.

Cropping systems have narrowed to maize and cassava, which provide basic household food security. Oilseeds (particularly simsim and sunflower) serve as the main cash crops and add diversity to crop rotations. Strong demand from processors has stimulated production through seed distribution and farmer training, creating informal contract-farming arrangements. Outside a few formal irrigation schemes, very limited irrigation is practised, mostly using watering cans.

Like in Buyende in North Busoga, the system is poorly integrated, with weak nutrient recycling. Farmers rarely apply farmyard manure or incorporate crop residues. Composting is uneconomical, and mulching only works in the first rainy season (July), when residues can partly decompose. During the long dry season residues desiccate and are often burned.

A specific challenge in Lango is the widespread rejection of mineral fertilisers. NGOs, projects, and companies promoting organic oilseeds advise farmers against fertiliser use, claiming it damages soils. In addition, farmers view fertilisers as ineffective because they require application every season, unlike organic inputs perceived to have longer-lasting effects. Finally, labor bottlenecks during the two annual weeding periods are even more severe as in North Busoga (as HHs have more land). Poorer households often sell their labor for weeding on better-off farms, leaving their own plots neglected and reinforcing cycles of low productivity and poverty.

3.6. Conclusion

Soil types and characteristics strongly shape land use patterns. Plinthosols, which form part of the cattle corridor from south-west to north-east Uganda, are characterised by low population density, poor soil fertility, and limited access to input and output markets. In technical terms, extensive grazing is the most sustainable form of land use. However, growing population pressure pushed households to replace traditional cattle with crops that generate more food and income per acre and per labor day. While crop cultivation offers short-term benefits, it accelerates soil fertility decline through soil mining.

The Ferralsols and Nitosols of the Lake Victoria Crescent provide better opportunities. This is the most urbanised part of Uganda, with high population densities and relatively good soils. These conditions allow for more intensive and diversified farming systems that integrate dairy, horticulture, and woodlots to respond to market demand. Nitosols in Lango can support similar trends, and indeed higher population densities are found in Lira and Dokolo. However, markets are less diverse and rainfall less favorable, limiting the extent of intensification.

Over the past decades of rapid population growth, farming processes have been effectively “reversed.” In the past, nature worked for farmers by regenerating tree cover, restoring grazing lands, maintaining soil fertility, and regulating pests and water flow in wetlands. Today, farmers must actively take over these functions. They must plant and manage trees and fodder crops, maintain soil fertility through amendments, control pests and diseases directly, and manage wetland water resources.

To make these investments viable, farmers require new crop varieties and livestock breeds that can respond to more intensive management. They also need reliable access to inputs, finance, and markets. This transition demands new knowledge and skills, alongside strong linkages to value chains. At the same time, successful intensification depends on working with nature – by adopting soil and water conservation practices that enhance natural ecosystem services and support the long-term sustainability of production systems.

4. Production and productivity

The production and productivity of the farming systems are shaped by multiple factors. This chapter begins by examining crop and livestock production (resp. 4.1. and 4.2). It then considers integrated farming practices, with a focus on how these practices differ across the farming systems (4.3). Subsequent sections assess access to inputs (4.4), knowledge and skills (4.5), finance (4.6), and markets (4.7). Section 4.8 analyses the availability of labor, while Section 4.9 explores yields, prices, and gross revenues. The chapter concludes with a review of off-farm income (4.10), gender dimension (4.11), social capital (4.12), household income (4.13), food security (4.14) and resilience and poverty indices (4.15).

4.1. Crop production

As INSPIRE targets households with less than 10 acres of land, the baseline survey was conducted among this group. The results show that 53% of households operate on less than 2 acres, while the remaining 47% manage between 2 and 10 acres. The following table presents basic data on farm size across the three farming systems.

Table 9 Farm sizes in the three farming systems (N= 1,100)

Farm size	Perennial	Legume	Oilseed	Female	Male	Average
Own land	1.9	2.9	3.6	2.4	3.3	2.8
Rented land	0.3	0.6	0.8	0.5	0.7	0.6
Total cropped	**2.2**	**3.5**	**4.4**	**2.9**	**4.0**	**3.4**
< 2 acres	72%	55%	33%	61%	42%	53%
> 2 acres	28%	45%	67%	39%	58%	47%

The relationship between farm size and population density is clear. In South Busoga, more than two-thirds of households own less than two acres, while in Lango the reverse is true, with two-thirds holding more than two acres. North Busoga falls in between.

The overall average farm size is 2.8 acres per household. Farm sizes are about 30% larger in the oilseed system and 35% smaller in the perennial system. Female-headed households own and cultivate 27% % less land than male-headed households.

The data show an active land rental market in the annual systems. On the one hand, this reflects that many households do not have sufficient land of their own. On the other hand, it suggests that a significant proportion of families possess more land than they are able to actively manage, often due to constraints in capital, labor, or both. The table shows the land allocated to the different crops.

Table 10 Allocation of land to the main crops (N=1.100)

Farming system	Crop	Share in respective sample	Area per grower	Acre for total sample	Share of total area
All three farming systems	Maize	82%	1.30	1.1	34%
	Cassava	54%	1.00	0.5	17%
	Beans	33%	0.70	0.2	7%
Perennial system South Busoga	Coffee	27%	0.78	0.2	7%
	Banana	24%	0.52	0.1	4%
Annual Legumes North Busoga	Soya bean	13%	0.94	0.1	4%
	Groundnuts	15%	1.04	0.2	5%
Annual oilseeds Lango	Simsim	28%	1.26	0.4	11%
	Sunflower	27%	1.28	0.3	11%

This table requires some clarification. In the third column, the percentage of households growing each crop reflects only those included in the survey sample (see Table 1). As a result, the land share of groundnuts and soy is slightly underestimated in the last column. Both are important crops in the perennial and oilseed farming systems (see Table 4), and their true share may be closer to 6–7%, which would raise the overall share of oilseed crops to about 10%.

Maize and cassava dominate, together accounting for half of all farmland in the project area. The remaining land is more diverse, with six crops each covering between 7% and 10%. Irrigated vegetables (mainly tomato, cabbage, eggplant, and watermelon) are grown by about 5% of all HHs. Sweet potato plays a minor role in all systems, while sugarcane in South Busoga and sorghum in Lango hold a more substantial share.

In the legume system 80% of households reported to have a kitchen garden. In the other two systems this was half of HHs: 51% in the perennial- and 49% in the oilseed system.

On average, maize and cassava jointly occupy 1.6 acres per household. Given that more than half of households have less than two acres in total, this suggests that most of them grow little else beyond these two staple food crops. By contrast, other crops tend to function as cash crops, cultivated mainly by better-off farmers. For example, in Lango, farmers who grow oilseeds allocate an average of 1.25 acres to them. In the legumes system this figure is about 20% lower, while in the perennial system it is 50% lower, reflecting the much smaller overall farm sizes there.

Irrigation

Because irrigation is a complex sub-system, a separate rapid assessment was carried out to capture existing practices. Irrigation is most common in the perennial system, where 10% of households engage in irrigated vegetable production. In contrast, uptake is much lower in the annual systems, at 5% in the legumes system and just 1% in the oilseed system.

Nearly all irrigation is manual and small-scale, relying on buckets, watering cans, or hoses for vegetable plots. Gravity-fed methods—such as flood or furrow irrigation—are not in use. Most water is sourced from surface bodies, including swamps (32%), streams (20%), and lakes (4%). Groundwater plays a smaller role, drawn equally from shallow wells (32%) and boreholes (28%).

Three main types of irrigation practice were observed:

1. **Supplementary irrigation** during dry spells;
2. **Shifting production cycles** to take advantage of seasonal market opportunities;
3. **Off-season production**, where farmers target high-value markets when prices peak.

The potential income gain increases substantially along this continuum, with off-season production offering the highest returns. Like in all farming systems horticultural crops command a much higher income per acre; please see par. 4.8 for some more details.

When asked about future irrigation potential, 45% of HHs reported no accessible water source. About 23% saw shallow wells as a option, while only 4% considered boreholes viable. Another 25% mentioned surface water sources: streams (15%), rivers (6%), and lakes (4%).

The study identified several strategic opportunities to strengthen irrigation practices and reduce unsustainable pressure on natural resources:

- Wetland cultivation is already widespread, but sustainability could be improved by raising productivity per unit of land. This would help curb the tendency to expand cultivation around wetlands. At the same time, irrigation expansion should be promoted in other areas.
- Water availability in and around wetlands could be enhanced through diversion systems or the development of larger reservoirs, particularly to support pumped irrigation.
- Low-cost shallow wells represent a promising and scalable option for smallholder irrigation.

The study distinguished 3 categories of farmers, each requiring a tailored learning strategy:

- Strategy 1 – Entry-level farmers: New entrants to horticulture can be supported by lead farmers with prior experience. Training priorities include nursery bed preparation, good agronomic practices, rainwater harvesting, and effective manual watering techniques.
- Strategy 2 – Experienced rainfed farmers: Groups already engaged in rainfed horticulture need support as they shift production to the dry season. Training should focus on irrigation timing and water application techniques.
- Strategy 3 – Farmers already using irrigation: These farmers benefit most from advanced training in improved methods, such as the use of furrows or basins combined with pumps.

To start the implementation of the irrigation strategy a detailed assessment was carried out and 53 irrigation hotspots were identified where in total 1,111 households cultivate vegetables over a combined area of 422 acres (so 0.38 acre or 1.500 m^2).

As we will see in par. 4.8 the gross margin of vegetables is very attractive. Income per acre for the benchmark crop, tomato, is more than one million UGX under rainfed conditions and with manual irrigation. When pumps are used and the production is shifted to the dry season, this can increase over four million. This could be doubled when the agronomic practices are further optimized (hybrid seeds; fertilisation; pest management).

These findings highlight irrigation as both a driver and a reflection of intensification in the farming systems. By enabling higher-value crops, improving resilience to climate variability, and creating new learning opportunities, irrigation stands out as a critical lever for transforming smallholder farming under growing population pressure.

4.2. Livestock

In Section 3.2 the role of cattle in the farming systems was explored; it showed 39% of all households keep cattle. In the perennial system this was only 26% and in the legume system 50%. The oilseed system scored 39%. This section focuses on small livestock, which can play an important role in household food security and income diversification. Overall, 75% of all households have some form of small livestock. This also means that 25% have none; generally, these are the poorest HHs.

Table 11 Small stock ownership across farming systems

	Perennial	Legumes	Oil seeds	Female	Male	Total
Goats	36%	49%	42%	41%	44%	42%
Chicken	42%	39%	42%	43%	38%	41%
Pigs	16%	14%	17%	14%	17%	16%
Sheep	1%	0%	13%	4%	5%	4%

Overall, the distribution of small animals is fairly balanced across the three farming systems. Female headed HHs have a relative preference for chickens. Goats and chicken are the most common small stock, each kept by some 40% of households.

Half of farmers with goats have 1-3 traditional East African Small Goats. One quarter has more than 10 goats. Average herd size is 4.5 and annual sales are a mere 25% (1.1 goat) at around 100.000 UGX each (both mature and kids). This illustrates the role of goats as a family saving; they can reproduce and grow without much cost, and can be sold at times of duress. In the perennial system less goats are found. In Lango 5% of the HHs report to have Mubende goats, a sturdy goat for meat production. The annual off-take was slightly better at 34%. In Lango sheep have a similar profile as goats.

The average flock size of local chicken is 12. Less than 1% of HHs have an improved breed: in the perennial system two HHs had 700 Kenbro between them (a free ranging, dual purpose bird). In Lango one HH has 100 Sasso (layers) and four other HHs had 35 between them.

Pigs are also relatively widespread, with one in six households rearing them—a notably high proportion. The vast majority (88%) have local pigs; on average 4.1. The annual offtake is 1.6 or 38%. A small group of 16 HH (1.5% of all HHs) keep an improved breed (White Large); on average 5.3 animal with a better off take of 3.8 per year or 71%. Most of these HHs (62%) live in the perennials system and 25% in the legumes system. Only two are on Lango (12%).

Rearing pigs is much more of a commercial enterprise than shoats. Prices of piglets of the White Large start at 100.000; a mature animal can reach well over a million. Unfortunately, the endemic African Swine Fever frequently interrupts the production and investment cycle.

The table shows the management practices applied by households rearing animals

Table 12 Management practices by households keeping livestock

	Perennial	Legumes	Oil seeds
Vaccination	42%	51%	42%
Regular veterinary services	31%	9%	24%
Separate housing	14%	27%	16%
Disease surveillance	18%	9%	2%
Supplementary feeding supplies	11%	3%	2%
Culling	2%	2%	7%
Correct stocking rate	5%	1%	1%
Biosecurity and safety	0%	0%	0%
None	35%	23%	29%

Stock management is poor indeed once again underlining the subsistence-oriented nature of the livestock production system. Less than half of households ensure their animals are vaccinated. Less than a quarter of HHs has access to regular veterinary services.

The poor access to veterinary services in the legume system stands out, as well as the some-how better management in the perennial system (veterinary services and supplementary feeding). However, as reported in Section 3.2 even in that system 36% of the milking cows is not vaccinated.

4.3. Integrated farming practices

The table below shows how often farmers reported using different forms of integrated farming practices across the three systems.

Table 13: Integrated farming practices per farming system (N= 1.100)

	Perennial system	Legume system	Oilseed system	**Total**
Intercropping	80%	84%	26%	63%
Crop rotation	22%	73%	86%	60%
Agroforestry	23%	36%	6%	21%
Zero-tillage	4%	9%	2%	5%
Improved weeding	5%	31%	10%	15%
Mulching	14%	14%	12%	23%
Burning crop residues	7%	22%	9%	13%
Manure own animals	18%	17%	6%	14%
Manure bought	2%	2%	2%	2%
Compost	8%	1%	1%	3%
Rain water harvesting	2%	2%	1%	2%
Grass bunds	1%	0%	4%	1%
Trenches	8%	7%	1%	5%
Contour farming	1%	0%	0%	0%

In the **perennial cropping system**, crop rotation is naturally limited, while intercropping - particularly banana/coffee - is widespread. Water availability is relatively good, which supports agroforestry practices; a fair share of households keep cattle and apply manure. Purchasing manure, however, is not common. Reported mulching levels appear low, though this may reflect farmers not counting the natural mulching in banana groves. Mulching may also be seen as less relevant given the absence of water stress. Weeding receives little attention for the same reason. Composting is somewhat more common here than in other systems, but still practiced by only a minority. About 8% of HHs use trenches, with other physical soil and water management measures being almost absent—consistent with the area's gentle slopes and adequate vegetation cover.

In the **legume system**, crop rotation and intercropping (e.g., maize/groundnut) are widely practiced. Water stress increases the attractiveness of mulching and improved weeding. Agroforestry is also relatively common, perhaps reflecting the widespread clearance of trees from public lands for charcoal production. Burning crop residues is frequent, while the use of manure matches levels in South Busoga. Small numbers of farmers practice zero-tillage or dig trenches. Other soil and water management techniques are largely absent.

In the **oilseed system**, crop rotation is the only practice adopted at scale. Intercropping is limited (26%), possibly because of higher labor requirements. Improved weeding is valued for reducing water competition, but again it is labor-intensive and beyond the reach of many households. Mulching is practiced by around 10% of households, helping reduce evaporation and sustain soil fertility. However, decomposition is slow due to limited moisture, and farmers are concerned that mulch may attract termites. Crop residues are also diverted to other uses such as livestock feed, fuel, or fencing. Other integrated practices, including physical soil and water management, are rarely applied.

An important qualification to these data is that most practices are applied only on part of the land – typically in banana/coffee groves near the homestead or in kitchen gardens. This highlights the broader issue of the spatial distribution of soil fertility. Although the baseline survey did not investigate differences in soil health across plots, this remains a critical issue in African smallholder systems. Substantial contrasts exist between kitchen gardens, homestead fields, and outer or bush fields. Over time, nutrients tend to be transferred from the outer fields to the inner ones, as food and crop residues are consumed and recycled closer to the homestead. Practices such as composting and mulching reinforce this process. While this concentration of nutrients can raise productivity near the homestead, it accelerates the degradation of outer fields. These areas often experience a decline in soil organic matter (SOM) and deterioration of physical properties—particularly in fragile Plinthosols.

The result is a paradox: while total farm production may increase through nutrient concentration, outer fields can eventually lose responsiveness to fertilisers, rendering them un-productive. Further details on this dynamic are presented in the Annex on ISFM.

Overall the use of **manure** is low, with only 6% of households applying their own manure. Given the critical role of crop–livestock interactions in integrated farming, it is worth examining what pro-portion of HHS with cattle actually apply manure. In the perennial system, 26% of households keep cattle, and 18% apply manure—meaning around 70% of cattle-owning families utilise their manure. In the legume and oilseed systems, the figures are 33% and 15%, respectively. One key factor is that the perennial system includes more dairy cattle (13% of all HHs versus only 2% in Lango). Dairy cows are typically tethered closer to homesteads (very few are even stabled), making manure collection and handling easier, resulting in higher-quality manure. Assuming all dairy cattle manure is used, the share of households applying manure from traditional cattle is around 40% in South Busoga, 21% in North Busoga, and just 10% in Lango.

Manure management is particularly challenging in Lango. Animals are mainly free-grazing or tethered along roadsides, and they sleep in open kraals where manure is exposed to the sun, causing nitrogen evaporation and loss. Incorporation into soils is equally problematic: during the dry season soils are compacted, while at the onset of rains, labor priorities shift immediately to land preparation and sowing. Estimates in the Annex show that the effective nutrient contribution of manure is 2 kg of N/acre in the perennial system and 1 kg/acre in the annual systems.

Composting is also largely restricted to the perennial system, practised by 8% of households. This reflects the availability of higher-quality biomass, which is easier to collect and process. Around 95% of compost is applied to banana groves. In the annual systems, the limited availability of quality biomass and the labor demands of chopping and processing make composting less feasible. Using crop residues as compost, as feed for livestock or as fuel is a logical step, but this risk exacerbating soil nutrient mining in bush fields, where fertility is already in decline.

As for soil and water conservation practices, **trenches** are not relevant in Lango and in Busoga, where rainfall is higher and moderate slopes exist, they are used by 7–8% of farmers. Focus group discussions indicate that trenches are often constructed to protect sugarcane grown in swampy areas. Measures such as **contour farming** and **grass bunds** are not applied, confirming earlier analysis (see Section 2.1) that erosion is not as a major challenge in the area.

4.4. Access to input

The table shows the responses of farmers when they were asked to rate the ease of accessing key agricultural inputs and services on a five-point scale, ranging from very difficult to very easy.

Table 14 Share of respondents indicating that access to these inputs is (very) difficult

	Perennial	Legumes	Oil seeds	female	Male	Total
Irrigation equipment	80%	94%	98%	89%	92%	90%
Mineral fertilizer	47%	78%	92%	71%	75%	72%
Manure/organic fertilizer	57%	67%	87%	71%	70%	70%
Agrochemicals	47%	73%	80%	66%	68%	67%
High-quality seeds	46%	72%	79%	63%	69%	66%
Tillage services	62%	64%	68%	67%	61%	64%
Farm tools	49%	56%	73%	61%	57%	59%
Transport services	31%	59%	69%	51%	55%	53%
Average	**52%**	**70%**	**81%**	**67%**	**68%**	**68%**

Irrigation equipment and modern inputs are very difficult to access. The same counts for manure. Even farm tools and local services like tilling and transport are not easily accessible for more than half of the farmers. There is a clear link with the farming systems; access is much better in the perennial farming system. It is most difficult in the oilseed system. There is no clear difference between male and female headed households. These data suggest that input constraints remain a critical barrier to improving productivity across all farming systems and particularly in the annual systems. In parallel, an inventory of agro-dealers was conducted to assess the availability of supply points and service providers in the project area. The results are summarised in the table:

Table 15 Distribution of agro-dealers

	District level	Sub county level	TOTAL
Jinja Rural	10	29	39
Luuka	5	4	9
Kamuli	14	0	14
Buyende	3	7	10
Kaliro	4	3	7
Busoga	**36**	**43**	**57**
Lira Rural	39	5	44
Dokolo	3	1	4
Alebtong	5	4	9
Amolatar	4	0	4
Lango	**51**	**10**	**61**
TOTAL	**87**	**53**	**140**

For obvious reasons, agro-dealers are concentrated in regional capitals and district towns. The seven rural districts have less than three agro-input dealers outside the district capital. This has a significant impact on the distances farmers' have to travel to purchase inputs. The table shows that half of farmers have to travel more than 5 km to an agro-shop.

Table 16 Distance to the agro-dealers

	Perennial	Legumes	Oil seeds	Total
< 2 km	51%	5%	9%	21%
2 – 5 km	32%	33%	32%	32%
5 – 10 km	14%	50%	45%	36%
10 – 20 km	3%	10%	9%	7%
> 20 km	1%	2%	5%	3%

Distances to towns are even farther. In the oilseed system in Lango, the average distance to the nearest town is 17 km. In the perennial system this is much shorter at 6 km, while the legume system in North Busoga is intermediate, with an average of 10 km. Distances to the nearest tarmac road are even greater, further constraining access: between 40 and 60 km in Lango, 21 to 31 km in North Busoga, and 5 to 13 km in South Busoga. These geographic barriers compound the challenges reported by farmers in accessing inputs, contributing to both higher transaction costs and delayed adoption of improved technologies.

Table 17 gives the use of external inputs and related expenses across different crops.

Table 17 Use of external inputs and the related expenses

	Maize	Beans	S'flower	Simsim	Soy	G'nuts	Coffee	Banana
Improved seeds								
HHs using improved seed	41%	60%	99%	50%	75%	76%	6%	10%
Costs of seed per acre	39,800	29,300	40,300	14,300	43,100	89,400	40,700	80,100
Agro-chemicals								
HHs using pesticides	19%	16%	1%	3%	35%	33%	4%	2%
Costs of pesticides /acre	14,400	17,200	-	-	37,500	75,400	41,000	17,500
Mineral fertiliser								
HHs using fertilizer	14%	5%	0%	0%	2%	5%	1%	1%
Costs of fertiliser/acre	30,500	27,000	-	-	15,000	25,200	25,200	8,000
Manure								
HHs using Manure	2%	0.5%	0%	0%	2%	2%	1%	3%
Costs of manure/acre	26,800	10,000	-	-	12,000	12,000	50,000	10,300
Compost								
HHs using compost	0%	0.5%	0%	0%	0%	0%	0%	2%
Costs of compost/acre	-	30,000	-	-	-	30,000	-	210,000

Improved seeds clearly stand out as the highest priority. Across all households, 42% invest in improved seeds for one or more crops. When considering all input expenditures, 76% of cash investments go toward seed. Pesticides are purchased by 19% of households and account for 14% of all expenditures. The remaining 10% of investments go toward soil fertility enhancement. Within this category, 70% is spent on mineral fertiliser, with more than half allocated to maize, followed by beans and groundnuts. A further 17% is spent on compost – 95% of it on banana production – while 13% goes to manure, used mainly on maize, coffee, and banana. Examining expenditures by crop, maize dominates with 31% of all input expenses, followed by groundnuts at 22%, sunflower at 17%, beans at 11%, and soy at 9%.

As explored in the Annex 1, mineral fertilisers have to play an important role in developing a more sustainable farming system. It is not only technically necessary, but it also provides an economic return for smallholders. Perhaps most importantly, like improved seed, it is a scalable technology that can be piloted at a very small scale and then expanded. To explore this further, the next two tables provide more detail on fertiliser use.

Table 18 Mineral fertiliser use in the three farming systems (N= 1,100)

Farm size	Perennial	Legume	Oilseed
< 2 acres	30%	8%	3%
> 2 acres	48%	16%	16%
Total	**35%**	**12%**	**9%**

Larger farmers use fertiliser about twice as often as smaller farmers. The difference across farming systems is even more striking. Only in the perennial cropping system is fertiliser use significant. In the annual cropping systems, fertiliser is used by 16% of larger farmers, but by fewer than 10% of small farmers – and in Amolatar, none at all. There are several reasons why fertiliser use is substantially higher in the perennial system:

- Smaller farm sizes force farmers to intensify and adopt fertiliser.
- Soils with higher Cation Exchange Capacity enhance the effectiveness of fertilisers.
- Greater soil organic matter further improves nutrient retention and delivery.
- Perennial crops ensure efficient uptake of fertiliser.
- Fewer dry spells reduce the risk of applying fertiliser without seeing additional yield.
- Farmers are more market-oriented and better integrated into value chains.

When comparing the share of households using fertiliser in Tables 17 and 18, the latter shows higher figures. This is because Table 17 captures answers to the general question, “Do you use fertilisers?” A notable share of those who respond “yes” may not actually be using fertiliser at the time of the survey. When the questionnaire probes further with crop-specific input data, fertiliser use is often not mentioned again.

For those who do apply fertiliser, the typical investment is UGX 20,000–30,000, which translates to just 4–8 kg per acre—a very small amount (as also observed with integrated farming practices). Overall application rates across all crops amount to only 0.5 kg/ha, which is below the national average of 2 kg/ha[4] for smallholders.

Table 19 Why farmers do not use mineral fertilisers

Reasons for not using mineral fertiliser	Perennial system	Legumes system	Oilseed system
It is expensive	89%	93%	73%
Not easy to access	13%	57%	25%
It will damage the soil	3%	9%	18%
It is not necessary (soil is good)	2%	9%	10%
It does not make economic sense	5%	4%	10%

Farmers’ perceptions of their soils are more realistic than those of the urban elite. Fewer than 10% believe their soils do not require fertiliser. For the overwhelming majority – around 85% - the main barrier is cost. Access is also a serious challenge, particularly in North Busoga, and to a lesser extent in Lango.

A considerable number of farmers believe mineral fertilisers damage the soil, with this concern especially common in Lango. Farmers there are also more skeptical about the economic viability of fertiliser use. As elaborated in Annex 1, these concerns are not unfounded and merit careful consideration.

4.5. Access to knowledge and skills

For farmers to transform their farming systems and practices, they need access to new knowledge and skills. This is essential for adopting and effectively using new technologies such as improved breeds, improved seeds, and other external inputs. The following table presents how farmers currently gain access to new information, knowledge, and skills.

Table 20 Source of agricultural information and knowledge for smallholders

	Perennial	Legumes	Oilseed	Overall
Friends and neighbors	34%	58%	44%	45%
Radio and television	33%	49%	54%	45%
Community meetings	9%	18%	11%	13%
Extension worker	10%	13%	12%	12%
NGO	17%	3%	6%	9%
Own reading	3%	14%	3%	7%
Own experience	2%	0%	4%	2%
Cooperative and farmer groups	2%	1%	1%	1%
No source	27%	14%	19%	20%

Like elsewhere in the world, farmers in the project area obtain most of their ideas from neighbors and friends, supplemented by community meetings. While this form of peer-to-peer learning is useful, it has limitations: it is not structured around clear objectives, and because peers often share the same limited knowledge, they are unable to help one another advance to a deeper level of understanding.

[4] See for example WB data https://data.worldbank.org/indicator/AG.CON.FERT.ZS?locations=UG

Mass media also play an important role. In Busoga, traditional media remain influential, while in Lango digital platforms are more prominent. These channels are well-suited for transferring information and raising awareness, but they are less effective in helping smallholders acquire practical skills or make informed investment decisions about new technologies. For that, more interactive and participatory learning approaches are required—approaches that can be facilitated by extension workers.

The government extension system, however, is extremely weak. With one extension worker for every 2,000 farmers, Uganda has one of the lowest coverage rates in Africa. Although a national strategy exists to increase the number of Government Extension Workers (GEWs), implementation has stalled, and currently only about one-third of posts are filled. Focus group discussions highlighted not only the scarcity of extension workers but also their lack of resources, with little or no budget for fuel and field activities. Senior government officials confirmed that no major improvements are expected in the short to medium term. In practice, this means that in the project area there is often only one GEW per sub-county—or fewer—and many lack the means to operate at all. This situation is reflected in the low outreach rate of just 12%. In fact, 74% of households reported never having interacted with a Village Extension Worker (VEW). Female farmers, in particular, are even less likely to receive extension services.

4.6. Access to finance

In 2024, one-third of households (33%) reported using formal financial services, with significant variation across regions: from 25% in Lango to 42% in North Busoga. Savings services were by far the most commonly used, with 24% of households participating.

Access is closely linked to farm size. Households cultivating less than two acres, had markedly lower engagement with formal services (27%) compared to 39% among larger households. Gender disparities are also evident: only 29% of female-headed households accessed formal financial services, compared with 34% of male-headed households.

Table 21 Type of formal financial service accessed by SHF in 2024 (N:1,100)

	Perennial	Legumes	Oilseed	Total
Formal financial services	**31%**	**42%**	**25%**	**33%**
Formal loan product	6%	3%	2%	4%
Bank account	2%	4%	3%	3%
Mobile banking	4%	17%	8%	10%
Formal savings product	22%	34%	17%	24%
Other services	4%	2%	2%	3%
No formal financial services	**69%**	**58%**	**75%**	**67%**

Households in the legume system stand out with comparatively better access to services, particularly mobile banking and savings products. While formal savings are relatively common, the share of households accessing formal loans remains very low. Barriers to credit are significant, with most institutions requiring land titles or other collateral, documented income, and an active bank account—conditions that many smallholders cannot meet.

A key reason for the poor access to finance is the near absence of farmer-owned SACCOs. Only a handful operate in Busoga, while none exist in Lango. Those that do exist are weak. A scoping of the six largest SACCOs found that only four could present a balance sheet, and even these had turnovers below 10% of the threshold required to qualify as a ‘Category C’ SACCO eligible for external capitalization (e.g. through PCP). Operational efficiency is also low, with turnover amounting to just 27% of total assets.

Even where SACCOs perform somewhat better, their terms and conditions resemble those of banks and microfinance institutions, creating similar barriers for smallholders. As a result, only 2% of all farmers are SACCO members – and these tend to be the better-off households.

From the perspective of smallholders, informal loans from Village Savings and Loan Associations (VSLAs) are far more attractive than formal credit. They are flexible, avoid time-consuming administrative hurdles, and repayments are more manageable. Indeed, 57% of all households belong to a VSLA, and more than 7,700 VSLAs were reported across the project districts.

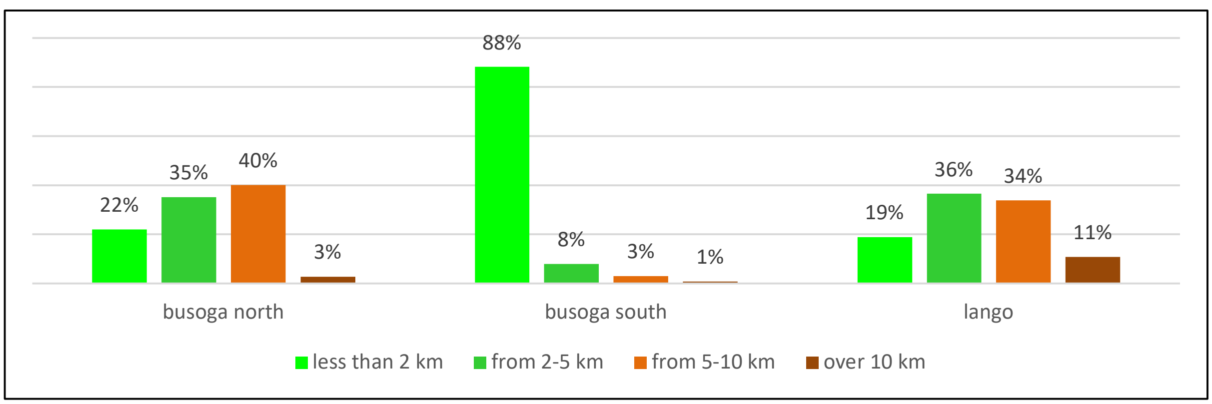
However, VSLAs also have clear limitations:

- Loans are small and rarely used for productive investments.
- Not all members can borrow simultaneously, which constrains timely input purchases.
- Although the average interest rate of 5% is only about half the rate charged by rural moneylenders, it is still significant and reflects four interrelated challenges:
    - A relatively high default rate due to the fragile nature of rural investments: climate risks, pests, floods, price fluctuations, theft, etc..
    - VSLAs lack the legal and social authority to demand collateral, so losses are collectively absorbed by all members.
    - The need to provide a meaningful return to members who only save and do not borrow—often the poorest households—thereby fostering solidarity.
    - A competitive interest rate is needed to attract savings in a context where capital is scarce; without this incentive, the poorest households might not save at all.
- VSLAs operate solely with members' savings; no external capital is injected.
- Savings are distributed at the end of each cycle, preventing the capital base from growing over time.

4.7. Access to markets

Infrastructure is a major constraint to marketing, with farmers citing poor roads (50%), long distances (33%), and lack of transport (35%) as the most pressing issues. The distance to sales points is illustrated in the graph below.

Figure 6: Distance to nearest salespoint for farmers by region (N:1,100)



In general, the distances are smaller than for access to inputs. While 21% of the HHs have access to inputs within 2 km, this is double here: 43%. And once again the farmers in the perennial system are much better off with 88% living within 2 km of a sales point, compared to only 20% in the annual systems.

In Busoga, most agricultural products are marketed through Jinja or nearby Iganga, where demand spans a wide range of crops. Markets in the region are relatively well integrated, with price differences between locations driven mainly by transport costs. In Lango, Lira serves as the main trading hub. Over the past two decades, it has grown into a significant agribusiness centre, particularly focused on oilseed crops.

Across both regions, there are stark disparities between urban and rural areas in terms of infrastructure and services, including roads, education, electricity, and water supply. These inequalities translate into a doubling of poverty rates – from 21% in urban areas to 42% in rural ones. Towns and cities also create specific markets for perishable products like dairy, vegetables, and fruits, where farmers can benefit from relatively higher prices and margins.

Most produce is sold directly to traders at the farm gate (57%). Sales through local markets or to traders at nearby trading centres account for 34%, while only 10% of households sell via agents. Farm gate trading is especially dominant in Busoga, where 80% of households sell directly from their farms. By contrast, in Lango the village agent model is relatively common, used by 27% of households. Local markets are also significant in Lango, with 76% of households participating, compared to only 4% in South Busoga.

Cooperatives, which could potentially play a key role in integrating smallholders into value chains, are currently very weak and have limited outreach. At present, they market only 2% of total produce, sourced from just 1% of farmers. Economically, cooperatives tend to focus on bulk trading, which yields low profit margins. Socially, many farmers perceive cooperatives as external organisations rather than member-driven bodies. A full 16% of households reported distrust in cooperative leaders. By contrast, private traders are viewed more favorably: only 6% of farmers reported distrust, 7% expressed higher trust, 58% reported a good level of trust, and 25% a fair level of trust.

Other barriers include lack of market information (33%) and lack of storage facilities (27%). By comparison, demand is less of a concern, with only 16% of households citing lack of buyers as a problem.

The production and sales scan of 147 households shed light on marketing practices at farm level. For many crops, the marketing window is short, with traders arriving during harvest to collect produce from more isolated communities. In the case of simsim, the window is particularly narrow, compelling farmers to sell their entire harvest at once. Other crops, however, are typically sold in several batches: groundnuts (61%), maize (48%), coffee (44%), and dried cassava (35%).

When asked why they do not sell collectively, farmers identified three reasons. The majority (68%) reported being poorly organised and/or not trusting cooperative leaders. About half (52%) said they had too little produce to sell collectively. Another 54% noted challenges with timing: some farmers need to sell immediately at harvest, while others prefer to wait.

The timing of sales is shaped most strongly by household needs and market conditions. For 82% of farmers, the primary driver is the need for cash, followed by price considerations (62%). Secondary factors include the availability of a buyer (16%) and storage capacity (10%). In the case of cassava, however, availability of a buyer is critical for 53% of households, likely because cassava does not have a fixed harvest season in the way that other crops do.

4.8. Labor

Most agricultural labor is provided by household members themselves. Table 17 summarises household composition and labor availability across the three farming systems.

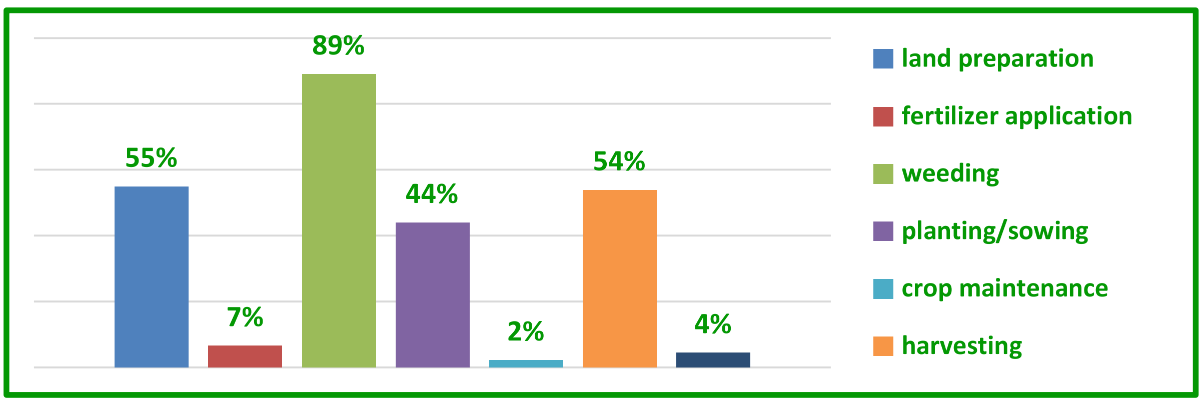
Table 22 Household composition and labor availability per acre (N = 1,100)

	Perennial system	Legume system	Oilseed system	Overall total
Average size HH	6.83	7.95	5.78	6.85
Average dependents	3.86	4.72	2.91	3.83
Dependency ration	130%	146%	101%	127%
Labor force / HH	2.97	3.23	2.87	3.02
Acres	2.18	3.48	4.41	3.36
Acre per able adult	0.73	1.08	1.54	1.11

Household size in Busoga is 28% higher than in Lango, with an average of 7.4 members compared to 5.9. The dependency ratio is also more burdensome in Busoga, where each working member supports more non-working dependents. On average, households across all systems have about three members available for productive work. However, farm size differences create notable variation: in the oilseed system, each working adult cultivates 1.54 acres, compared to just 0.73 acres in the perennial system.

Despite generally small farm sizes, 45% of households reported experiencing labor shortages. This challenge is particularly acute in Lango (65%), while it is lower in Busoga—38% in the perennial system and 31% in the legume system. Labor-intensive crops exacerbate this constraint; in particular, simsim production requires substantial hired labor. The next graph illustrates when labor shortages are most acute.

Figure 7 Share of HHs facing a labor shortage per activity (N= 397)



Weeding stands out as the main bottleneck in smallholder farming systems. It is highly time-consuming and must be completed within a short window – around four weeks into the rainy season – to prevent significant yield losses. During this period, better-off farmers often hire poorer farmers to weed their fields. In focus group discussions within the annual cropping systems, participants estimated that up to 20% of households are compelled to sell their labor for weeding, at the expense of attending to their own crops.

This bottleneck has direct implications for yields. Many households sow more land than they can realistically weed, and when labor becomes a constraint, they prioritise the best-performing plots while neglecting others.

In the annual cropping systems, particularly in Lango, a local institution (‘*alulu*’) emerged to address this shortage. Typically, a dozen farmers form a labor gang that works in rotation on each member’s fields. During peak periods, an *alulu* may even operate twice a day. This system fosters discipline and helps members sustain the demanding work under the sun.

By contrast, livestock management generates far fewer labor peaks, and therefore fewer shortages are reported. On average, only 14% of households cited labor constraints for livestock activities, although the figure is notably higher in Lango (33%).

4.9. Gross margins of crops

The table below combines average yields and farm-gate prices to calculate gross revenue. From this, the production expenses (as presented earlier in Table 11) are subtracted to determine the return to land and labor.

Table 23 Yields, Gross Revenues, Expenses and Return to Land and Labor

	Maize	Beans	S'flower	Simsim	Soy	G'nuts	Coffee	Banana
Share of HHs	82%	33%	27%	28%	13%	15%	27%	24%
Average acreage	1.30	0.70	1.28	1.26	0.97	1.05	0.78	0.52
Yield (kg/acre)	354	332	305	121	147	318	337	203 bunch
Sales price (UGX/kg)	731	3,020	1,282	3,419	1,691	4,532	2,735	10,250
Gross Revenue ('000UGX)	238	1,004	391	415	248	1,442	922	2,080
Total cash expenses	84	74	40	14	96	190	86	106
Return to Land & Labor	154	930	351	401	152	1,252	836	1,974

N.b. the amounts are in '000 UGX. The number of data sources differ for each crop and each line

The data need some qualifications. The high level of intercropping makes it very hard to know the income for each crop. We get an impression when we look at maize. In the oilseed system maize yields 395 kg/acre with only 12% being intercropped. In the perennial system this is resp. 243 kg/acre and 72% intercropping. On the other hand: beans yield 208 kg/acre with 17% intercropping in Lango and 261 kg/acre in South Busoga with 95% intercropping. This could reflect the sensitivity of beans for poor soil fertility and high temperatures (as a mono crop in Lango has more heat stress that an intercropped stand in Busoga). In the perennial system both coffee and banana are mostly intercropped: resp. 79% and 52%. In the legume system soy is often intercropped: 83%. Groundnuts are nearly the same with 76%.

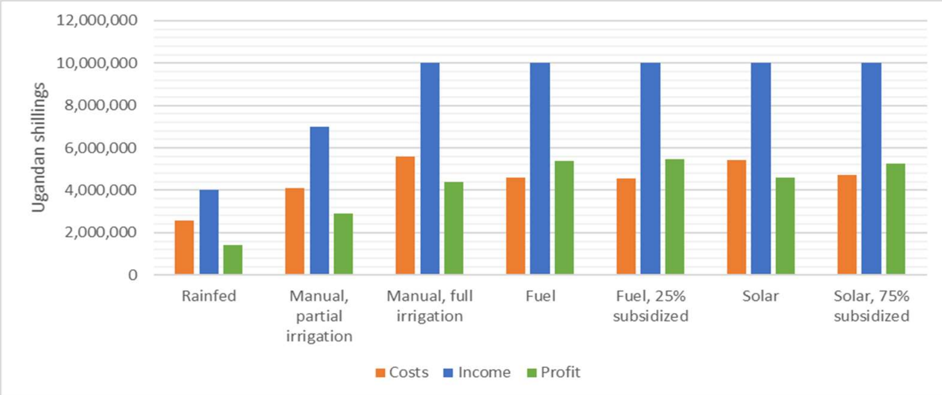
When we try to cluster the crops in terms of income generating capacity, we can conclude:

- Low return cereals/pulses: Maize and Soy.
- Moderate return oilseeds: Sunflower and simsim.
- Higher return legumes: Beans and groundnuts
- Moderate return perennial: Coffee
- High return perennial: Banana

Vegetables form a distinct category. For instance, an acre of tomato – with an estimated moderate yield of 4 MT/acre[5] – can generate a gross income ranging from 4 to 10 million UGX. The accompanying graph illustrates the cost-benefit analysis of tomato production under different irrigation methods (data based on FGD with selected horticultural farmers).

[5] Estimate based on yields mentioned by farmers. Literature mentions 4846 kg/acre. 4000 is taken as a lower estimate to stress the benefits of irrigated production even at such low production levels, and the potential for production improvement.

Figure 8 Cost Benefit Analysis of tomato under different irrigation systems



The analysis shows that it is economically rational for farmers to shift tomato production forward in the season by using irrigation through nurseries, or even to rely entirely on irrigation. This enables them to capture higher prices. Beyond timing, investing in irrigation equipment – whether fuel or solar pumps – provides significant advantages. Such investments allow farmers to produce fully in the off-season and to reduce labor costs compared to manual irrigation.

When comparing profit per day of labor, the differences are striking. Fuel pumps generate the highest returns, with 24,000 UGX profit per day, compared to 9,778 UGX per day under full manual irrigation and 12,253 UGX per day with solar irrigation. In practice, solar pumps only achieve profitability comparable to fuel pumps when subsidies are applied.

In par. 3.1. the income per head of dairy (incl. non-productive animals) was estimated at 800.000 UGX/year. Income from small stock proved very hard to estimate.

4.10. Off-farm income

While 98% of respondents reported earning income from their own farms, a large share of households also derive some income from off-farm activities.

Table 24 Sources of off-farm income

	Perennial	Legume	Oilseed	Total
Micro & small business	33%	43%	42%	39%
Working on other farm	3%	7%	22%	11%
Someone else's business	0%	0%	5%	2%
Formal employment	3%	2%	5%	3%
Farm-related services	3%	2%	3%	3%

Nearly 60% of households generate some form of off-farm income. Micro and small businesses are especially important, with 33-42% of households engaged in activities like shopkeeping, brickmaking, hairdressing, beer making, and boda-boda transport.

Farm labor and are more prominent in Lango; showing again that a substantial share of the household face a critical labor shortage for which they need to hire others. Formal job opportunities remain limited. Under the category of “other,” remittances from family members working in major cities are included.

4.11. Gender

In the baseline households were asked about the gender relations in the households. The table summarises the outcomes. It shows the total score of the top two answers out of a range of five, as well as the bottom two scores. The remaining share gave a neutral answer.

Table 25 Main outcomes of the score of gender relations at household level

Question	Perennial	Legumes	Oil seeds
How do you assess the gender balance in production tasks in the HH?			
Very well or well-balanced tasks	66%	55%	69%
Poorly or very poorly balanced	18%	7%	8%
How are decision made on production in your households			
Man and woman have an equal say and decide together	64%	65%	53%
Man usually decide after some discussion in the household	17%	24%	29%
Woman usually decide after some discussion in the household	7%	6%	4%
How are decision made on the spending money in your households			
Man and woman jointly decide how money is spent	65%	63%	57%
Man discusses with the family but decides in the end	12%	10%	16%
Man decides exclusively how money is spent	7%	16%	10%
Woman discusses with the family but decides in the end	6%	8%	4%
Woman decides exclusively how money is spent	2%	2%	1%
Gender equality in taking leadership positions in the community			
Equally easy for men/women to take leadership in community	78%	60%	56%
Easier for men to take up leadership position in community	19%	38%	39%
Easier for women to take leadership position in community	2%	2%	5%
Who can benefit from opportunities of (NGO or GO) projects?			
Both male and female members in equal manner	63%	64%	50%
Female members more than male members	29%	20%	35%
Male members more than female members	8%	12%	14%
Only female members	0%	5%	1%
What is your opinion on how your harmonious your household is?			
We live very harmoniously and face no or a few conflicts	92%	89%	85%
We do not live so harmoniously and often face conflicts	1%	2%	3%

The overall impression is that some 60%-65% have balanced gender relationships. In the other HHs men dominate the decision making. In general, the position of women in the perennial system in better; however the 18% indicating (very) poor gender balance in the HHs is a concern. The GESI report explains that despite the existence of reporting mechanisms, gender-based violence remains a serious concern - particularly in Busoga - where it is linked to poverty, alcohol abuse, and deeply entrenched patriarchal norms.

The report on the Political Economy links this to the sugarcane industry that weakened the social fabric as a dual rural economy was introduced in a pre-capitalist society. It seems the position of women in South Busoga improved due to a modernisation process; at the same time this leads to more (open) conflicts in the family. The tradition of polygamy in Busoga is an additional factor, weakening the position of individual women in a households.

The position of women in Lango is weaker as they are part of a traditional society. A study on traditional values in the Langi culture explains that '*in a traditional Lango home, a man does not decide on family-related matters without consulting his wife. The Lango believe that 'when a woman says something and you don't listen, you get into problems*'. This might be the ideal; in reality women are worse off than their peers in Busoga. The next table on access to land and loans for women confirms this.

Table 26 Access of women to productive resources: land and loans

Question	Perennial	Legumes	Oil seeds
Who has more easy access to land			
Equal access to land	54%	25%	17%
Men have better access	36%	67%	75%
Women have better access	5%	8%	7%

Who has more easy access to funds to invest?			
No difference between a woman or a man	57%	48%	38%
For a woman it is more difficult	26%	43%	45%
For a man it is more difficult	15%	6%	13%
For who is it easier to become member of group?			
No difference	78%	85%	66%
Easier for women	18%	11%	16%
Easier for men	4%	5%	18%

Access to land is a critical issue in any rural society. It is acquired through customary inheritance, purchase, renting, or borrowing from family members or friends. There are no legislative provisions that prohibit women from owning or inheriting land. In all FGDs on gender this was confirmed. Nevertheless, the data show that in reality it is not easy for women to gain access to land; in the perennial system the situation is considerably better than in the annual systems; particularly in Lango.

FGDs on gender relations confirmed that access and control are easier for men. Women's legal entitlement is often superseded by cultural norms which dictate that women cannot inherit or own land. In cases where women and girls do have access to land, they are often allocated land of lower quality. Since girls leave the household after marriage, land is only made available for a certain period. However, female members may buy land if the spouse or clan head consents to or is informed about the transaction. Additionally, women who return to their parental home after a divorce are often allocated some land. Widows inheriting land can lead to conflict, if it is not certain that she will stay in the house of her late husband, leaving a possibility of the land being transferred to another clan. One FGD in Luuka indicated that a widow could inherit and cultivate land, but not sell it.

Access to finance is another challenge for women – only 49% report having equal access; with a low of 38% in Lango. Barriers include lack of collateral, limited mobility, and restrictive social norms that discourage independent financial management. Becoming member of any group is also more difficult for women; again especially in Lango.

The INSPIRE report on gender and social inclusion gives a more rich picture. Women (and also persons with disabilities) also face barriers to market access and information, including time constraints, transport limitations, and gendered perceptions that marketing is a male role. Women are also less likely to receive support from extension workers.

Their overall workload remains high, as they juggle domestic responsibilities, caregiving, and farm labor. While women's participation in community leadership is growing, it continues to be hindered by low literacy levels, cultural norms, limited economic resources, and lack of confidence. Despite the challenges some respondents (e.g. in FGD and KIIs) noted signs of progress as well.

4.12. Social capital

The Political Economy Analysis conducted by INSPIRE highlighted both contrasts and parallels between Busoga and Lango.

In Busoga, abundant land and water attracted investors in sugar production more than a century ago. Jinja subsequently developed as the country's first industrial hub. Alongside this industrialisation, however, a dual rural economy emerged, where large-scale commercial sugar plantations operated within a largely pre-capitalist setting. The authority of local leadership, particularly the Busoga Kingdom, was weakened and often bypassed by dominant commercial and political actors.

In Lango, traditional leadership was never centralised, but the region held considerable political influence during colonial times, being both a key area for cotton production and a major source of soldiers for the colonial regime. After independence, Lango produced a national leader who governed for 15 years. Yet, over the past four decades, the region has suffered from internal conflict and increasing marginalisation within national politics.

Across both regions, the social fabric remains fragile. Local leadership is widely perceived as weak, with little influence over national decision-making and, consequently, limited access to public resources. Formal organisations are often viewed with mistrust, being seen as politicised and susceptible to resource misuse.

Local governments are severely under-resourced and therefore perform poorly. The number of extension workers is extremely low – only about one third of the planned positions are filled – and in some sub-counties there are no proper offices to operate from. Annual budgets can be as low as USD 10,000 to cover all public services, including roads and health.

Farmer support is delivered mainly through direct subsidy programmes such as Operation Wealth Creation (OWC), the Parish Development Model (PDM), and irrigation support under the Uganda Intergovernmental Fiscal Transfers Program (UgIFT). However, since these programmes are largely managed by the army, they often suffer from limited technical capacity, political interference, and misuse of funds.

In this vacuum, NGOs play a prominent role, though their engagement is selective and shaped by external (often Western) priorities. Around Jinja, for instance, dozens of NGOs work with smallholders in the perennial farming system, focusing on regenerative agriculture—most commonly through compost-making training. The baseline survey showed that these organisations reach 17% of households in this system, which indeed represents the group with the most potential. By contrast, outreach in the more challenging annual cropping systems is far lower, at just 3–6% of households.

The table shows how households look at their social capital at community level.

Table 27 Level of trust in community members and decision making

	Perennial	Legumes	Oil seeds
What do you feel about the level of trust among community members?			
Very good or good trust among community members	82%	80%	84%
Little trust in community members	7%	9%	3%
How do you assess the way community decisions are made?			
All people or most people have an equal say and decide	82%	80%	86%
Few people have a say and decide	12%	5%	1%

In contrast with the analysis of the general society, informal and traditional institutions at community seem to command great trust. Indeed in the PIP process so far local leaders have proven to be effective in mobilising their communities.

4.13. Household incomes

The table below presents the total household income across the three farming systems.

Table 28 Household income composition per farming system

	Lowest quintile	Second quintile	Middle quintile	Fourth quintile	Highest quintile	Total
Perennial system						
Income from crop sales	140,000	515,000	410,000	974,000	7,068,000	1,742,400
Income from livestock	0	0	31,000	352,000	4,539,000	984,400
Off-farm income	250,000	250,000	250,000	440,000	3,740,000	986,000
Total by quintile	390,000	765,000	1,442,000	3,069,000	12,890,000	3,711,200
Legume system						
Income from crop	50,000	242,000	604,000	1,260,000	4,870,000	1,405,200
Income from livestock	0	0	0	152,000	1,878,000	406,000
Off-farm income	250,000	250,000	750,000	1,160,000	4,610,000	1,404,000
Total by quintile	481,000	1,068,000	1,799,000	3,211,000	9,926,000	3,297,000
Oilseed system						
Income from crop sales	196,000	294,000	838,000	1,810,000	6,820,000	1,952,400
Income from livestock	0	0	0	159,000	1,725,000	376,800
Off-farm income	250,000	250,000	280,000	780,000	3,670,000	1,046,000
Total by quintile	446,000	1,069,000	1,858,000	3,541,000	9,959,000	3,374,600
Overall average						
Income from crops	128,667	350,333	617,333	1,348,000	6,252,667	1,700,000
Income from livestock	0	0	10,333	221,000	2,714,000	589,067
Off-farm income	250,000	250,000	426,667	793,333	4,006,667	1,145,333
Total by quintile	439,000	967,333	1,699,667	3,273,667	10,925,000	3,460,933

n.b. Total incomes per quintile do not tally as for each income category the quintiles were defined separately. The totals of all quintiles do add up 'normally'.

Average annual household income is UGX 3.5 million[6], or approximately €850. Differences across farming systems are relatively small. Households in the perennial system are slightly better off; while they cultivate less land, they earn substantially more per acre and have more income for livestock (milk). The perennial system has a higher level of inequality, with 69% being earned by the highest quintile, compared to 60%in the annual systems. Income from livestock is even more skewed with the 20% wealthiest HHs taking 92% of all income. This is partly due to the fact that it was not possible to collect data on the production and home consumption of small stock. However, even an additional 100.000 UGX of home consumption of eggs or chickens for the poorest quintile will not undo this high level of inequality.

Agriculture contributes UGX 2.3 million per household per year. Off-farm income adds UGX 1.1 million. Farm size strongly influences income: households with less than 2 acres earn an average of UGX 2.6 million annually, compared to UGX 4.3 million for those with 2–10 acres. Gender disparities are also pronounced: female-headed households report incomes 43% lower than those headed by men. Home consumption represents a substantial share of the income from crops: between 33% and 40% across the different groups.

Average household income remains well below the poverty line, estimated at around UGX 10 million (depending on the definition and source). Only the wealthiest 20% of families reach or exceed this threshold. Excluding this top 20%, average income drops to UGX 1.97 million (≈ USD 500). For these HHs, crops provide 45% of income, off-farm sources 33%, and livestock 23%. The dependency on crops increases further among the poorest quintiles, leaving them more vulnerable to price volatility and climate risks.

4.14. Food security

Food security is a cornerstone of a resilient livelihood. The majority of HHs use most of

[6] This differs from household income data mentioned in the Inception report and Table 14 in the Livelihood report. The reason is a wrong formula in an Excel sheet. The data mentioned can also be found in the Livelihood report; in Annex 2.

their crops for home consumption. Between 63% and 88% of the main food crops – maize, beans, cassava, and banana – are consumed within the family. In the perennial system, this figure reaches as high as 90%, largely due to the small average farm size. In other systems, home consumption typically ranges from 60–80%. Coffee and sunflower function almost entirely as cash crops, while simsim and groundnuts fall in between, with around 45% consumed at home. For soy, the share is lower at just 22%.

The table shows the home consumption of the households of the main food crops.

Table 29 Home consumption of the main crops (kg/year)

	Perennial	Legumes	Oilseed
Maize	172	240	202
Beans	171	21	27
Soy/groundnuts		25	
Simsim			19
Subtotal	**342**	**286**	**248**
Cassava (fresh / starch)	430	539	225
Banana (fresh / starch)	138		
Subtotal	**568**	**539**	**225**
TOTAL	**912**	**825**	**472**

n.b. As cassava is harvested intermittently, its yield is difficult to measure. It is assumed that it yields 5 MT/ha. Banana yields are based on the assumption that one bunch is 10 kg.

Lango stands out with a much lower level of home consumption. While beans used to be a major contributor to the diet, low yields (due declining soil fertility) means less HHs produce it (17%). So even as they consume 75% of their harvest, the contribution to the diet is limited. The low sales also means that (according to FGDs) the area has changed from a beans exporting area to a bean importing area. Starch crops are very important indeed; especially cassava in the legumes system. In the perennials system bananas make an important contribution as well.

The last table shows the answers to the question: does your household have enough food throughout the year?

Table 30 Level of food security per farming system and gender

	Perennial	Legumes	Oil seeds	Female	Male
Enough food in almost all months	51%	47%	15%	38%	37%
Not enough in some months	42%	47%	57%	48%	49%
Not enough in half of the months	5%	5%	18%	8%	10%
Not enough in almost all months	3%	2%	11%	6%	4%

There is a marked difference between Busoga and Lango. In the latter 29% of households have insufficient food for six or more months per year. In Busoga this is only 7-8%. There is not difference between female and male HHs. One explanation could be that female HHs get more assistance from others to feed their family.

This is in line with the data in table 30. A major explanation is that the share of home consumption of the total harvest is much lower in Lango. On average 52% of the three main crops (maize/beans/cassava). In the legume system this is 71% and in the perennials system 88%. These are substantial differences. Apparently HHs have needs that are even more urgent than food. It is hard to identify what that could be. In any case, it once more underlines the hardship in Lango.

4.15. Resilience and Poverty Indices

A special survey was conducted among 169 HHs to establish the baseline values for GOAL's Resilience Index (RI) and the Poverty Probability Index (PPI). The table presents the main results.

Table 31 Resilience index per farming system

	Social	Economic	Environ-mental	Total Index	HIGH	MEDIUM	LOW
Perennial	4.7	2.7	5.5	**4.3**	25%	57%	18%
Legumes	4.6	2.4	5.2	**4.1**	16%	80%	4%
Oilseed	6.3	2.6	6.7	**5.2**	6%	68%	25%
Average	**5.2**	**2.6**	**5.8**	**4.5**	**16%**	**68%**	**16%**

Note: The Resilience Index scores range from zero (highly resilient) to ten (very low resilience).

Households in the legume system are most resilient as the have the least very vulnerable households. The perennial system has a similar average score; yet it has quite some more households with a low resilience; similar to the higher level of inequality in incomes as reported in Table 28.

Households in Lango are less resilient than those in Busoga. Social resilience there is low as they score poorly on three questions related to decision making at household level; in Lango this is more patriarchal. The score on environment resilience is lower in Lango as they plant less trees and have less knowledge on – and are less active in- environmental action. The scores on economic resilience are similar across the farming systems. This is in line with the outcomes of the baseline survey on income.

The trust in community institutions is lower. This is different from the data in Table 27 where the level of trust in communities is slightly better in Lango than in Busoga. The difference in outcomes is due to the difference in the questions asked. In the baseline the question was '*Do you trust the community?*' In the Resilience Index the question was: *Do you trust the community institutions*? So in Lango people trust each other, but not the institutions. Most likely this refers to the formal village, parish and sub county leadership.

Also here a substantial gender gap can be seen; overall 31% of the female headed household have a low resilience score; against 11% for men. Again Lango stands out with 50% of female headed households having a lo resilience against 16% of male headed HHs.

Across all systems, scores for the economic dimension are higher than those for social and environmental dimensions. This does not imply households are economically secure. The Poverty Probability Index (PPI) data show that:

- 80% of households live below the $2.50/day/person poverty line, and
- 34% live below the $1.25/day/person threshold.

These findings align well with the baseline data where 20% of households earned a living income of UGX 10 million corresponds to the $2.50/day/person group. The 25% of HHs that do not earn enough to meet basic caloric needs correspond to those below $1.25/day/ person.

Gender-disaggregated data show that female-headed households are less resilient, although the differences are smaller than those between Lango and Busoga.

5. Conclusions

This final chapter presents the key findings and recommendations both at the level of the farming systems and for the further development of the PIP approach and related materials.

5.1. Farming System level

Findings

Driven by population growth, all farming systems are undergoing a transition from largely nature-based production to man-made production systems. Population growth creates additional stress on production systems, including pests and diseases, drought, weed pressure, and declining soil fertility. Since expanding the cultivated area is neither feasible nor desirable, the only viable pathway is sustainable intensification. This pathway is labor-intensive and requires the use of modern inputs and technologies, which in turn depend on improved knowledge and skills, access to finance, and secure market opportunities. Smallholders are only willing to invest in intensification when they are confident of reliable markets for their produce. The table shows the most important characteristics of the three farming systems from a sustainable land use perspective.

Table 32: Main characteristics of the three farming systems

Characteristics	Perennial Int. FS	Annual Legumes FS	Annual Oilseeds FS
Dominant soil type	Ferralsols/Nitosols	Plinthosols	Ferral- & Plinthosols
AnnualwWater balance	+ 400 mm	- 100 mm	+ 200 mm
Inh/km^2	ca. 450	ca. 400	ca.190
Key-crops	Banana/coffee	G'nuts/soy/beans	Sunflower/simsim/soy
Farm size (acre)	2.2	3.4	4.4
HH with < 2 acres	72%	55%	33%
Vegetables (irr.)	10%	5%	1%
HH with cattle	26%	50%	38%
% of cattle that is dairy	60%	20%	5%
Low soil fertility	52%	61%	28%
Soil erosion	1%	11%	1%
Compost use	8%	1%	1%
Mineral fertiliser use	25%	8%	9%
Lack of markets	3%	16%	36%
Casual labor	3%	7%	22%

In Lango, where population density is lower, soil fertility and weed pressure are (still) less acute challenges compared to Busoga. However, the same low density also constrains access to both input and output markets, limiting opportunities for intensification.

There are clear differences between the perennial and annual systems in terms of sustainable intensification. The perennial system (banana/coffee/dairy) demonstrates a relatively successful and gradual intensification pathway. A reliable milk market supports more intensive dairy farming, which in turn enables integrated farming practices such as fodder production and integrated soil fertility management (ISFM) that combines organic and mineral fertilisers. Adequate moisture levels also facilitate nutrient recycling through mulching and composting. With reasonable soils and good market integration, farmers in this system are able to invest in mineral fertilisers. As a result, households in the perennial system achieve incomes comparable to those in the oilseed system—despite cultivating only half the land area.

The transition from a nature-based production system to a man-made one is considerably more difficult in the annual systems. As extensive livestock production declines, it is not being replaced by intensive dairy but rather by extensive crop cultivation. The benefits of organic matter are difficult to realise due to limited and poor-quality biomass and manure, insufficient moisture, labor shortages, and lack of mechanisation. In this context, the use of mineral fertilisers will be critical to preventing further degradation of the farming systems. However, farmers face major constraints in accessing fertilisers, as well as the small loans required to purchase them. In some cases a mindset change is needed as well.

Across all farming systems, smallholders face severe service gaps. Long distances and poor roads result in higher input prices and lower farm-gate prices for outputs. In the perennial system, access to inputs is better and buyers are readily available. By contrast, in Lango both input and output market access is a challenge for between one-third and one-half of households. Access to finance is largely restricted to VSLAs, which depend on members' own savings. Coops and SACCOs have only reached the top 1–2% of better-off farmers and remain distrusted by smallholders in rural communities. Similarly, with only one extension worker per 2,000 households, services are limited to a small minority of better-off farmers. The private sector plays only a limited role and also tends to focus on the same segment.

Income inequality within farming systems is very high. Overall, only about 20% of households earn a decent, living income. These households are typically engaged in high-value activities such as dairy and horticulture, enabling them to invest in quality inputs and access better markets. The remaining 80% subsist on around 2 million UGX per year (€500) for an average household of seven members. Roughly one-third of this income is derived from off-farm activities, while two-thirds of agricultural income comes from crops. For the poorest half of households, this dependency on crops rises to around 75%.

Finally, in all systems social and political capital is limited. The social fabric is weak, and the Political Economy Analysis highlights that cohesion is primarily at the community level. Early experience with the PIP process under INSPIRE confirms that rural communities are capable of mobilising themselves for collective action, typically focused on public goods such as repairing roads or planting trees, often through informal groups. VSLAs are a clear example of how such cooperation can be extended into the economic domain, with potential for strengthening resilience and local economic organisation.

Recommendations

There are a number of general recommendations that cut across all farming systems. The first, and most important one, is to use a comprehensive approach, grounded in the subsistence-oriented farming systems and practices. The PIP approach used by INSPIRE is very appropriate for this. It supports communities and households in a joint planning, learning and implementation, taking their own resources and ambitions as the main point of departure in an inclusive, bottom-up process.

A second general recommendation is to support households to move into more remunerative enterprises. From maize production to legumes or oilseed. From legumes to vegetable and livestock. From production into value addition and marketing. From individual sales to collective sales. This requires a comprehensive approach, covering all aspects of production and market integration, as well as access to finance.

As INSPIRE aims to increase yields with 50%- and incomes with 30%- access to external inputs and capital is crucial. As this exposes (poor) HHs to additional risks they need adequate practical knowledge and skills about the innovation/technology that they invest in.

All steps in the process should build on the available social capital in the form of households and trusted, informal community level groups and, doing so, further strengthen them. Joint action on common goods (like PIP-community Action Plans) should be combined with joint economic development. Networking is the name of the game.

Sustainability is key. In environmental terms this means securing the future natural resource base, mostly by planting trees and improved wetland management. In economic terms this means working closely with the private sector to ensure that they a sustained commercial interest to work with the communities after project exit. Institutional sustainability is needed as well; most practically by engaging the local government (sub county and district level). As both the commercial and institutional players are weak, selected farmers organisations could be strengthened so they can sustain project interventions after the phasing out of INSPIRE.

As this study describes the present farming systems as they are (based on baseline data) it is not possible to formulate recommendations on the technologies or innovations that could be promoted by the project. This is also not the philosophy pf the project. INSPIRE does not promote specific technologies; it simply supports communities and households to develop integrated plans on a comprehensive vision of a sustainable and resilient future livelihood. Based on the demands arising from these plans, INSPIRE assists them in obtaining access to the necessary skills, inputs, finance and markets.

While the final decision on which innovations households want to test and to apply rests with themselves, this analysis can be used to formulate a number of general options or direction for a more resilient, sustainable and productive farming system. The most fundamental one is to promote integrated farming, IPM and ISFM. More details on this can be found in the Annex. Other elements are:

- Enhance tree planting in public spaces, woodlots and agroforestry configurations, via nurseries and training
- Enhance sustainable, wetland management models, balancing short term economic interest of communities (e.g. vegetable production) and long-term sustainable water management
- Improve field crop production via (skills) training on SWC, IPM, ISFM and GAP and via improved access to input (seeds, fertilisers) and markets.
- Improve the kitchen gardens (in economic and nutritional terms) via composting, key-hole gardening, mulching, fruit trees
- Intensifying coffee production via (rotational) stumping and banana via more active suclker management
- Horticulture: improve access to water and better irrigation methods for vegetable production. Training and access to high quality inputs and markets.
- Improve the dairy system via fodder production (e.g. on contours), agroforestry (Calliandra), improved housing and veterinary services (vaccinations); supplementary feeding. As the EKN funded Include work on this in Busoga, this is not a priority for INPSIRE.
- Improved piggery, goat keeping and poultry by improving access to new breeds and skills on improved management (housing, feeding, veterinary care) and markets.

5.2. Adjusting the PIP to the lowlands

In the highlands, the PIP approach centered on addressing physical land degradation, with a strong focus on soil and water conservation through measures such as trenches, contour bunds, mulching, and tree planting. From a technical perspective, these interventions are relatively straightforward and can be standardised across farming communities.

In the lowlands, however, the primary challenge is the decline in production due to pests

& diseases, weeds and a decline in soil fertility. Here, the emphasis shift towards designing effective Integrated Soil Fertility Management (ISFM) and Integrated Pest Management (IPM) strategies. Unlike erosion control, these cannot be easily standardised. In each farming system the optimal balance between organic and mineral fertilisers (ISMF) depends both on the specific farming system and on the resource base of individual households. IPM depends on the crop and the agroecological context.

Nevertheless, some directions on ISFM emerge. In the perennial system, priority should be to build on existing manure management practices, while complementing them with targeted applications of mineral fertilisers. In the annual systems, where biomass is scarce and labor constraints are acute, the focus should be on promoting the use of mineral fertilisers, supported by mulching where feasible. On the IPM side priority needs to be given to the low hanging fruit, like training farmers on pest-scouting and economic thresholds and on how to minimise the negative impact on the human health and the environmental when spraying does become a necessity. The overarching factor on IPM and ISFM is that farmers need to become better farmers by better observing and understanding the agro-ecological context in which they produce their crops and animals.

To reflect these realities, the PIP modules and training manuals must be revised and tailored to the needs of lowland farming systems, ensuring they provide context-specific guidance for farmers navigating the shift towards sustainable intensification.

Annex I Integrated Soil Fertility Management

1. The challenge

Maintaining and enhancing soil health and fertility is probably the most critical challenge for developing more sustainable farming systems and resilient livelihoods. The decline in soil fertility is a major concern in all three farming systems. Farmers report that the "original, natural yield" of about 800 kg/acre has halved over the past two decades.

This decline is mainly due to the lack of time for nature to replenish the nutrients removed by crops. Fallow periods have virtually disappeared, while new challenges are becoming more severe: (micro-)climate change, pests and diseases, and erosion.

This Annex focuses on the decline in soil fertility as the actionable entry point for INSPIRE in its efforts to improve the sustainability of farming systems through better soil and water management practices. Reducing soil mining via organic and mineral fertilisers not only improves soil fertility, but also helps to control pests and diseases and reduces water stress caused by (micro-)climate change. It also enables farmers to adopt improved, short-maturing crop varieties that are critical in responding to shorter rainy seasons.

Section 2 of this Annex explores the issue soil mining and land degradation. The next Section looks at possible solutions. In both, a set of calculations is presented to assess the extent of nutrient depletion and the feasibility of different solutions. These calculations are, by their nature, simplifications. The results should be treated with care, and used only to understand the broad dimensions of the problem and the main directions for solutions.

Section 3 considers the way forward in INPSIRE. It explores how the findings can be integrated in the PIP approach, the foundation of the project, as well as in the group extension method that is integrated in the PIP approach; Farmers Learning Groups. This section lays out a ToR of the INSPIRE Task Force (lead by WENR and Resilience) that will advise the project on the most appropriate sustainable farming practices for the three different farming systems. This has an IPM and a ISFM component.

2. Losses via soil mining

A simple calculation can illustrate the amount of nutrients removed by crops. With a maize yield of 500 kg/acre, about 7.5 kg of nitrogen (N) is extracted through the grains (assuming 9% protein, of which one sixth is N). In addition, around 1 MT of maize stover and roots contains about 0.6% N (equivalent to 6 kg), of which approximately half is lost (3 kg). This brings the total N loss to at least 10 kg/acre. This estimate is consistent with the table below, which presents the losses of N, P, and K in Uganda for four important crops in the project area.

Table 33 Nutrient removal per MT and acre for four main crops

	Maize	Rice	Beans	Cassava
Nutrients removed in kg per MT				
N	20	21	48	3
P	9	7	13	1
K	24	30	40	3
Yield in MT/acre				
	0.5	0.8	0.3	4
Nutrient removed in kg/acre				
N	10	16.8	14.4	12
P	4.5	5.6	3.9	4
K	12	24	12	12

Source: IFDC/AFAR, 2018

The N losses for maize are consistent with our calculation. For rice, they are substantially higher. Although beans can fix N (via Rhizobium spp.), the final N loss is similar, as beans have a much higher protein and N content. As a starch crop, cassava produces much larger quantities of yield while extracting comparatively fewer nutrients.

These calculations remain superficial. There are also natural additions of N through N-fixing micro-organisms (both symbiotic and free-living), rainfall (especially thunderstorms), and run-on erosion from adjacent plots. At the same time, there are further losses through processes such as run-off erosion, leaching, and denitrification. In climax vegetation these processes generally balance out, but under a cropping regime the net balance is usually negative. In some cases, the deficit can be severe, for example with high erosion or leaching.

In the project area, erosion is relatively limited. Data from Kamagre et al.[7] show an average loss of 800 kg of topsoil/ha/year, which translates to 160 kg/acre/season. With a soil organic carbon (SOC) content of 3%, a C/N ratio of 20, and an enrichment factor of 2, this equates to 0.5 kg of N/acre/season— 5% of the losses caused by harvest removal. Leaching is another challenge; on skeletal sandy Plinthosols, it is estimated at 2 kg/acre/year. As we will see below there is some small natural additions of organic matter and N as well.

Here the (simplistic) point of departure is that at least the nutrient losses through harvest removal should be replenished to maintain sustainable land use. Failure to do so will lead to impoverished soils that no longer respond adequately to fertilisers, making investments in improved seed and fertiliser unprofitable. Tittonell and Giller (2013) summarise this process as follows:

> *Discontinuous, insufficient or no fertiliser application over a certain period of time may lead to severe soil degradation through nutrient depletion and loss of organic matter. When fertiliser or organic matter applications restart after a certain period of cultivation without them, soils may not respond immediately. Often crop productivity may not be raised back to the yields attained before fertilisation was interrupted, creating a new system state at lower equilibrium and consequently a very resilient yield gap. The two states, responsive and non-responsive soils do not necessarily represent a continuum. Reversibility may be lost when a certain threshold of soil degradation is surpassed. The magnitude of the distance between these two alternate states is known as hysteresis. This is a concept common in ecology, but it has also been used to characterise phases of land rehabilitation.* [8]

[7] Karamage F., C. Zhang, T. Liu A. Maganda and A. Isabwe. 2017. Soil Erosion Risk Assessment in Uganda

[8] Tittonel, P and K.E. Giller. (2013) When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crops Research. Vol. 143. P. 76-90.

The nutrients removed from the soil represent a substantial monetary value. For example, the removal of 10 kg of N per acre is equivalent to about half a bag of DAP, which sells for 160,000 UGX. This means that the N losses alone amount to 80,000 UGX per acre – close to half of the net margin from an acre of maize. When scaled up to all INSPIRE's targeted households, with an average farm size of 2.8 acres cropped twice per year, this translates into an annual loss of approximately 28 million USD.

3. Looking for a solution: Integrated Soil Fertility Management

To minimise soil mining, INSPIRE will promote Integrated Soil Fertility Management (ISFM), using the definition from the ISFM Handbook:

> *A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic and economic principles*.

A first logical step is to explore the use of crop residues to replenish removed nutrients. Using nitrogen as a (simplified) indicator: to return 10 kg of N to the soil, a farmer would need to apply 3 MT of compost (with 1% N content and a 33% mineralisation rate in the first year). This requires around 6 MT of crop residues – the equivalent of the above ground biomass of maize stover from ten acres. At system level, this is problematic since it would deplete those other acres, and in practice, it is not feasible: smallholders cannot collect, process, and apply such large amounts of biomass. Using biomass from outside the cropping area is even more challenging due to labor requirements and low quality (e.g. too woody material). In annual systems, the lack of moisture further hampers adequate decomposition.

Livestock offers a second pathway for nutrient recycling. A detailed analysis of the nitrogen cycle in mixed farming systems of Eastern Uganda[9] found that traditional cattle kept in kraals make available about 5 kg of N per head of cattle for use on crops. This translates into approximately 3 kg/acre in the legume system and 1 kg/acre in the oilseed system. However, the economics are not particularly attractive: only 21% of households in the legume system and 10% in the oilseed system make use of this resource. These cases represent courageous efforts by smallholders to maintain soil organic matter (SOM) and sustain soil health, and this should be further promoted.

The situation is more favorable with dairy cows in the perennial system. They produce more manure, of higher quality, and it can be collected and handled more effectively. According to the same publication, a well-managed zero-grazing dairy cow can make available up to 50 kg of nitrogen per head for use on crops. Under the low level of dairy management in the project area (with < 10 l/day; tethering rather than zero-grazing) the N availed is estimated at 30% of this potential. The 2.4 dairy cows per HH are thus producing roughly 35 kg of N (sufficient to sustain 3-4 acres). With 13% of the HHs owning these cows and 70% of them suing the manure, they contribute around 3 kg of N/acre at system level.

While the optimal use of all available biomass should remain an objective in any sustainable land use initiative, it is clear that biomass and manure alone cannot stop the decline in soil fertility at scale. Prospects are generally more positive in the perennial system, where both

[9] Snijders, P, D. Onduru, B. Wouters, L. Gachimbi, J. Zake, P. Ebanyat, K. Ergano, M. Abduke and H. van Keulen (2013). Effects of cattle and manure management on the nutrient economy of mixed farms in East Africa: A scenario study. African Journal of Agricultural Research

biomass and manure are more abundant and decompose readily, particularly under banana/ coffee systems that respond well to such inputs. The challenges are even greater in the annual systems. Here, mulching appears to be the most appropriate option, but it is only applied by a minority of farmers, and the quantity of nutrients it contributes is insufficient to maintain nutrient balance and soil health.

As recycling locally available nutrients has a limited (potential) impact beyond the richest farmers, external inputs in the form of mineral or organic fertiliser have to be added to the ISFM mix; even to a level that they have to become the 'engine' of the mix. We start looking at mineral fertilizers, and then move on to the organic options.

The research team on Optimizing Fertilizer Use in Africa (OFRA) published a paper on Economic Optimal Rate (EOR) of fertiliser in the Lake Kyoga basin (LKB with Plinthosols) and the Lake Victoria Crescent (LVC with Ferralsols).[10] One of their critical assumptions is that smallholders require a Return on Investment on their additional investment of 100%. In practice this depends much on the risks associated with the investment. If smallholders are well aware of the risks this can be reduced to 50%. The table shows their first level outcome:

Table 34 Economic Optimal Rates of N, P and K in LKB and LVC

	Kg N/acre		Kg P/acre		Kg K/acre	
	LKB	LVC	LKB	LVC	LKB	LVC
Maize	28	53	8	5		
Banana (<20 MT)		40		16		39
Finger millet	61		14			
Sorghum	35		7			
Upland rice	83	77	29	15		
Bean	31	30	14	14		
Groundnut			27	27	8	14
Soybean			15	18	29	

N.B.: LKB = Lake Kyoga Basin. LVC = Lake Victoria Crescent

In the Lake Kyoga Basin (LKB), the Economic Optimal Rate (EOR) is 28 kg/acre of N for maize and 31 kg/acre for beans. The expected return per kg of N is 25 kg of maize for the first 30 kg, but falls sharply to only 3 kg for the second 30 kg.

In the Lake Victoria Crescent (LVC), the EOR for maize is 53 kg/acre, while it remains the same for beans. Here, the expected return for the first 30 kg of N is 43 kg of maize per kg of N, dropping to 13 kg for the second 30 kg. For beans, the initial response is 32 kg per kg of N in both zones, but this declines to just 1 kg for the second increment.

The EOR for sorghum is similar to maize. Upland rice, with a higher market price, has a substantially higher EOR, while finger millet shows a moderate improvement. In contrast, soybean and groundnut do not show an economically attractive response to low N rates.

When it comes to phosphorus, the EOR in LKB ranges from 7–15 kg/acre for most crops, with an outlier of 27 kg/acre for groundnut. In LVC, the EOR for P is higher, between 15–20 kg/acre. In LKB, the return for the first 5 kg of P is 33 kg of maize per kg of P, dropping to 17 kg for the second 5 kg. In LVC, the return is 42 kg for the first 5 kg, but only 10 kg for the second 5 kg. For other cereals, the P response is not attractive. However, soybean and groundnut respond strongly in LVC, with 80–90 kg per kg of P for the first 5 kg/acre, halving for the second 5 kg. In LKB, beans show the same response, while soybean reaches only half of that level.

[10] Kaizzi C. Kayuki, K.C. N. Angella and K.F. Musisi (2017) Optimizing Fertilizer Use within the Context of Integrated Soil Fertility in Uganda. In: Fertilizer Use Optimization in Sub-Saharan Africa (2017). CABI.

Potassium (K) is only economically viable for banana, soybean, and groundnut.

The OFRA team also determined optimal rates of N, P and K for three categories of small-holders. At one end are those with sufficient resources to apply fertiliser at the full Economic Optimal Rate (EOR) across all of their land. A second group is able to purchase fertiliser for only about two-thirds of the EOR, while the most resource-constrained farmers can afford no more than one-third of the recommended application.

Table 35 Optimal fertiliser rates in Eastern Lake Kyoga

	Urea at planting	Urea 2nd weeding	DAP at planting	TOTAL
	Poorest farmers			
Finger millet		17	14	**31**
Sorghum		11		**11**
Upland rice		17	13	**30**
Bean	12			**12**
Groundnut			14/12 TSP	**26**
	Middle level farmers			
Maize	17	17		**34**
Finger millet		17	22	**39**
Sorghum		19		**19**
Upland rice		38 panicle in.	33	**61**
Bean	18			**18**
Groundnut			40	**40**
Soybean			25 TSP	**25**
	Better off farmers			
Maize		43	10 (point)	**53**
Finger millet		41	28	**69**
Sorghum		24	14	**38**
Upland rice		54 panicle in.	31	**85**
Bean	14		27	**41**
Groundnut			40/14 13*	**67**
Soybean			37 TSP	**37**

Source: Kaizzi, C.K. et al. (2017)

The main conclusions are:

- Using urea at planting is hardly recommended. The likely reasons include the natural nitrogen flush that occurs at the onset of the rains, which is usually sufficient for initial crop growth. At this stage, crop root systems are still very shallow, so any extra nitrogen is easily leached. In addition, stimulating vegetative growth too early can increase the risk of crop failure if a dry spell follows.
- The best investments for poorer farmers are limited to 20–25 kg of nutrients per acre:
  - Cereals: 10–15 kg of DAP at planting and 17 kg of urea at 2nd weeding
  - Beans: 12 kg/acre of urea at planting.
  - Groundnuts: 14 kg/acre of DAP and 12 kg/acre of TSP at planting.
- The best investments for better-off farmers average around 56 kg of nutrients per acre. This includes a substantially higher proportion of urea. There are, however, considerable differences in the requirements between crops.

The OFRA team also analysed the impact of a range of organic fertilisers as part of a broader Integrated Soil Fertility Management (ISFM) strategy. The objective was to see to what extent mineral fertiliser application rates could be reduced when different organic fertilisers were included in the mix. The results are presented in the following table.

Figure 9 The impact of organic manure on the optimum fertiliser gift

ISFM practice	Urea	DAP or TSP	KCl	NPK 17-17-17
	Fertilizer reduction, % or kg/acre			
Previous crop was a green manure crop	100%	70%	70%	70%
Fresh vegetative material (e.g. prunings of lantana or tithonia) applied, per 1 t of fresh material	4 kg	2 kg	2 kg	8 kg
Farmyard manure per 1 t of dry material	5 kg	3 kg	2 kg	10 kg
Residual value of FYM applied for the previous crop, per 1 t	2 kg	1 kg	1 kg	3 kg
Dairy or poultry manure, per 1 t dry material	9 kg	4 kg	5 kg	16 kg
Residual value of dairy and poultry manure applied for the previous crop, per 1 t	2 kg	2 kg	1 kg	3 kg
Compost, per 1 t	8 kg	3 kg	3 kg	15 kg
Residual value of compost applied for the previous crop, per 1 t	3 kg	2 kg	1 kg	5 kg
Rotation	0% reduction but more yield expected			
Cereal-bean intercropping	Increase DAP/TSP by 7 kg/ac, but no change in N and K compared with sole cereal fertilizer			
Cereal-other legume (effective in N fixation) intercropping	Increase DAP/TSP by 11 kg/ac, reduce urea by 9 kg/ac, and no change in K compared with sole cereal fertilizer			

Note: these data are in line with Muhereze et al. (2020)[11].

One ton of dry matter (DM) of farmyard manure can replace 10 kg of NPK-17/17/17, equivalent to a value of 40,000 UGX. Dairy manure is around 60% more effective, bringing the value of one ton to 64,000 UGX. One ton of compost is valued at 15 kg of NPK, which would cost about 60,000 UGX. These values can be compared with some actual market prices for compost:

- A company in Kampala sells quality compost (4% N) at 150,000 UGX per 50 kg bag.
- A second supplier offers vermicompost (1% N) at 200,000 UGX per 50 kg bag[12].
- In Jinja, good compost is available at 40,000 UGX per 50 kg bag.
- Online, prices range from 20,000 UGX to 60,000 UGX per 50 kg, for "organic black soil" and compost made from chicken manure, respectively.

All these products are many times more expensive than mineral fertiliser. Even if smallholders can produce compost at a much lower cost, it would still be too expensive to apply at scale on outer fields. In practice, most compost is produced and marketed in towns, often from urban waste or by-products of agricultural industries (including poultry). Its main use is in nurseries for ornamental crops and in gardening by the better-off urban population. The recently announced 180 million USD in investment (by Itracom Fertilizers) in an organic fertiliser facility in Mpigi can give a boost to this industry.

Since small amounts of fertiliser appear to be the most viable option, their economic returns in the project area need to be assessed. Using 10 kg of N per acre (costing 80,000 UGX) can increase maize yields by 250 kg, generating a value of 160,000 UGX. This results in a return on investment (RoI) of 100% and an increase in net incomes of 80,000 UGX per acre, or about 50%. Half of this nitrogen will remain in the crop residues and root systems, making a small but positive contribution to soil organic matter (SOM).

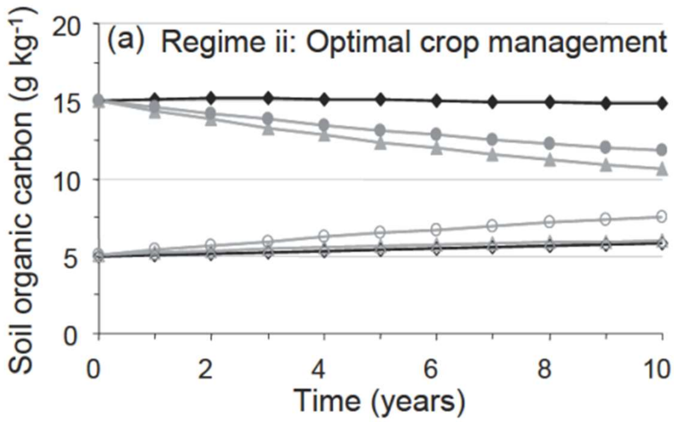
Ugandan experts indeed recommend the use of mineral fertilisers to kickstart productivity on poor soils, as they improve yields, incomes, and SOM. While the idea that mineral fertilisers can increase SOM may seem counterintuitive, the outcome depends on complex, iterative interactions between soil types and crops. The next graph illustrates this

[11] Muhereza, I, D. Pritchard R. Murray-Prior and D. Collins (2020). Nitrogen value of stockpiled cattle manure for crop production. African Journal of Agricultural Research. Vol 16 (5). Page 574-584.

12 Fryer, B. P. Ellssel,F. Nyakanda & S. Saussure . 2024 Exploring the off-farm production, marketing and use of organic and biofertilisers in Africa. A skiing strudy DesiraLift.

relationship.

Figure 10 Relation between long term fertiliser gifts and SOM

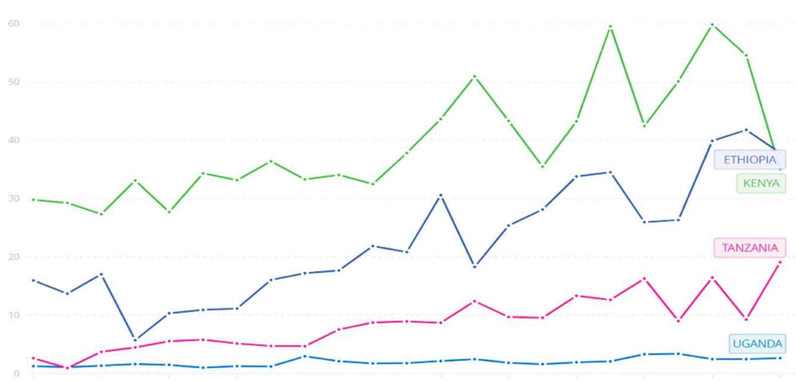


Source: Fermont, A.M. 2009. Cassava and soil fertility in intensifying smallholder farming systems of East Africa. PhD. Wageningen.

The graph is based on a calibrated nutrient cycling model and illustrates the effect of applying mineral fertilisers to maize (black line) and cassava (grey lines) over a ten-year period. The first key observation is that the graph confirms the general rule: any fertiliser regime applied continuously to a crop leads to a new equilibrium level of Soil Organic Matter (SOM). For more fertile soils with a Soil Organic Carbon (SOC) content of 1.5%, the effect is that fertility remains stable under maize but declines under cassava. In contrast, on poor soils with an SOC of 0.5%, SOM increases over time – substantially so in cassava. Yields rise and soil fertility improves, as fertiliser generates more biomass, particularly leaves that decompose quickly under cassava's closed canopy, thereby enhancing soil health.

Equally important, though not shown in the graph, is the decline in yields and SOM that would occur when no fertiliser is applied. This decline is steepest in the first five years after new land is opened (or following a long fallow period), then continues at a slower rate thereafter. Even modest applications of fertiliser help reduce soil mining and support smallholders in maintaining yields. Against this backdrop, the very low levels of fertiliser use at the national level deserve special attention. The next graph illustrates long-term fertiliser use in Uganda compared with some neighboring countries.

Figure 11 Fertiliser use in Uganda as compared to neighboring countries



Source:https://data.worldbank.org/indicator/AG.CON.FERT.ZS?end=2022&locations=UG-KE-ET-TZ&start=2000

Fertiliser use in Uganda is five to ten times lower than in neighboring countries. More strikingly, levels have not changed since 2000, despite the country signing the Abuja Declaration at the African Fertiliser Summit in 2006, where all African governments pledged to increase fertiliser use to 50 kg/ha.

While soil scientists widely recognise this as a problem, influential actors continue to advise farmers not to use fertiliser. Each does so with its own political or economic motivation:

- Since independence, politicians have claimed that Uganda's soils are naturally rich and therefore do not require fertiliser. From a technical perspective this is difficult to justify. A more plausible explanation is that it benefits the urban elite, as scarce foreign exchange does not have to be allocated for fertiliser imports and can instead be directed toward consumer and luxury goods.
- NGOs and donor-funded projects often take inspiration from Western contexts, where the over-use of mineral fertilisers is indeed a challenge and organic produce can secure premium prices. In Uganda, neither of these conditions applies.
- International companies that benefit from premium markets in the West sometimes tell Ugandan farmers that mineral fertilisers damage soils. For instance, oilseed companies in Lango profit from encouraging farmers to deepen soil mining for short-term gains, often at the expense of long-term soil health.

This challenge is compounded by issues in international trade[13]. Because of limited competition and a relatively small market, fertiliser import prices in Uganda are 10–20% higher than in Kenya and Tanzania. In addition, the in-country mark-up on fertiliser in Uganda is higher than in Kenya (74% compared to 44%). Uganda launched a fertiliser subsidy program in 2016, but it was phased out in 2022 due to misuse- precisely when Tanzania introduced its own subsidy scheme and maize prices were depressed across the region.

The impact of these dynamics is evident in production trends. Since 2000, crop yields in Uganda have declined by about 10%, while yields in neighboring countries have risen substantially. During the same period, Uganda's cropped area has expanded by more than 50%. This expansion highlights a critical problem. Because yields on virgin land are higher with the same level of effort, the cost of production is lower. In effect, this amounts to soil mining in its most extreme form: selling off nutrients accumulated naturally over centuries within just a few years. Typically, soil fertility declines very rapidly in the first five years after land is opened. At scale, such expansion keeps food prices low, which further reduces the financial attractiveness of applying fertiliser to already cultivated land.

It is, of course, important to acknowledge the drawbacks of continuous fertiliser use as well. A narrow focus on NPK often results in deficiencies of key micronutrients such as zinc (Zn), boron (B), and sulphur (S). While Uganda lacks a comprehensive soil map, limited data from Lango confirm that these elements also constrain crop production.[14] In response, major fertiliser companies have established blending facilities that allow them to market more complex fertiliser formulations. These could be piloted within the Farmer Learning Groups (FLGs) of INSPIRE (as recently suggested by Grainpulse).

Kaizzi et al. (2017) provide an excellent overview of soil fertility management in Uganda. *The country's soils are inherently of low fertility, with limited nitrogen (N) and phosphorus (P) availability. Soil fertility is closely linked to soil organic matter in the top 20 cm, which is highly vulnerable to losses through erosion once vegetation cover is removed. Such erosion*

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[13] The data in this paragraph are from: Mahuma, A, N. Landani, S. Roberts. 2024. The state of competition in Tanzania's fertilizer markets. CCRED, African Market Observatory Working Paper 2024/02. November 2024

[14] IFDC and AFAP. 2018 Assessment of Fertilizer Distribution Systems and Opportunities for Developing Fertilizer Blends. UGANDA. Report for AGRA.

leads to permanent declines in both soil fertility and land productivity. Nutrient removal through crop harvests, combined with further losses from runoff and soil erosion, is not adequately compensated by the use of crop residues, manure, or fertiliser. This results in negative nutrient balances across all agro-ecological zones (AEZs). In the Lake Victoria Crescent, for instance, nutrient depletion amounts to 82 kg of N/ha, 8 kg of P/ha, and 80 kg of K/ha. In the Lake Kyoga Basin, the losses are lower due to reduced yields, but remain significant – typically 40–60 kg of N/ha.

Tillage is commonly done using hand hoes or animal traction, with crop residues generally removed from the field. Current fertility management practices include farmyard manure, crop residues, compost, fertiliser, crop rotation, and—though increasingly rare—the practice of leaving land fallow for several years. However, manure and fertilisers are applied on only 7% and 1% of land parcels respectively, and by just 24% and 2% of smallholders. Their use is largely confined to small plots such as home gardens.

Some farmers attempt to manage runoff and erosion, though with varying success, while others make little to no effort. Crop residues for soil application are often unavailable due to competing demands for fuel and livestock feed. Manure use is further constrained by the labor required to collect and apply it, as well as its relatively low nutrient content. Green manure has been shown to supply sufficient nitrogen for subsequent crops, but it requires land that could otherwise be used for food or cash crops and is therefore not widely practiced. The transfer of plant materials from field boundaries or nearby fallow and grazing areas offers some potential in sub-humid zones, but is less feasible in semi-arid areas. In practice, such measures are mostly applied in banana production systems.

4. The way forward

Considering the complexity of the soil fertility challenge, it is not desirable to formulate uniform recommendations to sustain soil health and to improve yields and incomes. Next to the differences between the three farming systems, we have to deal with a range of crops, with different types of soils and fields, and with the different resources available to the different types of farming households. Indeed, at the end of the day each famer has to take her own decision. To support them in this decision-making process, PIP farmers are stimulated (in Module 3 of the PIP) to reflect on five key-principles when they design their Integrated Plot Plan:

- Capture water where it falls
- Increase organic matter in the soil
- Support life in the soil
- Restore the nutrient balance
- Optimize farming efficiency and sustainability

This is then translated into five best practices.

1. Permanent land management (soil and water conservation) practices
2. Non-permanent land management (soil and water conservation) practices
3. Soil fertility management practices
4. Crop management practices
5. Other practices and innovations

As the Module 3 manual focuses on the challenge of soil erosion, the solutions focus on soil and water management conservation practices. Based on the present Farming System Analysis the focus should shift to IPM and ISFM. At the same time economic aspects need to be taken into account as well. In the present setup the *importance* of certain practices is stressed, yet the *feasibility* and *economics* go unmentioned. This needs to be amended under the key-principle '*Optimize farming efficiency and sustainability*'.

Lastly the manual needs to distinguish between the farming systems, the types of farmers (with and without livestock), the type of fields etc. The present version is oriented towards developing Integrated Plot Plans (IPPs) for kitchen gardens. This is useful in terms of learning about soil and water conservation practices, yet it will have a limited impact on the whole farm and will not lead to the project targets of 50% higher yields and 30% more income for households.

The present PIP modules support PIP Innovators to understand the principles of conservation agriculture and integrated farming. This is followed by demand driven training on their IPP-plots. The latter are generally small plots like kitchens gardens for which sufficient organic materials can be found and where crops are grown that respond well to this (e.g. banana or pumpkins). Farmers Learning Groups (FLGs) support farmers in translating what they learned on their IPPs to the whole farm. Generally, this refers to crops on bush fields. Doing so FLGs integrate the lessons learned from IPPs with other GAPs needed to attain the targets on increase yields (50%) and incomes (30%). As there is not enough biomass for the whole farm, inevitably this leads to a new ISFM mix with relatively more mineral fertilisers. It might also lead to more SWC measures as outer fields tend to more erosion prone than kitchen gardens. A FLG can also be on livestock; like how to manage modern chicken breeds. It can also be storage: how to prevent Bruchids eating all the beans in a store? Or what is the impact of PICS bag?

The CVC coordinates all these learning processes in consultation with the PIs. It decides on priorities based on PIP plans, on the outcomes of IPPs and FLGs, and on the progress with economic initiatives (like nurseries, input supply and marketing).

A FLG is a group of 20-30 farmers that jointly learn about new practices that are piloted on the farms of three elected Lead Farmers. FLGs are based on a well-structured and participatory learning process: farmers formulate upfront about which technologies they want to learn; then they observe and discuss these technologies as they are being piloted on the fields (Learning Plots) of Lead Farmers and, lastly, they assess the suitability of these technologies for them, in technical and economic terms, in an Internal Review.

In the first step of a FLG, members define the innovation package (= logical set of practices or technologies); in doing so reflect on five issues:

- What soil and water management practices can be used to avoid (further) physical land degradation? Think of contour bunds, trash lines, mulching or tree planting.
- What (preventive) Integrated Pest Management practices can be used to minimise pests & diseases? Think of planting date, hygiene, spacing, intercropping, rotation etc.
- What Integrated Soil Fertility Management practices can be used to sustain soil fertility and soils health? Think of mulching, manure or compost, mineral fertiliser etc.
- What external inputs can be used to optimise the yield and income? Think of improved seeds and varieties; (type of) mineral fertilisers; (organic) pesticides.
- What are the critical agronomic practices that the lead farmer needs to apply? Think of land preparation, planting, weeding, pest scouting, spray applications etc.

So IFSM is part of the deliberations facilitated by extension workers. It is their task to ensure the dialogue is grounded in farmers' realities (e.g. asking for farmers already applying certain practices), while enriching it with information and experience from other contexts.

The latter is complex: which practices can the extension worker recommend based on which facts, data, experiences? Using blanket recommendations is risky, whether it is about compost or about mineral fertiliser. The former might be too much work, the latter might be too expensive.

Giller et al. (2010)[15] describe this dilemma via the concepts of *best-bet* and *best fit*. The former is a blanket recommendation that is assessed to offer the best average outcome on average fields. The best fit aims at working with farmers to see where, when and how different ISFM packages can be applied in different farming systems, with different types of farmers, on different fields, soils and crops.

At the start of INSPIRE we have to work with the *best bet* recommendations as generate by experts and research. When it comes to GAP the recommendations by NARO will be a starting point (modified by senior project staff). When it comes to ISFM the point of departure for organic fertiliser will be to promote mulch (and thrash lines) in all three farming systems.

In the perennial system the best bet for those who have cows will be to improve manure handling and composting. All will be advised to use at least one bag of fertiliser per acre. This is only to compensate for a (major part) of the nutrients removed by the harvest and it is expected to have the highest efficiency and impact. People can add a top dressing when the circumstances allow them to do so.

In the annual farming system the starting point will be to use half a bag of fertiliser. It will compensate for most of the macro-nutrients lost, it generates food and income and it offers farmers a chance to observe and learn about the pro's and cons' of using fertiliser. Lastly even half a bag is already a serious expense for a household.

Using these *best bets* enables the project to get feedback from smallholders on the benefits and challenges different IFSM mixes. This is essential for moving from *best bets* to *best fits* as described by Giller et al. (2010): *The aim is to engage with farmers through participatory action research to get a better insight into farmers constraints and understand how technologies need to be locally adapted. This allows 'ground rules' to be distilled that form the basis for development of extension materials in each of the target areas. A major issue in this context is the diagnosis of soil fertility constraints by farmers in order for them to engage in site-specific nutrient management practices using such ground rules.*

In INSPIRE a Task Force (TF) is established to work along these lines. It is led by an expert of WENR in coordination with the Pathway 2 manager of Resilience. It works on both IFSM and IPM. The ultimate aim of the TF is to support the field staff with adequate '*ground rules*' in their dialogue with farmers at two critical moments:

- in PIP Module 3 farmers prepare their IPP. At present the PIP modules are being amended to cover the pro's and con's of different ISFM practices and to expand the aspect of '*Optimize farming efficiency and sustainability*'
- in FLG Step 1 farmers discusses the practices to be piloted on the Learning Plots.

[15] Giller, K.E., et al. (2010) Communicating complexity: Integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. Agricultural Systems (2010).

> Economic losses via soil mining have to be included in the dialogue. Understanding that the value of the N sold via the harvest is one third of the return on land and labor for maize, might contribute to a change in the mindset.

Initial communications with stakeholders lead to the following questions and considerations to be addressed by the Task Force. At the time of writing the first steps have been taken on IPM; the ISFM process still needs to be initiated.

Integrated Soil Fertility Management (ISFM).
While the principles of ISFM are well known and agreed by all stakeholders in many situations the question remains: what is the optimal combination of organic and mineral fertilisers? In the project area 95% of the compost used only in one crop (banana) while mineral fertilisers are concentrated in a few crops. At the level of farming system there are also serious differences; e.g. while 30% of the HH in the perennial cropping systems uses mineral fertiliser this is only 3% on the oilseeds system.

The first assignment for the taskforce is to better understand the challenges of organic and mineral fertilisers across the three farming systems for different crops, different types of farmers (rich/ poor and with and without livestock) and different types of fields/soils.

This starts with three basic questions:

- What is the availability of organic- and mineral fertilisers?
    - Organic: What biomass is available where? In what form can it be found? How useful are the different types of biomass (manure/ compost / crop residues or mulch)? In what amounts? Who owns it? What are the alternative uses?
    - Mineral: What types are available, where? What is the quality? And in what quantities do farmers buy it?
- What are the costs of organic- and mineral fertilisers?
    - Organic: What organic fertiliser are available on the market in the farming systems? Against which price? What is the physical and chemical quality? What are the costs of smallholders to produce organic fertilizers themselves (e.g. compost)? What are the application methods and related costs?
    - Mineral: What are the costs of different types of mineral fertilisers in the three farming systems? What are the application methods and costs?
- What is the impact organic- and mineral fertilisers on soil health and yields?
    - Organic: What is the impact of mulch and compost on soil health and yields in the different farming systems
    - Mineral: What are the costs of different types of mineral fertilisers in the three farming systems?

As INSPIRE is not a research project, the answers will be first of all sought with PIP Innovators applying IFSM practices on their IPPs. This will be combined with KIIs with experts. Action research with selected PIs can give insight in complex issues like the amount of biomass and labor involved.

Once the basic issues are clear, the next step would be to formulate suggestions on how IFSM package can be integrated in the Learning Plots of FLGs. The feedback and learnings from these FLGs in their Internal Review will then be the base for a further upscaling; both via IPP and FLGs.

In this process we have to develop a typology of fields. The main distinction is between kitchen gardens, homestead fields and bush fields. Each have their own economics, crops, soils, response to different ISFM mixes etc. This is a complex assignment as it needs to be done for each farming system. And it might even differ within a system as a result of secondary factors like livestock ownership and soil types (HHs near a samp etc.).

Integrated Pest Management (IPM)

The second dimension is the use of non-chemical control measures in IPM. While judicious use of pesticides can be justified in case of serious damage to crops, it is more desirable to prevent the development of pests and diseases or to control them via cultural, mechanical or biological measures. This requires insight in the life cycle of the pests & diseases, the agroecological context in which they thrive and the resources of the smallholders (in terms of time, skills and money). The Task Force will seek to identify potential IPM measures via a number of ways:

- Inventory of problematic pests & diseases for PIP farmers via Focus Group Discussions. In these FGDs the present IPM practices of farmers will also be described; 7% of all farmers say they use natural pest control measures (mostly in soy, tomato and g'nuts)
- Inventory or existing IPM practices from WUR experts; literature review; Ugandan research institutes; projects in Uganda, CABI, etc.
- Short list a limited number of options and discuss the options in FGD.

When PIP farmers are willing to pilot the proposed measures, Action Research FLGs are setup where the pests, the crop, the measure and the harvest will be closely monitored by project staff. Considering the complexity of the issues the recommendations can also be piloted first on semi-commercial farms.

Another element of IPM is improving the use of pesticides which relates to:

a. Pest scouting and threshold levels
b. Selection of pesticides: specific, effective, less hazardous, availability, price etc.
c. Adequate spraying in terms of timing, walking, application, wind etc.
d. Proper use of knapsack sprayers: mixing, water quality, nozzle type, etc.

One question that needs to be addressed is: who will be trained and how can the trainee use his skills for other farmers? As horticultural farmers tend to spray most, they need special attention. One question is: can trained farmers generate some income form their skills by spraying for others? As a proper training takes at least three days, only a limited number of farmers can be trained. Who can be that? Pathway 3 needs to be involved as well, as agro-dealers also need to be trained and could be a hub in disseminating the skills.