Food system analysis of Arua District in Uganda

Report 1: Proposed research framework and description of the food system

Nico Rozemeijer and Marlene Roefs

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This paper describes the different components of the food system of Arua. The inventory is a first step in a research assignment between Wageningen University and relevant stakeholders in Northern Uganda. The research is meant to understand how food systems in less favoured areas in East Africa can be enhanced. On the basis of a theoretical food systems model, data were collected on food production in the area, the socio-economic context, the environmental conditions, and food security status. Information was retrieved partly through desk research and partly through district consultations in October 2019. The model and therefore also the information collected draws upon a wide variety of factors influencing food security and in this way paints a comprehensive picture of the food system.

The resulting quick scan will be the basis for the next step in the research process: furthering our understanding of the functioning of the multifaceted food system of Arua and why it is currently underperforming; how different components are interrelated and how these relationships explain strengths and weaknesses, robustness of the system and the potential to sustain the expected changes in the region for the decades to come such as population growth, influx of refugees, urbanisation, globalisation, climate change, changing food preferences. Better understanding amongst science and stakeholders will ultimately assist in designing, choosing and pushing the "right" buttons in the system expected to lead to effective interventions for improved food security of Arua.

Keywords: food system, Uganda, Arua, refugees, food security, nutrition, agriculture, climate, population growth.

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Summary

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1 Background

The current East African population will more than double to 851 million by 2050 assuming medium population growth rates (UN, 2019). Agriculture is the most important source of livelihood for the majority of the rural population. However, it currently does neither provide sustainable livelihoods to the rural population nor adequately supplies food to the urban population. This results in widespread hunger, poverty, soil degradation, depletion of freshwater resources, low investments in agriculture and migration to the cities, especially of youth. How will this look like in 2050?

The share of urban population in the region will double from 23% in 2010 to 47% in 2050 (UN-HABITAT, 2010). In addition, increasing wealth of the urban population will contribute to more diversified diets, which has implications for nutrition security, food safety and food quality demands. Especially in the well-endowed highlands of East Africa, increased competition for scarce land and water resources between agricultural and non-agricultural use is already observed (Pender et al., 2006) and results in decreasing farm sizes (Masters et al., 2013). Current agricultural production systems in the well-connected rural areas of the East African highlands intensify, and increasingly more remote rural areas need to contribute to meeting urban food demand. What implications do these trends have for food systems in less favourable rural areas of East Africa?

The transition in rural areas of East Africa takes place against the backdrop of global change processes. Increasing food supply to urban consumers and providing sustainable livelihoods for rural populations – be it by land expansion, productivity improvements, reduction of post-harvest losses, agribusiness growth, creation of non-agricultural off-farm employment—need to consider the potential implications of and consequences for rising GHG emissions, declining freshwater resources, and degrading land resources and biodiversity.

The main question in this research is through what pathways less-favoured rural areas of East-Africa can become more food secure in a sustainable manner, and underlying food systems more robust.

Recently, 'food systems' thinking has been coined to address the multiple challenges that go beyond the traditional focus on increasing agricultural production to improve food security (Ingram, 2011; Van Berkum et al., 2018). Food systems comprise all the processes associated with food production and food utilisation: growing, harvesting, packing, processing, transporting, marketing, consuming and disposing of food remains. All these activities require inputs and result in products and/or services, income and access to food, as well as environmental impacts. A food system operates in and is influenced by social, political, cultural, technological, economic and natural environments (Van Berkum et al., 2018).

The Wageningen University and Research Knowledge Base project 'Improving food systems in less-favoured rural areas of East-Africa'[1] aims to apply the food systems thinking to identify transition pathways for contributing to sustainable food systems in less-favoured rural areas in East Africa in the medium term (2030–2050). Testing of the accompanying analytical framework is done in case study areas in Uganda and Ethiopia.

One of the case study areas is the Arua district in the West Nile region of Uganda. Arua lies approximately 420 km by road, northwest of Kampala, the capital of Uganda. The location of Arua district on the West Nile places it at the centre of cross border commerce with DR Congo and South Sudan. Arua district (4274.13 km^2; UBOS, 2012), with the largest town and capital with the same name, is now one of the fastest growing economic centres of Uganda not in the least because of the

[1] The project 'Improving food systems in less-favoured rural areas of East-Africa' is one of the projects in the Knowledge Base (KB) program Food security and valuing water.

influx of refugees especially from South Sudan. Recently, new refugee settlements, Imvepi and Omugu, have opened in the Arua district.

In the Arua district, the research is done closely with the Nutrition and Income Generation Intervention (NIGI) project and Training for Green Jobs, a Nuffic-funded Orange Knowledge programme (OKP) project. The NIGI project focusses on improving access to, and consumption of, nutritious crops as well as by increasing income for refugees and hosts communities from production, processing and trade in crops. See Appendix 1 for a summary of the NIGI project. The OKP project targets the improved connection between agricultural education and labour markets.

This report (the first in a series) describes a quick scan of the Arua food system based on a review of available literature and data, and a scoping mission of various authors to Arua district in October 2019 when various stakeholders were consulted (see Appendix 4). The objectives of this report are threefold:

1. Describe the research framework to identify and develop transition pathways for less-favoured rural areas contributing to sustainable food systems in East Africa;
2. Provide a quick scan of the food system of Arua district as the first step in implementation of this framework; and
3. Outline the follow-up steps for better understanding and improving the Arua food system.

In chapter 2, the food systems approach of Van Berkum et al. is briefly described. It forms the basis for the research and development framework that is elaborated in that chapter. The framework is meant to operationalise the food systems approach by creating room for stakeholders to engage in the research and by adding an action-oriented step-wise process approach. This research and development framework will be used to identify food systems transition pathways over the course of the current research project duration. In Chapter 3, the data collection methodology used to characterize the Arua food system from different disciplinary perspectives, is presented. In the subsequent four Chapters the major components of the Arua food system are described: the socio-economic drivers (Chapter 4), environmental drivers (Chapter 5), food system activities (Chapter 6) and the food system outcomes (Chapter 7). Finally, in Chapter 8 the further research steps are proposed.

2 Food systems approach

2.1 Introduction

Various conceptual frameworks have been developed to support food systems thinking (Ingram, 2011; HLPE, 2017). Although these frameworks differ in detail, they all try to capture the complexity of food systems by mapping the interactions between food system components, feed-back loops among food system components, and trade-offs between food system components.

In this paper we use the food systems approach developed by Van Berkum et al. (2018) as starting point to analyse food systems. They distinguish socio-economic and environmental drivers that together with food system activities result in food system outcomes. Figure 2.1 shows a map of the relationships among the food system drivers, activities and outcomes.

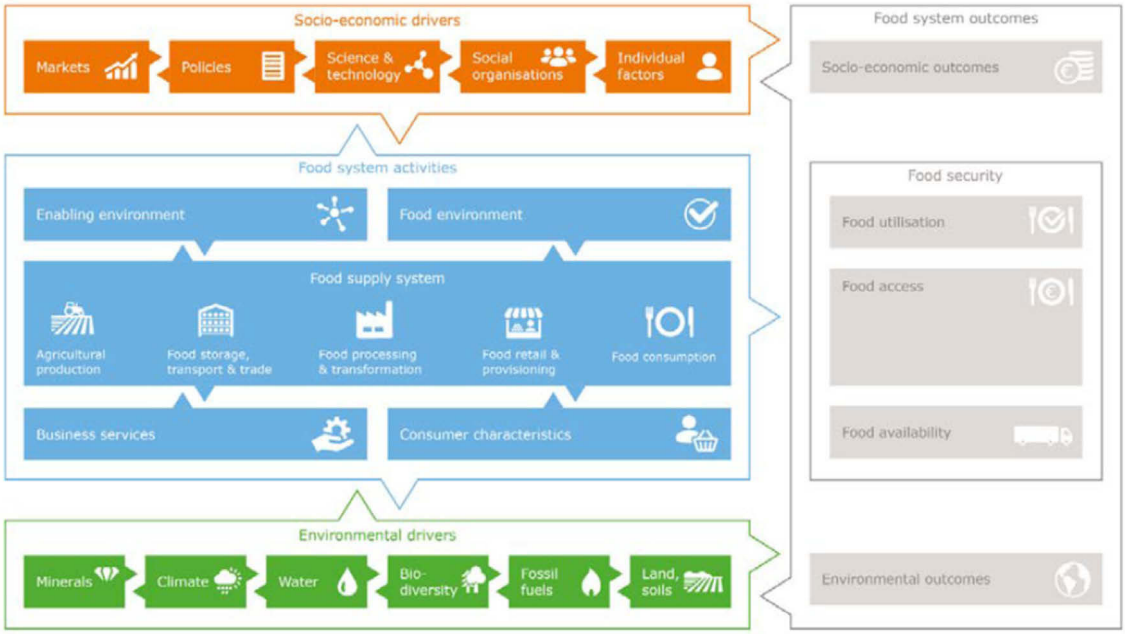


Figure 2.1 *An example of mapping the relationships among food system drivers, food system activities and food system activities (Source: Van Berkum et al., 2018).*

A food systems approach (FSA) is a useful interdisciplinary conceptual framework for research and the setting of policy agendas aimed at sustainable solutions for the sufficient supply of healthy food. The approach analyses the relationships between the different parts of the food system and the outcomes of activities within the system in food security, socio-economic and environmental terms. Feedback loops are a distinguishing factor in systems thinking: they occur between parts of the food chain (production, processing, distribution and consumption) and from the socio-economic and environmental outcomes of food production and consumption (such as food security and soil depletion) back to that production and consumption. The approach emphasizes the non-linear processes in the food system, and the possible trade-offs between policy objectives. The food systems approach highlights the interdependent nature of the agricultural sector. It shows how production systems, consumer behaviour, food security, climate change, natural conditions (i.e. the available natural resources) and socio-economic trends interact with one another. It prevents people from becoming mired in silo thinking, whereby possibilities for enhancing food security are sought within a single subsystem without taking into account the effects of an intervention in other parts of the

system, thereby overlooking possible trade-offs. Systems thinking also broadens the perspective when seeking solutions for the root causes of problems such as poverty, malnutrition and climate change (Van Berkum et al., 2018).

The approach offers at least three benefits. First, it provides a checklist of topics that should at the very least be addressed when it comes to improving food security, certainly in relation to other policy objectives. Second, FSA helps to map the impact of environmental and other changes on food security by pointing to the various vulnerabilities of the food system. In that sense the approach can contribute to the search for possibilities for strengthening the system's resilience to climate changes or other shocks. Third, it helps to determine the most limiting factors for achieving food security, and hence identify effective interventions aimed at improving food security (Van Berkum et al., 2018).

The food systems approach offers a helpful structure for analysis of the food system in Arua but falls short on the following:

1. The research process steps for giving an action perspective to the analysis in order to remove bottlenecks that contribute to the current food insecurity in Arua and improve the performance of the food system;
2. Embedding the analysis in a transdisciplinary research framework that engages local stakeholders in the understanding as well as improvement of the Arua food system. Such embedding is necessary to develop and implement knowledge and research tools with stakeholders as the main change actors.

2.2 Towards a transdisciplinary analytical research and development framework

A transdisciplinary analytical research and development framework is proposed for analysing food systems with the aim to design and develop food systems interventions (Figure 2.2). The framework is derived from the DEED (Describe, Explain, Explore, Design) research cycle with co-learning amongst researchers, farmers and other stakeholders influencing and influenced by every step in the research process (Giller et al., 2008). The proposed research framework has the following characteristics:

- It is **iterative**, the evaluation of newly designed interventions is an integrative part of the framework through a feedback loop;
- It is **interactive,** the description and analysis of the a given food system is implemented together with the stakeholders as well as exploring options for improvement, and designing interventions. Stakeholders, i.e. relevant organisations at the relevant governance levels are key in validating research agenda, process and results. A continuous process of stakeholder engagement is needed for local knowledge, ensuring the relevance of research, co-creating of knowledge, co-designing of development options, and to ensure ownership of proposed interventions.
- It is **stepwise**, outlining the various steps required to implement a sound analysis and design of interventions for improving the food system.

0. Preparatory steps included the selection of the food system under study as well as its spatial and temporal boundaries. These choices determine the stakeholders that need to be involved from the start of the research process. Hence an additional step may be a stakeholder analysis that identifies the relevant stakeholders and the roles they fulfil within the given food system. Subsequently, four research steps are identified:

1. Describing the food system. In this step the different elements of the food system are described. It includes question such as: How food insecure are people? What are current food system activities and what determines their performance? What are the policies influencing its functioning? What is the relation between the food system and its environment, e.g. in terms of soil erosion and water use? In this step it is important to agree on the proper metrics of food system outcomes with stakeholders.

These metrics, each based on a combination of multiple indicators, are used to characterize sustainable outcomes of food systems. Examples: food nutrient adequacy; ecosystem stability; food

affordability and availability; food safety just to mention a few. Each of the metrics - you may call them aspired system outcomes – comprise multiple indicators that are combined to derive at an overall score (0–100). These metrics can be deployed by decision-makers to set meaningful goals, track progress, and evaluate the potential impact of food system interventions intended to improve sustainability and food security outcomes (Gil et al., 2019).

In this step, data related to the various drivers need to be collected. Essential data not available from existing literature, surveys or databases need to be collected locally in collaboration with stakeholders. Subsequently, a quantitative description is made of system elements, to gain more insight in past and current system functioning. Some food system elements are described more qualitatively as they are inherently qualitative, such as certain socio-economic drivers, or because quantitative data is lacking. The key focus in this step is to identify the most important drivers of change and constraints that determine current food system outcomes. Understanding the historical functioning of the food system may provide insight in such drivers and constraints, and in the opportunities to manage and overcome them in the future. The outputs of this step is a case study description of the selected food system. Typical tools used in this step are rapid rural appraisals; time series analyses of databases, for example, on climate variables, market prices and agricultural statistics; and (results of) market and consumer surveys.

2. Understanding the food system. The information collected in step 1 is used to understand the relationships between drivers, activities and outcomes of the food system. Better understanding of the performance of food system is necessary to identify the bottlenecks resulting in undesired outcomes or in the underperformance. How are the different components impacting each other? What are the root causes of deficiencies in the system. At what "buttons" in the system can we push to intervene, and how will the system respond if we want it to improve upon food availability, or improved nutrition and what will then be the impact on both environment, and socio-economic context of, for example, vulnerable people?

Different qualitative and quantitative analytical tools and stakeholder engagement methods need to be used. Analysis of the various relationships needs to be done from different disciplinary perspectives to triangulate information:

- Trend analyses may give insight in the direction and pace of the food system change over time, and main system drivers;
- Qualitative tools may consist of narratives and results of stakeholder discussion groups;
- Quantitative tools may include the use of simulation models and statistical methods.

Critical is to involve stakeholders to validate results and to provide feedback on overlooked or underexposed elements.

3. Developing scenarios and exploring options for enhancing performance of the food system. Most likely, step 2 will identify a range of bottlenecks and constraints affecting the current food system's performance. It will also provide an overview of the potential of the area to meet future targets for food security (aspired outcomes). Based on scenario analysis, step 3 explores the options to overcome the constraints and bottlenecks and achieve the desired food system outcomes. Shared vision development most likely the preferred scenario - portraying a desired food system, and how to get there will be one of the activities in this research phase. This is often a daunting task as different stakeholders may have different interests that result in conflicting perspectives. Showing the implications of continuing the current "business-as-usual" scenario may help to unite stakeholders and to stimulate thinking about alternative futures. Addressing the diverse drivers of change that are affecting scenarios ranging from climate change, international markets, civil war in neighbouring countries to soil degradation require the involvement of multiple stakeholders at local, national and international level. Research can support the development of scenarios, for example, by sketching current trends, quantifying potential effects of climate change on agricultural production, or developing protocols and requirements of product tracking and tracing to guarantee better product quality. Research can also improve insights in the possible trade-offs of various options or scenarios for example by quantification in cost-benefit analysis. This will provide stakeholders with a more informed choice between options for possible interventions in the food system.

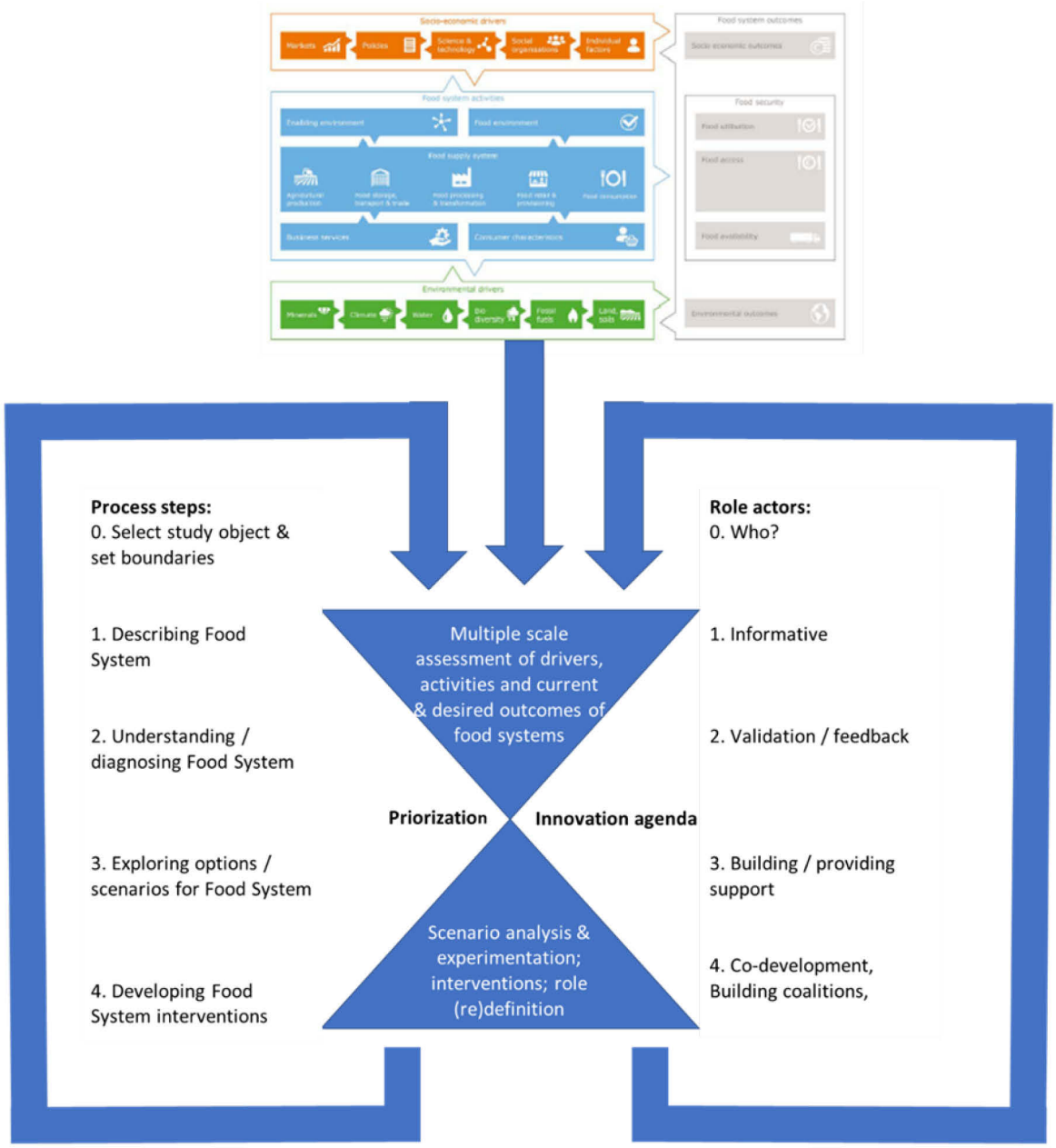


Figure 2.2 *A transdisciplinary analytical research and development framework for understanding and intervening in local food systems (Based on Giller et al., 2008; and Van Berkum et al., 2018).*

4. Developing food system interventions. The options that are most promising, most feasible and that have the support of stakeholders need to be further designed and developed in this step. Interventions can be of a more technical, political or of more institutional nature.

Whether the interventions identified in step 4 will be implemented within the KB project or whether the foundation will be laid for a follow-up project, depends on how fast the first three steps of the R&D framework can be carried out and on whether the required resources are available. In the latter case, interventions will be designed and funding agencies will be approached with proposals to support the further development and implementation of proposed interventions. Monitoring of the effects of new interventions would take place in the next loop of the R&D framework (the evaluation of newly designed and developed interventions is an integrative part of the framework through a feedback loop).

2.3 Need for a transdisciplinary research process to create impact

Giller et al. (2008) in presenting their DEED (Describe, Explain, Explore, Design) research cycle add the prefix "NE" resulting in the NE-DEED. NE stands for "negotiated" and refers to the transdisciplinary nature of the proposed research methodology. The word transdisciplinary research means moving beyond scientific disciplinary boundaries by engaging stakeholders in research activities. It means moving away from providing solutions and plans **for** stakeholders to the support of negotiation processes between stakeholders based on negotiated shared understandings of the problems and opportunities for change (Giller et al, 2008). It means co-learning amongst researchers, farmers and other stakeholders influencing and being influenced by every step in the research process (Giller et al., 2008).

In terms of research steps a start is made by identification and engagement of all relevant stakeholders in Arua from local to national, and if relevant international level. Research data are jointly collected and shared. Subsequent steps include 1) (joint) analysis of the food system, and validation by stakeholders; 2) exploring options for making the food system to perform better, becoming more resilient, more sustainable all depending on the aspired food system outcomes that will have to be defined, or better, negotiated amongst stakeholders (the prioritized innovation agenda); and 3) jointly designing interventions that generate the desired effect in the medium term (2030–2050).

3 Data sources used

In the following sections we describe the elements of the food system of Arua district as shown in Figure 2.1. The resulting quick scan of the Arua food system helps to strengthen understanding of the elements, linkages, drivers, outcomes of the current food system.

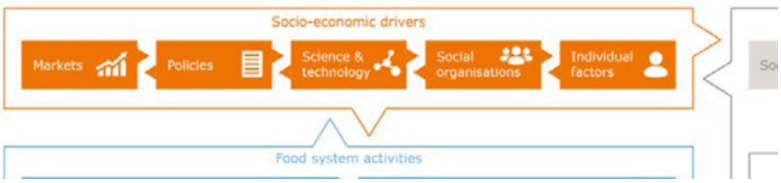
The data and information used to describe the Arua food systems are based on a comprehensive review of the relevant literature. This included the review of reports published by various NGOs related to refugee aid services provided in the Arua. Although some reports address the wider North West Nile region they still gave relevant insights for our case study as conditions are quite similar. We indicate in the text whether the information given is based on another area than the Arua district.

In addition to information from the literature, data of Living Standard and Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) study of World Bank have been analysed. The LSMS-ISA is a household survey project established with a grant from the Bill and Melinda Gates Foundation and implemented by the Word Bank. The project collaborates with the national statistics offices of eight countries in Sub-Saharan Africa including Uganda to design and implement systems of multi-topic, nationally representative panel household surveys with a strong focus on agriculture. The primary objective of the project is to foster innovation and efficiency in statistical research on the links between agriculture, socioeconomic status, non-farm income activities and poverty reduction in the region. In Uganda, the LSMS-ISA has supported multiple rounds of a nationally representative panel surveys. Data are available for 2009-10, 2010-11, 2011-12, 2013-14 and 2014-15 of which the 2014-2015 data set has been used in this report.

For assessing the agricultural production potential of Arua and resource use efficiencies, data of global yield gap atlas (www.yieldgap.org) have been unlocked and analysed.

Last but not least, a selection of the authors visited Arua district in the period October 7-12, 2019. A food system mapping workshop with local stakeholders was held October 8, 2019 at Muni University in Arua city. During the workshop available knowledge was validated with stakeholders (Appendix 4) and lacking information collected. After the workshop, various bilateral meetings with stakeholders were organized to gain a more profound knowledge of various food systems components. Insights and understanding of the food systems activities were further enhanced during several field visits in Arua district.

4 Socio-economic drivers



4.1 Markets

In general, markets in Arua district and the wider West Nile region are poorly developed. The majority of the host communities in the West Nile region have historically been reliant on subsistence agriculture. As a result, the supporting markets necessary to promote commercial agriculture (such as of supplies of seed and fertiliser, demand by processors, efficient market channels) have remained underdeveloped (Hemberger et al., 2018). Main food crops are cassava, maize, beans, sesame, groundnuts and sorghum, while the major cash crop is tobacco. Sesame (locally called simsim) is also increasingly produced for cash. About one-third of the population is still engaged in barter trade (UNHCR & WVU, 2017). Cattle farming plays a minor role in the livelihood strategy of most farmers in Arua district but is of more importance for people towards the Nile where more grazing land is available.

Refugee settlements have detrimental effects on existing markets. Local food markets are affected because of the food aid imported from outside the West Nile region. Surplus food aid is sold on the local markets which may reduce the incentives for local farmers to produce for the market. Hemberger et al. (2018) described that prior to the Bidi refugee settlement in the west Nile, bordering Arua district, 10 large traders used to bring in cereals to the nearby local market in Yumbe. Since the food aid distributions started nine traders shifted to other types of businesses.

Aid assistance programs also seem to have a negative influence on the development of seed and agricultural input markets: aid organisations that provide seeds and other agricultural inputs for free undercut the availability of agriculture inputs on local markets (Hemberger et al., 2018). There are various agro-input dealers in the city of Arua but their product range is limited and they are too far away to serve refugee settlements. Few input sellers operate outside the city of Arua but they offer even a more limited stock of agricultural inputs.

Having said that, refugee settlements do offer opportunities for the development of markets. In many of the refugee settlements, refugees get small plots of land for crop production or lease land from host communities. In addition, after having received food aid for one year, refugees have the choice to enrol in a cash transfer program, which means that they either have to buy food or produce on their own. Received cash or earned cash prompts petty trade in the refugee settlements. Hence, there is a potential for economic growth for both refugees and host communities (Hemberger et al., 2018).

With policies changing from in-kind food relief to cash-based relief, food trade is becoming a lucrative source of livelihood for households in host settlements. Preliminary findings of WFP market price analysis indicate an increase in retail food prices since January 2019, compared to the last quarter of 2018, with Northern Uganda the most affected. However, the majority of the refugees receiving cash-transfers are still able to buy an equivalent of their previous food basket (WFP, 2019).

Apart from the cash-based relief, the food prices increment was also a result of the poor yields due to the prolonged dry spell that affected the first harvest season in most parts of Uganda (UNHCR May 2019). There are currently no figures of the accurate price increases but FEWSNET (2019) reported a big price increase of basic commodities in early 2019 around refugee settlements.

Outside the city of Arua few roads are paved. Dirt roads are in poor shape, especially during the wet season. A 50 km trip from Arua to Omugu settlement takes about 1.5 hours by car. Farmers living further from the main dirt roads are only reachable through small trails, limiting market access. Arua District Local Government (2012) gives detailed information on the (quality of the) road infrastructure and shows that about 50 and 10% of the feeder roads and community roads (gravel or earth), respectively, was in a good condition.

Electricity from the grid outside Arua city is rare. However, many farmers have solar panels for light and recharging mobile phones.

Although the Census data of 2014 on ICT use in Arua is outdated because of the recent rapid spread of ICT it gives an indication of the digital infrastructure and penetration of ICT in Arua (UBOS, 2017). In 2014, about 6% of the population used internet, while about 27% of the population owned at least one mobile phone. During the scoping mission in October 2019, the mobile communication network was generally fine, also in the Omugu settlement.

The West Nile region is the three-country point bordering Uganda, Congo and South-Sudan. Arua city is well-positioned to become a key hub for investment and regional trade. The government planned all kinds of infrastructural projects, such as a direct railroad and ferry to respectively Mombasa and Kampala, and an upgraded airport. This type of investments once effectuated will affect the functioning of the food system.

4.2 Policies and regulations

4.2.1 National policies

Development policies for Arua are largely influenced and governed by national development policies. Uganda's long-term development vision is formulated in the country's Vision 2040. The Government of Uganda (GoU) aims to drive economic development through implementation of a series of five-year National Development Plans (NDPs). The first NDP (NDP-I) covered the period 2010-2015 and described the country's medium-term strategic direction, development priorities, and implementation status. The second NDP (NDP-II) covers the period 2015-2020 and aims at propelling the country towards middle income status by 2020 through strengthening of competitiveness for sustainable wealth creation, employment and inclusive growth. The NDP-II aims to achieve an average economic growth rate of 6.3% and reduce poverty levels to 14.2%.

The Uganda Green Growth Development Strategy (UGGDS 2017/18 –2029/30) aims to ensure that the goals of the Uganda Vision 2040 and the NDPII 2015/16-2019/20 are attained in a sustainable manner. The UGGDS has five focus areas whose selection was informed by empirical macroeconomic analytical studies that identified the areas with the highest green growth potential in terms of investments and contribution to the achievement of national development goals and targets. The focus areas are:

i) Sustainable agriculture production through upgrading the value chain of strategic commodities and enterprises with a focus on irrigation and integrated soil fertility management;
ii) Natural capital management and development which focuses on tourism development, sustainable forestry, wetlands and optimal water resources management;
iii) Planned urbanization and development of green cities (comprehensive economic physical planning and sustainable procurement and interlinkage between the rural raw materials production base and industrial production in cities);
iv) Sustainable transport with a concentration on multi-modal and mass transport systems for urban areas and development, utilization and interconnectivity of planned national and regional transport connectivity; and
v) Energy for green growth with increased emphasis on renewable energy investment through biomass energy for electricity and improved technology for enhanced efficiency in using biomass for domestic and industrial uses, enhancing solar power potential for on-grid exploitation of geothermal energy and reinforcement of environmental, health and economic safeguards for energy generation.

4.2.2 Refugee rights policies

Arua district hosts a large part of the refugees that have been offered residence in Uganda and with about a quarter of its population being refugees, national refugee policies and responses are very relevant to Arua. In 2016, the Government of Uganda pledged to continue its refugee settlement approach, i.e. provide newly arrived refugees with access to education and employment opportunities, and finalize and implement its Refugee and Host Population Empowerment (ReHoPE) framework (IRC, 2018). The government's ReHoPE strategy—a multi-year strategy for enabling self-reliance and resilience among refugees and host communities—is integrated into the UN Development Assistance Framework for Uganda (UNDAF 2016-2020). The Settlement Transformation Agenda (STA), a part of Uganda's five-year National Development Plan II (2016-2020), recognizes that refugee-hosting areas are in need of special attention due to the added demands of hosting displaced populations, and aims to integrate refugee services structures within government structures. A Government directive also commits humanitarian actors to ensure that 30% of assistance services (other than food assistance), where appropriate and feasible, benefits the host community (UNDP, 2018).

As part of Uganda's settlement policies refugees are given land under the premise that this enables self-reliance in the medium- and long run. The allocation of land among refugees is guided by the Refugee Act (2006) and Refugee Regulations (2010). The Office of the Prime Minister (OPM) negotiates the provision of land for the allocation of refugee settlements with the district governments. It often concerns communal land or land from large land owners. Usually, negotiations with the

communities are based on the commitment of OPM and UNHCR to install infrastructure such as health centres and schools in the affected districts which would benefit Ugandan host communities.

Refugees can use the assigned land, but they neither have land ownership nor the right to sell, rent out or use the land as collateral for credit from financial institutions (UNDP, 2018). Although most land of refugees is accessed through OPM also other modes are used by refugees to access land (Table 4.1).

Table 4.1 *Different modes of land access (in %) by refugees in Arua district (FAO & OPM, 2018).*

Mode of land access	%
Received from the Government	91.3
Agreement with hosts on land use rights	3.3
Inherited or received	1.6
Purchased	1.1
Just walked in	0.9
Without agreement but with land use rights	0.8

OPM allocates land at household level irrespective of household size (UNDP, 2018). Because of the land allocation policy of the Government of Uganda, most refugees (54%) in Imvepi and Rhino refugee settlements have plots of 400 to 900 m^2 which can be used for backyard gardening (UNHCR & WVU, 2017). Most of the plots (54%) in the host communities are bigger and vary between 0.4 and 2 ha. 17% of the poorest host population have plots measuring between 900 and 5,000 m^2.

Access to employment by refugees is also addressed in Uganda's ReHoPE framework. The 2006 Refugees Act grants refugees the right to: (1) engage in agriculture, industry, and business, whether as workers or proprietors; (2) practice their profession, provided they are properly qualified with recognized certificates; and (3) access formal and informal employment opportunities wherever available in the country and without the need to first obtain work permits, which is strictly required for all who are not East African citizens. Accordingly, refugees are exempt from fees for obtaining work permits, clearly intended to facilitate local integration and stimulate self-reliance.

Refugees in Uganda are entitled to freedom of movement, although they can be lawfully subject to "reasonable restrictions" on the grounds of national security or public order. This right is generally maintained for refugees living in urban areas. But refugees residing in gazetted rural settlements are usually required to obtain administrative permits to leave and return to their designated settlements. In addition, refugees have a right to freedom of association, but this does not extend to political and for-profit associations or trade unions.

There are detailed provisions in the 2010 regulations designed to operationalize provisions of the Refugees Act regarding the registration of refugees and the issuance of identification and travel documents, which affects the ability of refugees to exercise freedom of movement for their economic empowerment regarding opportunities within or outside of Uganda. Newly arrived refugees are expected to report to settlement commandants to be registered, after which they are entitled to relief assistance. The inter-ministerial Refugee Eligibility Committee determines the refugee's status and, once granted, each refugee family is allocated a plot of land by OPM (see before) and provided with basic assistance, such as ration cards entitling them to monthly food and non-food items.

4.2.3 Economic policies

Uganda Investment Authority (UIA) is promoting the One Stop Centre concept at the district level where the Chief Commercial Officer is facilitating new investments, and to ensure that all required steps in investment start up. UIA has established a District Investment Committee (DICs) to attract and facilitate investments, and to provide the necessary aftercare in different sectors (UIA & UNDP, 2017).

The lack of credit is the primary obstacle for all, including refugees to engage in employment opportunities or business activities (Microfinanca, 2018). Other important challenges include transportation (distances, accessibility and costs), lack of markets, and certain regulatory restrictions such as ID and administrative requirements and the recognition of competences and skills. Regarding agriculture, the primary issue is access to land and water (especially in the West Nile).

Access to formal financial services is limited, primarily due to physical inaccessibility. Financial service providers are usually far from where residents and refugees live and relatively hard to reach. Consequently, most people rely on semi-formal and informal services (Microfinanca, 2018). In a UNHCR study from 2017, about 51% of the refugees and host community members relied on friends and families for credit (UNHCR & WVU, 2017). Savings groups provided about 18% of all credits to refugees and host communities. However, the availability of funds from such informal sources is limited and the call for formal business loans is great (Microfinanca, 2018).

The heavy reliance on rain-fed and subsistence agriculture continues to expose the economy to risks from adverse weather, and these risks are likely to grow under most scenarios for future climate change (World Bank, 2015).

4.2.4 Environmental and climate mitigation policies

Uganda is vulnerable to climate change, and the impacts of climate change are already being experienced in the region. (Ministry of Water and Environment, 2015). Increased occurrences of drought conditions and reduced / more variable rainfall across much of the country will impact agriculture, livestock and human health. This will especially be impactful for the northern and central zones and traditional 'cattle corridor' already at risk from increasing aridity (Ibid).

The United Nations Framework Convention on Climate Change (UNFCCC) requires Uganda to submit national greenhouse gas (GHG) inventory report on their current and planned GHG emissions (every four years with flexibility). As a developing country with commitments to the UNFCCC, Uganda possesses measurement, reporting and verification (MRV) practices. The Paris Agreement (2015) requires the committed countries to report and meet their Intended Nationally Determined Contributions (NDCs) (Wilkes et al., 2017). The NDCs are essential for providing an action plan in tackling climate change; however, Uganda's priority is adaptation (Uganda Coalition for Sustainable Development, 2017). The basis for the inventory reports are the guidelines published by the Intergovernmental Panel on Climate Change (IPCC, 1997; 2006). These guidelines mention three approaches in reporting GHG emissions: Tier 1, 2 and 3 where 3 is the most advanced and 1 is the most basic approach. Tier 1 approach using only regional fixed values does not account for changes in animal productivity and animal production parameters, making it unsuitable if mitigation options are to be assessed. The Tier 2 approach needs regular updating (e.g. emission factors) if it is to reflect the changes in animal production, productivity and GHG emissions (Wilkes et al., 2017).

Uganda's climate mitigation actions are aimed at reducing N_2O and CH_4 emissions (Republic of Uganda, 2014). In the agricultural sector, priority actions focus on improving the production efficiency of livestock, manure management and application of appropriate sustainable land management practices, including minimum tillage, efficient use of fertilizers and manures, and promotion of low-carbon crops such as upland rice. Mitigation actions related to forest degradation and deforestation as major sources of GHG emissions are mainly focussed on awareness raising and capacity enhancement in the field of monitoring. The latter is most relevant in the context of Arua.

Uganda has a well-developed policy and legal framework for the forest sector and for other related sectors such as agriculture, water, energy, tourism, climate change, land, and gender. Forest resources in Uganda are managed under a two-tier system distinguishing between government-managed areas (such as Central Forest Reserves (CFR), Local Forest Reserves (LFRs), and Wildlife Conservation Areas) and forests on communal and private land. The Ministry of Water and Environment (MWE) has the mandate for the management and development of forest resources. Key legal and policy documents are the National Environment Act (2019), the National Forestry and Tree Planting Act (2003), the National Forest Regulations (2014), the National Forestry Policy (2001), the Wildlife Act (2000) the Local Government Act (1998), and the Land Act (1998).

Uganda's Nationally Appropriate Mitigation Action on climate smart dairy livestock value chains (NAMA) (Arnaoudov et al., 2017) highlights three objectives: i) increasing milk productivity and income; ii) adapting to climate change along the milk production value chain; and iii) reducing GHG emissions. The measures that are of interest to reduce GHG emissions are feeding livestock on improved forages, improving quality of feed as well as improved manure management e.g. bio-digestors. Concepts of NAMA are shown in Figure 4.1.

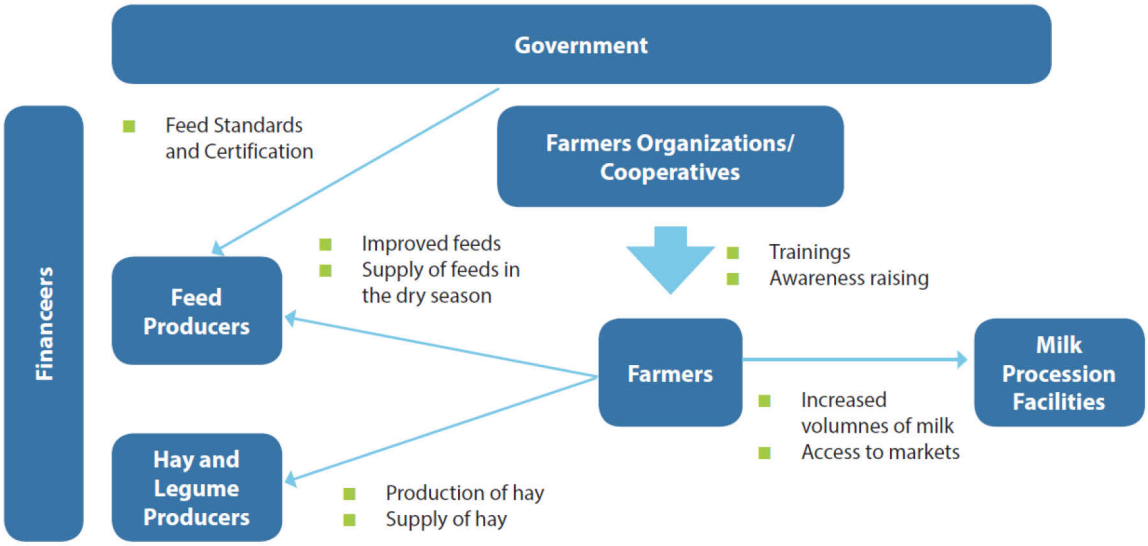


Figure 4.1 *Nationally Appropriate Mitigation Action (NAMA) concepts (Source: Arnaoudov et al. 2017).*

The United Nations Office for Project Services (UNOPS) in partnership with UNHCR is developing a framework and strategic direction to ensure provision of safe water in Imvepi and Rhino settlements and neighbouring host communities meeting medium to long term demands (25-year horizon), in a sustainable and integrated manner for the refugees, the host communities while also meeting environmental requirements (UNOPS, 2017).

4.3 Science & technology

4.3.1 Research and development

The Government of Uganda established a Ministry of Science, Technology and Innovation (MOSTI) to guide policy and coordinate scientific research, development and the National Innovation System in Uganda. March 2017, the Government launched a platform for planning, budgeting and general discussions relating to Science, Technology and Innovation (STI). The STI Sector consists of: i) Ministry of Science, Technology and Innovation; ii) Uganda National Council for Science and Technology (UNCST); iii) Uganda Industrial Research Institute (UIRI); and iv) Presidential Initiative on Banana Industrial Development

The UNCST was established to implement the provisions of the UNCST Act 1990, CAP 209. The primary goal is to develop and implement ways of incorporating science and technology in the national development process. The Council advises the government on relevant policy matters and coordinates research and development activities in Uganda. The UNCST has been coordinating policy aimed at shortening the cycle of technology mastery and knowledge and at deepening technology. Unlike many African countries, Uganda commits part of the government budget—equal to 0.3 percent of GDP— to spending on research and development.

The UIRI undertakes civil and building construction projects and consists of twelve professional lines ranging from Construction Project Management, Architecture, Quantity Surveying, Civil Engineering, Mechanical and Electrical engineering, Environmental assessment to Masons and Painters. It is also among others responsible for the construction of a model dairy farm in Karubuga, Juice processing facility in Itojo Ntungamo District, Wine processing in Maziba Kabale District, Peanut Processing facility in Kumi District, Meat Processing in Arua District, Animal feeds processing facility in Busiika Luwero District, Palm Oil processing facility in Kanungu District.

4.3.2 Universities and national agricultural research

Currently, there are four universities in the Arua district. Most of them are relatively new and they do not all have (yet) a faculty related to food systems:

Nile University is a private university that has been established in 2018. It offers Postgraduate courses in health services management and undergraduate courses in Business Administration and Management, Ethics and Development Studies, Agricultural Economics and Agribusiness Management, Agricultural Entrepreneurship, Primary Education. It also offers subject related diploma courses, though not related to agriculture.

Muni University is a new government university established in 2012 with its main campus at Muni Hill in the town of Arua. It offers bachelor degrees in IT, education, nursing, business management and has recently developed a BSc in agriculture.

Islamic University in Uganda, Arua Campus is a private university offering courses at certificate, diploma, undergraduate and postgraduate levels. offering courses at certificate, undergraduate and postgraduate levels in Science, Education, Management Studies, Arts & Social Sciences, and Islamic Studies & Arabic Language.

Uganda Christian University, Arua Campus was established in August 2003. Formerly, it was St. Paul's Regional Theological College, offering diploma and certificate courses in Theology and training of Lay Readers in the West Nile region and beyond. At its inception, four departments (i.e. Theology, Business Administration, Social Sciences and Education) were established for bachelor's degrees.

The National Agricultural Research Organization (NARO) has several research locations, as well as extension services in different areas that conduct applied research and outreach. The city of Arua hosts one of the NARO's, the Abi Zardi Agricultural research & development institute which has own

experimental facilities and about 20 permanent staff members. Very few private companies conduct agricultural research.

4.4 Governance

Uganda is a democratic republic with a governance system comprising national and local governments. The constitution provides for a system of decentralisation and local governments, which is further consolidated in the Local Governments Act 1997 (Cap. 243). In urban settings, there are city, municipal, division/town, ward and cell councils. In rural areas, there are district councils, counties (which are administrative units without a council), sub-county councils, parish councils and village councils. The local government act provides for a minimum of 30% of council seats to be reserved for women and in 2013/14, local government expenditure was 15.1% of total government expenditure. The primary sources of revenue are transfers from national government; however local governments are mandated to raise revenue locally, including property taxes, licences and user fees. Responsibility for transport and environmental protection is shared between national and local governments. Districts and municipal councils are also responsible for the provision of primary and secondary education, safe water supplies and public health, and are encouraged to devolve some services to the lower tiers. Local economic development (LED) is the responsibility of the districts and lower tiers of government (see CLGF Uganda country profile 2017-18 for more detail).

Arua District is one of 33 districts in the Northern region of Uganda. It has 7 main sub-administrative units consisting of 6 counties and Arua city (Figure 4.2).

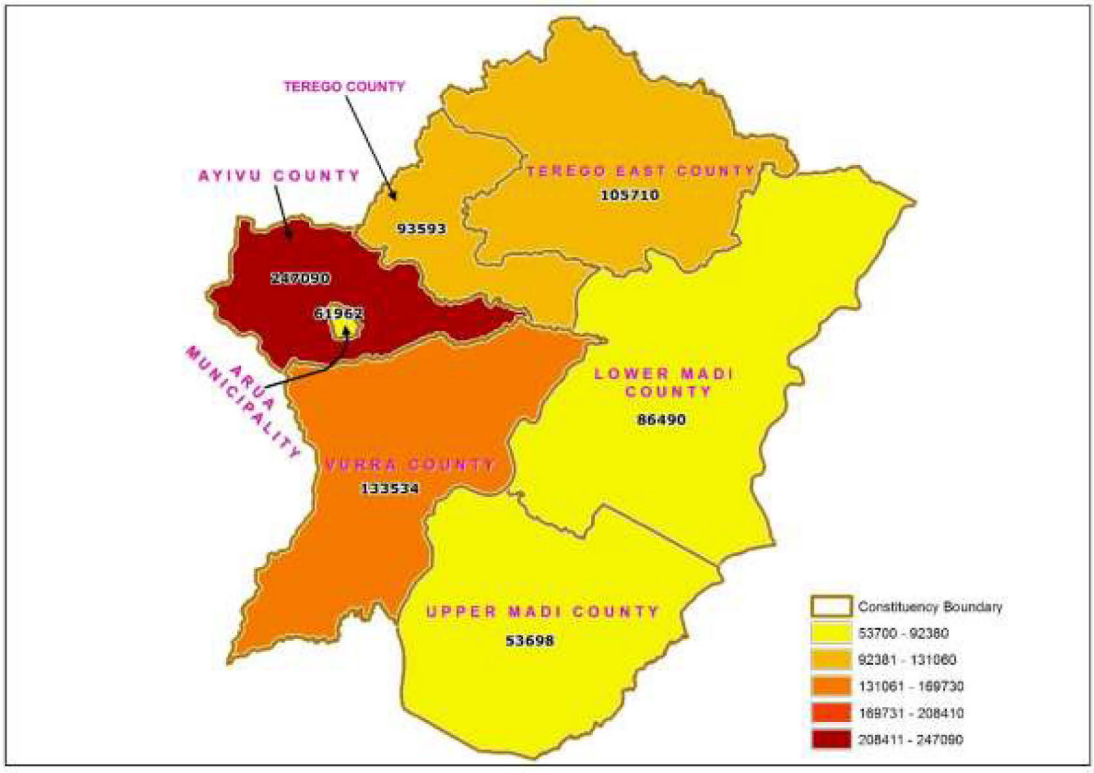


Figure 4.2 *Arua District and its population in counties (Source: UBOS, 2017).*

The Office of the Prime Minister (OPM) is the major agency to coordinate the refugee settlements and, for example, it monitors and registers the number of refugees entering Uganda. Uganda's protection environment for refugees is founded in the 2006 Refugee Act and the 2010 Refugee Regulations. These regulations allow refugees freedom of movement, the right to work, establish a business, own

property and access national services, including primary and secondary education and health care (UNDP, 2018). Many other organizations are involved in offering services to refugees:
107 organisations, including 21 national NGOs, 73 international NGOs, 11 UN agencies, and 2 bilateral development organisations (UNHCR, 2019).

The engagement of the private sector in improving food security is limited. This is related to the challenges in creating an enabling business environment, and in fuelling job creation and economic growth.

At a lower governance level, i.e. farmer cooperatives and farmer associations, the organization of farmers is limited. Achayo (2018) gives an overview of 18 cooperatives and registered farmer associations in Arua, the largest farmer group has about 90 members, but the majority have fewer than 30 members. Focus of these cooperatives and farmer associations are sesame and soybeans, to a lesser extent tomatoes and other vegetables. There are no cooperatives managing livestock which is indication of the low commercial development of the livestock sector in Arua.

4.5 Demographics

According the latest population census of 2014, the population of Arua district was 782,077 (UBOS, 2017). The population in 2018 is estimated at 867,700 (UBOS, 2018), which means an annual population growth of approximately 3%. The high growth rate is reflected in age distribution, i.e. over 55% of the population is younger than 17 years and almost 77% is younger than 30 years (UBOS, 2017).

The census data of 2014 did not include the large refugee population that has settled in Arua in recent years. Uganda has a long history of both hosting refugees and being a country of origin of refugees. Since its independence, Uganda and especially the West Nile region has hosted refugees under progressive refugee laws. The first major influx was in 1955, when 80,000 Sudanese refugees entered Uganda. Ever since, refugees from (South) Sudan, Rwanda, the Democratic Republic of Congo, Somalia and Burundi have entered and left the country. However, for many refugees, repatriation is not an option due to the instability in their home countries. Northern Uganda itself was for decades battleground of the Lord's Resistance Army of Joseph Kony resulting in massive people's displacement around Arua.

According the latest Uganda Refugee Response Monitoring of June 2018, Arua district hosted 271,655 refugees that were registered in the Refugee Information Management System (RIMS) - Office of the Prime Minister (UNHCR, 2018a). This implies that in 2018 the total population of Arua district was 1,139,355 persons of which almost 24% were registered refugees. More than 90% of the refugees in Arua are from South Sudan and the remainder is from DRC (UNHCR February 2018). The refugee population of Arua sharply increased as from 2016 to 2018 (from 4.5% to 24% of the total population in Arua).

According to a representative survey under host and refugee communities (UNHCR & WVU 2017), under the refugees, 62% of the households are headed by women. In host communities, only 28% of the households are female headed (UNHCR & WVU 2017). Among the refugees, approximately 3% are child headed families (children below 18 years). About 60% of the refugee households was not engaged in any economic activity and about 15-20% of the households was engaged in petty trade and casual labor (UNHCR & WVU, 2017).

In the population census of 2014, 146,627 households were registered, which means an average household size of 5.3 persons, which is larger than the national average household size, i.e. 4.7 (UBOS, 2017).

The Uganda Vision 2040 proposes four regional cities and five strategic cities in the course of Uganda's urbanization. Arua is one of the four regional cities. Still, less than 8% of the 2014 census population lived in Arua city, which is indication of the rural character of the district. The majority of the

population lives in the rural areas and is organised in so-called Parishes, the smallest administrative unit in Uganda. It reflects also the large refugee settlements in the fairly remote areas of Arua (Figure 4.3). This contributes to a relatively high population density of approximately 2.7 persons/ha, which is higher than the national average density of 1.8 persons/ha (UBOS, 2016).

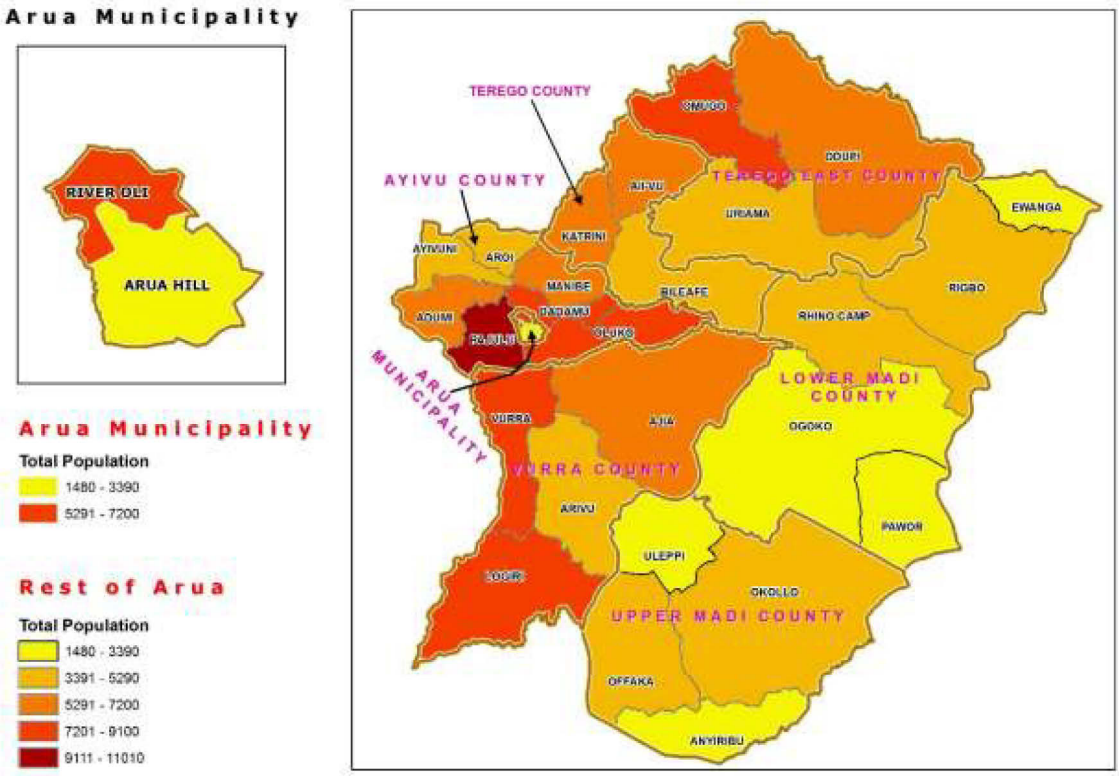


Figure 4.3 *Distribution of population by sub-county in Arua District (Source: UBOS, 2014).*

About 80% of the households in Arua district depends on subsistence farming as a main source of livelihood (UBOS, 2017). However, over 90% of the households has at least one member engaged in non-agricultural household income generating activities. Over one fifth, 22%, of the resident households received remittances from abroad. In the city of Arua, the percentage of households receiving remittances was twice as high.

Based on the Census data of 2014, over 10% of the youths in Arua (persons aged between 18-30 years) was not employed or studying (UBOS, 2017). About 16% of the young in the age of 6-15 years does not attend school and about 28% in the age cohort 10 - 17 years is illiterate. For about 10% of the households the nearest public primary school is at least 5 km away. Secondary education is even less accessible, for 44% of the households the nearest public secondary school is at least 5 km away (UBOS, 2016). Within this context, it is not remarkable that 47% of age cohort 10-17 year is working.

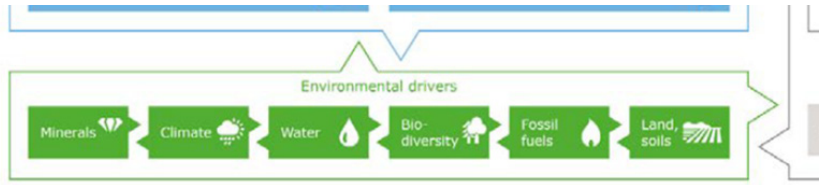
4.6 Socio-cultural relationships

Generally, the relationship within refugee settlements and between refugee and host communities is friendly and peaceful with intermarriages between different groups. In some regions, local integration has occurred, partly due to the long stay of refugees in these regions (UNDP, 2018). Some hostilities arose due to host communities feeling that refugees were being favoured by the government. However, the government adheres the policy that host communities must be provided with 30% of all services provided by aid organizations to refugees. In some parts of the West Nile region, conflicts

occurred associated with land access and use, more specifically on the use of land for grazing and for crop production (WB, 2016). However, in general, there are no major conflicts, also not between different groups of refugees. The government and aid organizations are aware of potential tensions and conflicts between various refugee groups and houses some groups at a safe distance from others. However, generally, they make every attempt to foster coexistence among the groups (WB [World Bank], 2016).

Although current conflicts among different population groups are limited, the number and type of conflicts are on the rise and it is expected that these will continue as the number of refugees has increased in recent years while coordination between physical planning at district level and refugee settlement planning is lacking (UNDP, 2018). Disputes may arise between refugees and hosts related to land access, but also between the Government and host communities and landowners who offer their land to settle refugees. In addition, conflicts are expected to increase once refugee return to their home country. There have been disputes about the ownership of woodlots planted on community land after departure of refugees (UNDP, 2018).

5 Environmental drivers



5.1 Climate characteristics

Arua district has an equatorial savannah climate with dry winters according the Köppen-Geiger climate classification (Kottek et al., 2006). The average annual rainfall is about 1200 mm per year but tends to decrease in recent years (Figure 5.1). The annual rainfall typically shows a bi-modal pattern with minor rains in April/May and major rains from July to October (Figure 5.2). Over 600 mm (50%) of the total rainfall is in these four months. In this period, rainfall approximates the mean monthly potential evaporation, which ranges from 130 to 180 mm. Temperature is stable throughout the year and varies between daily maxima of 30°C to average daily minima of 17 °C (Figure 5.3). Especially maximum temperatures tend to increase in recent years (Figure 5.4).

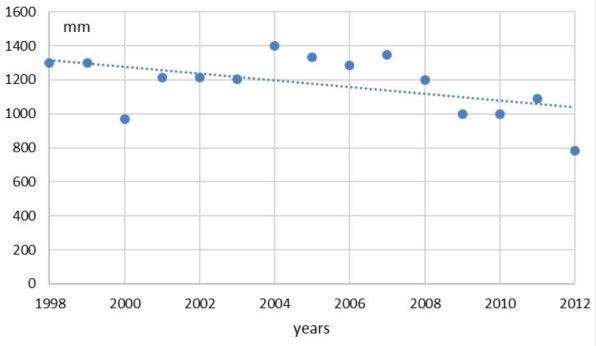


Figure 5.1 *Total annual rainfall in the period 1998-2012 in Arua (based on http://www.yieldgap.org/).*

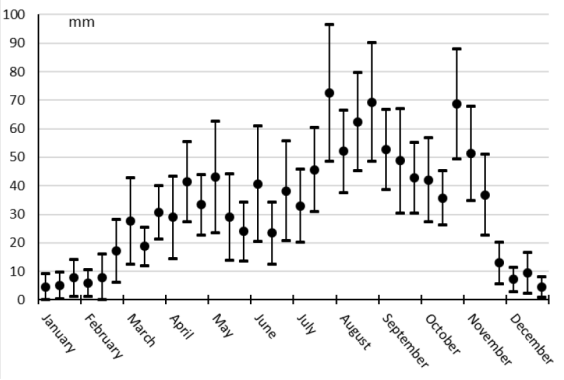


Figure 5.2 *Fifteen years average decadal rainfall (mm) in the period (2002-2012) and 95% confidence interval (based on http://www.yieldgap.org/).*

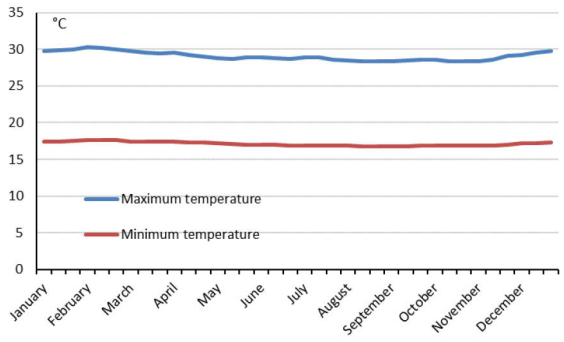


Figure 5.3 *Fifteen years (2002-2012) average decadal minimum and maximum temperature (°C) in Arua (based on http://www.yieldgap.org/)*

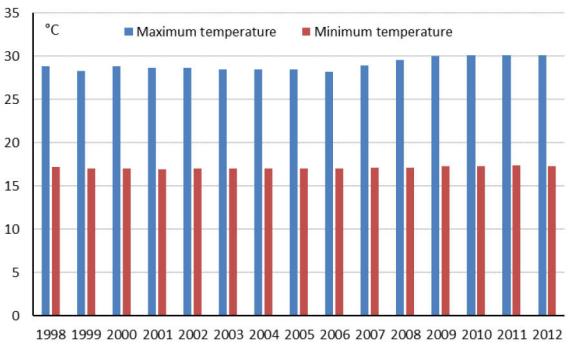


Figure 5.4 *Average annual minimum and maximum temperature in the period 1998-2012 in Arua (based on http://www.yieldgap.org/).*

5.2 Water resources

Arua district is generally dry with several areas exhibiting low ground water potential according to the ground water maps obtained from the Ministry of Water and Environment. The area is also covered by several rivers most which are seasonal. The Nile River borders the district (UNOPS, 2017). There are also ground water resources supplying water via springs and wells (Kansiime, 2013a).

Arua has 2,579 domestic water points which serve a total of 653,607 people – 592,087 in rural areas. 364 water points have been non-functional for over 5 years and are considered abandoned. Arua has 5 piped schemes (UNOPS, 2017).

According to UNOPS, there is still a deficit in the water required to meet the demands of the current population in Arua. It expects that the situation will be exacerbated with increased demands resulting from growing population in the refugee settlements and host community over time, seasonal availability of water especially ground water, challenges with water quality resulting from contamination and depletion/system failure resulting from uncontrolled extraction and improper installation of water facilities. The uncontrolled extraction can also have serious environmental consequences in the long run, UNOPS warns. The district has the following water sources:

- The River Anyau - The source of water for Arua town is River Anyau, which is sourced in the Ezuku Forest, in the Democratic Republic of Congo. The National Water and Sewerage Corporation pumps water from River Anyau, treats it and supplies it to areas within and outside Arua municipality. The water supply situation is reliable during the wet season, but is severely affected during the dry season when the water level in the Anyau is reduced (Kansiime et al., 2013a).
- The Nile - Although the Nile is a very reliable water source, it is not strategically located and less than 0.2 percent of the total area of the district. It benefits only Madi-Okollo County.
- Seasonal rivers - The seasonal rivers within Arua municipality normally dry up during the dry season (Kansiime et al., 2013a).
- Groundwater - The groundwater is obtained from boreholes and from protected and unprotected springs spread within Arua Municipality. Some boreholes and spring water sources are contaminated by faecal matter from nearby pit latrines and septic tanks in the Central Business District (Kansiime et al., 2013a). However, in various parts of Arua groundwater can only be found at 80 m or deeper, which makes such resources uneconomically to exploit, for example, for irrigated agriculture.
- Wetlands - Wetlands cover approximately 3% (215 km^2) of the total land area of the district. This allows water to stay in one place long enough to maximize infiltration and thus access to water for plants. However, encroachment of the wetlands for crop cultivation is common and unless the trend is reversed, the district's wetlands will be destroyed in the future.

5.3 Energy sources

Forests and woodlands are expected to satisfy over 88% of Uganda's primary energy demand in 2019 through the provision of firewood and charcoal. According to the Uganda Green Growth Development Strategy 2017/18 – 2030/31 (UGGDS), the energy sector presents major challenges and opportunities. Uganda's energy balance is dominated by biomass while fossil fuels and electricity are other important sources of energy. The total electricity supply fell short of its demand over the past years as supply was growing at a rate of 7%, while demand was growing at 11 to 12%. The projections of Uganda Vision 2040 are that per capita electricity consumption will reach 3,668 kWh/capita (2040) from 75 kWh/capita (2010) if the country is to achieve its long-term development targets (UGGDS).

At a national level, fuel wood is consumed at about 28 million tonnes/year of tree biomass and another 16 million tonnes of wood are annually transformed into 1.8 million tonnes of charcoal using inefficient kilns. An additional 2.3 million tons of tree biomass is consumed in brick making and by educational institutions, among others (MEMD [Ministry of Energy and Mineral Development], 2014). The volume of biomass energy use has created opportunities for electricity cogeneration by the use of bagasse from sugar factories, and use of agro-processing vegetal waste including maize cobs, rice

husks, coffee husks for thermal energy in industry. The main factors in Uganda driving up energy demand is the high population growth rate of 3.2% a year and the low level of electricity access, currently estimates at 14%.

In Arua, both host and refugee communities have little access to modern sources of energy and predominantly rely on traditional biomass for cooking (UNDP, 2018b). Less than 11% of the households in Arua district had access to the electricity grid in the population census (UBOS, 2016). However, solar panels are increasingly used in off-grid situations for light and charging mobile phones. Wood remains the main source of fuel used for the cooking stoves. It is sourced mainly from nearby bushland and woodland areas and from the market (WB & FAO, 2018a).

5.4 Land use

The majority of refugee and host communities are arable farmers. In 2005, the majority of the land in Arua district was used by small scale farmers, 63.4% (Table 5.1; UBOS, 2019a). In addition, Table 5.1 shows the land use types of the entire West Nile region, which suggests that land use in Arua is more intensive, i.e. about 10% more land is used by small scale farmers than in the rest of the West Nile region. Crop farming combines both annual and perennial crops often in intercrops. The main food crops in the West Nile region are cassava, potatoes, maize, beans, banana, sesame, groundnuts sorghum and rice, while the major cash crop is tobacco. For refugees, one of the main challenges is a secure access to land. For host communities, it is secure access to irrigation water (FAO and OPM, 2018).

The natural vegetation of Arua district is classified as savannah grassland (UBOS, 2012). About 20% of the area is grassland, with some patches of woodland and bushland (5.7 and 6.3%, respectively; Table 5.1), and a small wetland area around the Enyau River (1.5%). Woody tree species that are commonly found in the region and used by host communities as well as refugees as a source of food and income are described in Appendix 2.

Table 5.1 *Land use types (in % of the total area) in the West Nile area and Arua in 2005, data updated in 2018 (Source: UBOS, 2019a,b).*

	West Nile	Arua
Total Area (ha)	1,577,272	429,916 [1)]
Hardwood plantation	0.3	0.4
Softwood plantation	0.1	0.1
Tropical High Forest normal stock	0.0	0.0
Tropical High Forest low stock	0.1	0.0
Woodland	8.9	5.7
Bushland	10.1	6.3
Grassland	21.4	20.7
Wetland	1.6	1.5
Farmland small scale	54.2	63.4
Farmland large scale	0.5	0.0
Built up areas	0.6	0.7
Open water	2.1	1.2
Impediments	0.0	0.0

1) Note that the total area differs slightly from the surface area mentioned earlier because of inconsistencies in statistical data.

5.5 Soil and terrain characteristics

Figure 5.5 shows various maps of Arua with major soil and terrain characteristics. Table 5.2 shows the percentage of area with soil types in Arua and is based on Figure 5.5 (A). Arenosols and leptosols together make up almost 75% of all soils in Arua district. See Appendix 3 for a general description of the prevailing soil types in Arua.

The spatial distribution of the soil types coincides with altitude and terrain characteristics. The more clayey ferrasols are found in the high lands in the South West of Arua district bordering DRC (compare Figure 5.5 (A) and (B). Leptosols are stretching from North to South in the centre of Arua district and are bordered on the East and West by arenosols, which are often eroded soils. Small patches of cambisols are found within the area with leptosols (Figure 5.5(A)). Vertisols are mainly found at the valley bottoms of the rivers running from the higher altitude area and the supplying rivers towards the Nile.

Most soils are fine texture with loose structures, and they are easily eroded and leached. Especially along the valleys (vertisols) and the slopes of the hills (arenosols) soils are fertile thereby promoting small-scale farming. The ferralsols and leptosols on the hill tops have often a limited soil depth making them less suitable for agricultural production. If the soil depth is deeper than 15 cm, as is the case in the relatively flat areas, soils are fairly fertile. This is especially the case for the vertisols along the valleys due to alluvial deposits found along the lower portions of the slopes. Lateritic layers in soils will reduces rooting depth and therefore water and nutrient availability especially when these layers are close to soil surface. These lateric layers have been observed in the soils of the Omugu refugee settlement. The acidity of prevailing soils in Arua district vary between a pH of 5.5 and 6.5 and do not provide a major limitation to crop production (data not shown).

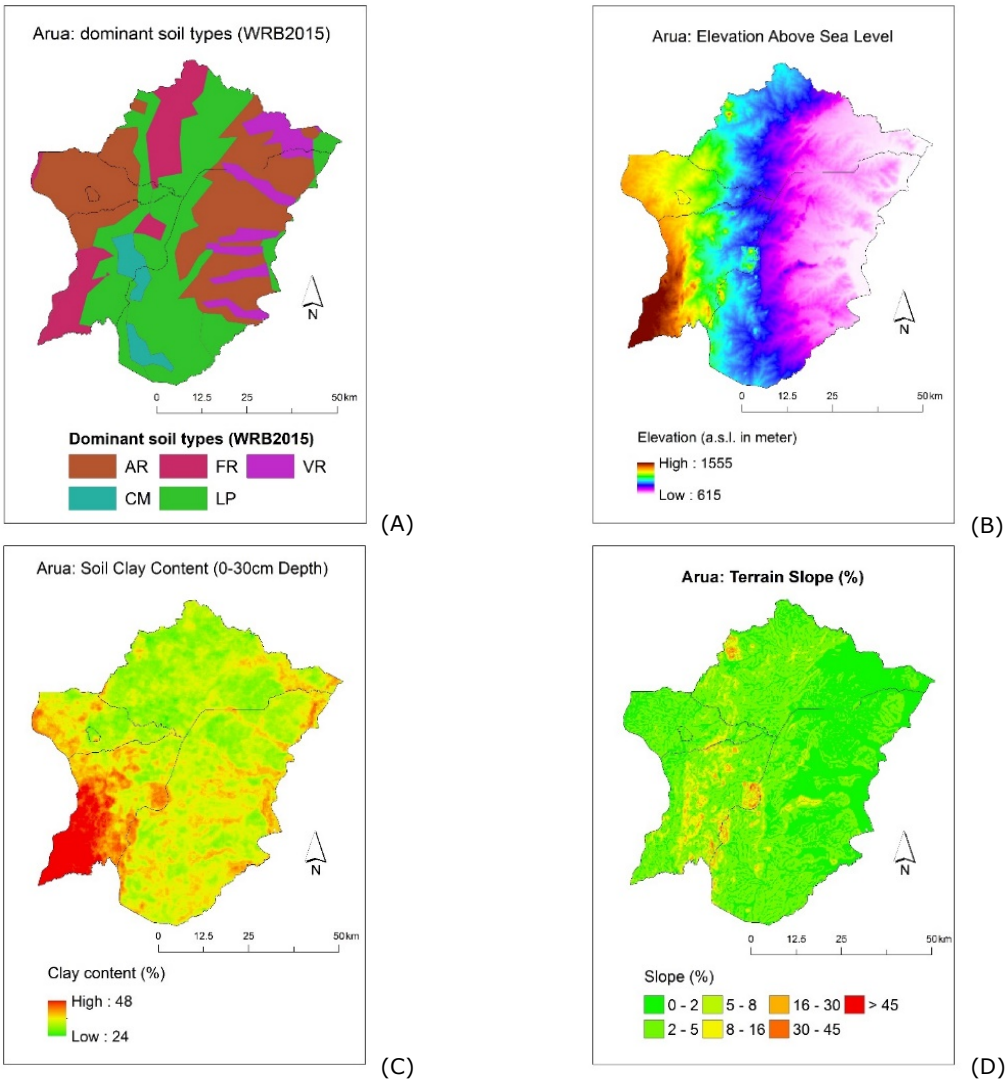
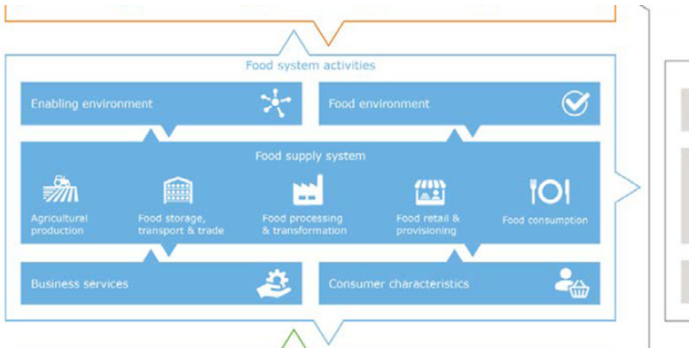


Figure 5.5 *(A) Distribution of dominant soil types in Arua district, (B) elevation differences across Arua district, (C) Soil clay content in 0-30 cm layer and (D) Terrain slopes in Arua district. See Table 5.2 for abbreviations of soil types in (A).*

Table 5.2 *Distribution of soil types in Arua (based on WRB, 2015).*

Soil Type	Subgroup	Full name	% of Arua
AR	ARl	ARENOSOLS_DUNES	36.5
CM	CMo	CAMBISOLS	3.8
FR	FRh, PTu	FERRALSOLS_NITISOLS_PLINTHOSOLS	12.6
LP	LPe, LPq, FL	LEPTOSOLS_ FLUVISOLS_REGOSOLS	38.9
VR	VRe	VERTISOLS	8.2
			100

6 Food system activities



6.1 Production systems

Agricultural production in Arua is categorized as the West Nile System, which is characterized by mixed cropping with a variety of crops and livestock activities (Pilipavicius, 2015). The main crops grown are cassava, maize, groundnuts, beans, sesame (simsim), sorghum, millet and soya (Table 6.1 and Figure 6.1). Vegetable crops produced are mainly tomato, onion, and okra (UNHCR & WVU, 2017; Achayo, 2018). The major cash crop of the area is tobacco, which is the main source of cash income for a majority of the population (Obwona 2006; Pilipavicius 2015; UNHCR & WVU, 2017). Many households have fruit trees around the homestead as a source of food, income and firewood. Some of the most common tree species are eucalyptus, mango, avocado, papaya, and lemon (Nyamukuru et al., 2015). Although accurate statistical data are lacking on the crop distribution, crop type areas and number and types of animals in Arua district the distribution of crops and livestock as described in the literature (e.g. Table 6.1) was confirmed during the scoping mission in October 2019.

Based on a study in the entire West Nile region among the refugee and host populations it seems that maize is more common among refugees than the host population, which seems to rely more on cassava (ISSD, 2015).

Table 6.1 *Common crops and livestock in Arua District (Source: Obaa, 2005).*

Commodity	Crop type/Animal type	Frequencies	Percentages (N=160)
Crops	Cassava	113	94.2
	Groundnuts	106	88.3
	Beans	98	81.7
	Maize	72	60.0
	Sorghum	67	55.5
	Millet	55	45.8
	Tobacco	50	41.7
	Simsim	38	31.7
	Vegetables	31	25.8
	Pigeon pea	30	25.0
	Rice	28	23.3
	Cowpea	26	21.7
Livestock/poultry	Goats	115	95.8
	Chicken	103	85.8
	Cattle	63	52.5
	Pigs	18	15.0
	Sheep	14	11.7
	Guinea foul	11	9.2
	Ducks	5	4.2

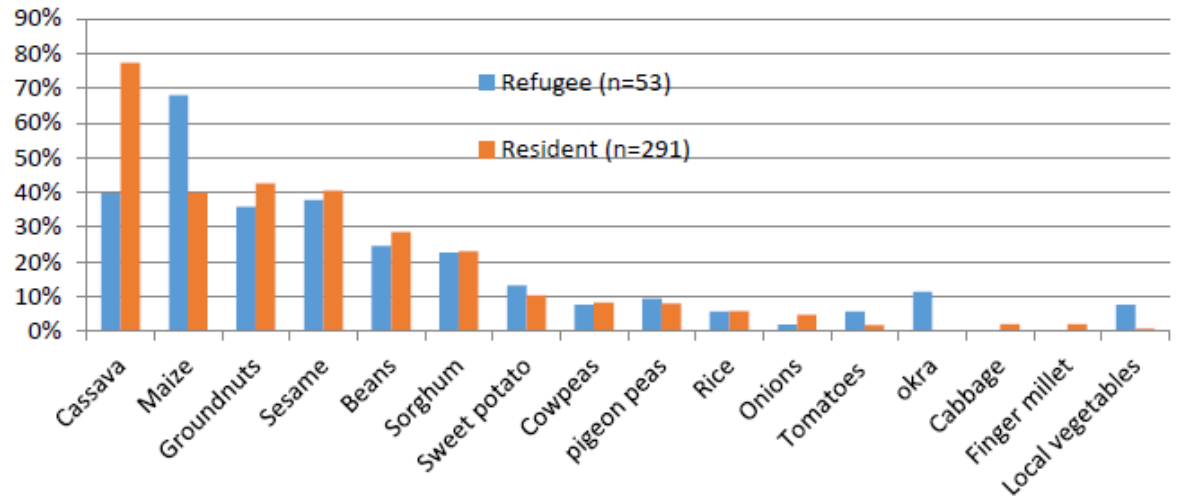


Figure 6.1 *Percentages of crops grown in the West Nile sub-region in 2014 by refugees and host residents (Source: ISSD, 2015).*

6.2 Farm size

Refugees have access to plots of about 400 to 900 m^2, while the majority of the population in host communities have land holdings of 4,000 to 20,000 m^2, which are fragmented in smaller plots (e.g. 1,000 m^2 ≈ 0.25 acres) that are far away from each other (UNHCR &WVU, 2017). As a result, farmers spend quite some time walking between fields and homestead as only few farmers own a means of transport (e.g. bicycle, motor bicycle).

The small size of the farms is the result of the custom of inheriting the land to the children (sons) and dividing it amongst them. This has been occurring for many generations, and each generation the farms become smaller. Moreover, buying land is an obstacle for consolidation of larger plots of land. However, renting land is very common but the extent of renting is unknown. In addition, many households live as extended families of which the members can have ownership rights over different plots. This makes it very difficult to collect accurate data on the average land holding size of a household.

6.3 Cropping calendar

The cropping calendar of Arua is directly linked to the rainfall pattern, as almost little to no irrigation takes place. Arua has a bimodal rainfall pattern (Figure 6.2), with a minor rainy season in April/May and a major rainy season from July to October. Tobacco is only grown during the first rainy season, the same plot is then used in the second rainy season to grow groundnut, beans or other crops.

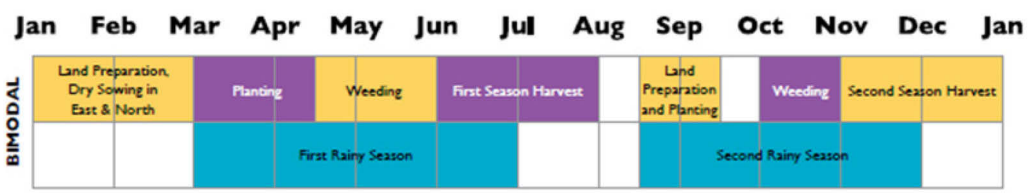


Figure 6.2 *Cropping calendar in Arua (Source: UNHCR & WVU, 2017).*

6.4 Cropping activities

Predominantly, land preparation is done by hand using a hoe, which is labour-intensive and limiting the area that can be cultivated. In addition, observed land preparation during the October 2019 scoping mission was suboptimal resulting in clods, uneven field conditions and poor weed control.

Sowing is done mostly by broadcasting, rather than row planting. The majority of used seed is farm-saved. Other seed sources are agro-input dealers, seed aid, and cooperatives, such as Social Network Seed (SNS) or Community Based Seed (CBS). The seed rates used on average are higher than the recommended seed rates, which is probably due to the method of broadcasting (Figure 6.2). Most vegetable crops as well as finger millet, sweet potato, sesame and cow peas are grown as sole crops, while maize, cassava, pigeon peas, rice, groundnuts, and beans are often intercropped (Figure 6.3).

Table 6.2 *Average seed rate (kg/acre) for major crops grown in West-Nile sub-region (Source: ISSD, 2015).*

Crop	Arua	Recommended
Cassava	284	255
Maize	12	10
Groundnuts (unshelled)	48	42
Sesame	8	3
Beans	35	30
Sorghum	6	4
Cowpeas	4	4
Pigeon peas	11	8
Finger millet	14	2

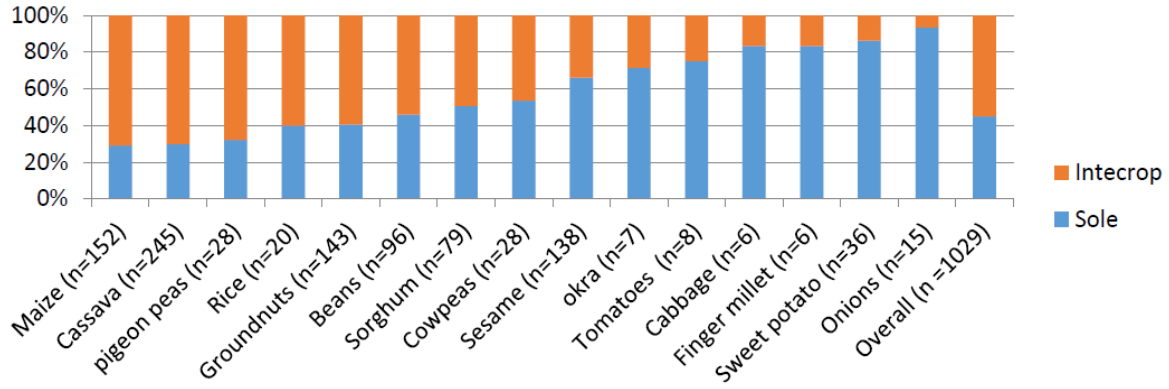


Figure 6.3 *Cropping practices (sole versus intercrop) in the West-Nile sub-region (Source: ISSD, 2015).*

Weeding after crop emergence is done by hand, which is a labour-intensive activity. During the scoping mission in October 2019, most cropped plots faced weed problems.

Agricultural production depends predominantly on rainfall and irrigation is almost non-existent in Arua. Tobacco farmers tend to raise seedlings in seedbeds using irrigation water but after planting of the seedlings no irrigation takes place. Within the NIGI project a similar approach is promoted for producing vegetables under host communities. Because vegetables are sensitive to drought especially in the early stages, farmers water smaller vegetable plots and seedbeds with cans. For growing crops in the dry season from December to early March access to irrigation water is a precondition.

The majority (99%) of the farmers in the West Nile region do not use inorganic fertilizers, and only about 3% of farmers apply organic fertilizers to cultivated land (ISSD, 2015). The reasons why farmers refrain from using fertilizers are that (i) some farmers consider their soil fertility to be good

enough and think that applying fertilizer would "spoil" their soils, (ii) the high cost of fertilizer, and (iii) the lack of knowledge on usefulness of fertilizer to boost crop yields. Available mineral fertilizers are Urea, NPK, and DAP, but these appeared not readily available from agro-input shops in Arua.

Pest and disease control is hardly practiced. Agro-input shops in Arua only sell a few types of pesticides, among others the common fungicide Mancozeb. Many of the traditional cassava varieties in farmer plots showed virus symptoms potentially reducing yields.

Major harvests (e.g. cassava, sesame, maize, sorghum) are in November and December, while minor harvests (tobacco) occur in July. In most cases, harvesting of sweet potato is done according to daily food requirement and performed manually with a stick fork. In dry seasons, sweet potato vines are removed 3-7 days pre-harvest with a sickle or knife to toughen the skin of the root but in wet seasons, this process is not carried out to reduce the risk of post-harvest diseases. The roots are removed with a blunt stick, hoe or by oxen-drawn ploughs (Abong et al., 2016) to allow new root development. By-products from farms such as the vines of sweet potato may be used as animal fodder.

Although no systematically collected yield statistics from Arua district are available from the (local) government, crop yields data collected by others indicate very low yields, in most cases less than 1.5 t/ha for the major crops including maize, groundnuts, sesame, beans, sorghum and sweet potato (Figure 6.4 (A)). Note that the Global Yield Gap Atlas (GYGA) estimates current maize yields in Arua a bit higher than shown in Figure 6.4, i.e. 1.7 t/ha (Section 7.3.1). Almost half of the farmers in West Nile (47%) considered their own yields as fair, around 39% considered it poor, and only around 14% considered their crop performance good (ISSD, 2015; Figure 6.4 (B)). Yield estimates of crops grown in the refugee settlements are estimated to be around the same order of magnitude (UNDP, 2018).

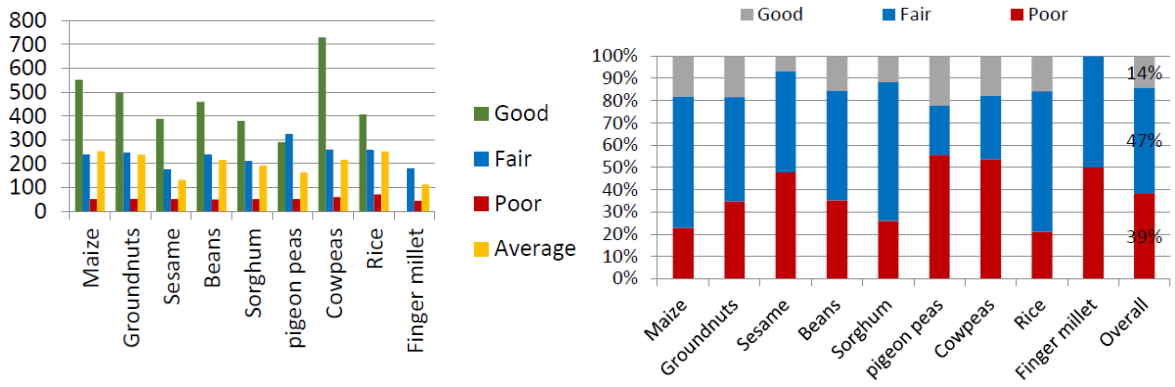


Figure 6.4 *Average yields (in kg/acre; left panel) and crop performance in the Western Nile region of Uganda according farmers (right panel) (Source: ISSD, 2015).*

6.5 Livestock Management Systems

Because detailed information on livestock in Arua district is lacking, this section describes livestock in the context of the West Nile region (Achayo, 2018):

- **Beef**: Natural pastures are present for beef cattle feeding. However, these pastures are wasted during dry season when they dry and are burnt. Animal herds are communally grazed. Individuals within a village or clan pool their animals together into kraal and graze them on communal land. Cattle rearing is not a very common practice on the uplands of Arua due to the high human population density and dominance of crop farming.
- **Dairy**: Dairy cattle under the zero-grazing system have been introduced in the districts of Arua, Moyo, Zombo and Yumbe. However, Yumbe and Moyo districts registered high mortality rates.
- **Small ruminants (goats and sheep)**: Small ruminants are mainly raised through tethering at subsistence level especially in nucleus human settlements and fragmented land where crop farming is the primary activity. Communities mainly keep local breeds of goats and sheep. Whereas farmers

appreciated the economic roles of goats in generating household income, sheep are reared mainly for cultural reasons especially in Muslim dominant communities.

- **Piggery**: Piggery is an economically viable livestock enterprise in some parts of west Nile region, especially in rural areas and Christian dominated communities. Peri-urban areas of Arua district are less suitable for piggery due to the diversity of religions. The enterprise is predominantly at subsistence level with farmers keeping on average 2-5 pigs per household. Pigs are managed on backyard and scavenging systems in peri urban areas and rural areas, respectively, with the majority of the pig keeping households having 2-5 local pigs. The reasons why piggery is popular is because pigs take relatively short time (about 6-9 months) to attain a market weight of 90 Kg, and they require small space and have high carcass dressing weight. A few farmers keep pigs in intensive system. However, hot climate conditions in the West Nile region, low feed resources, water shortages and religious reasons do not favour the development of piggery enterprises.
- **Poultry**: Local chicken is the main poultry species reared together with others like turkeys, ducks, Guinea Fowls, geese and pigeons. Chicken are mainly kept in a free ranging system. In the peri-urban and urban areas of Arua exotic breeds are commercially reared. Acquiring inputs like day-old chicks and feeds is a continuous challenge, as they need to come from Kampala. Previous attempts by individual farmers, government programmes and NGO's to introduce exotic chicken breeds have had major setbacks due to high mortality rates, high cost and poor-quality feeds and low market for broiler birds. Broilers are perceived to have soft meat which the population does not appreciate. Hence, the only market available for larger-scale broiler farming are hotels (where its deep-fried) in the region. The demand for eggs within the region and neighbouring countries appears to exceed the current production.
- **Apiary**: The West Nile region has been identified as one of the best honey-producing regions; it produces up to three-quarters of honey in Uganda (Acai et al, 2010). Both modern (KTB & Langstroth) and traditional beehives (Log hives) are used for beekeeping, characterized by low colonization rates and high rate of absconding. The modern beehives have been reported to be very expensive.
- **Aquaculture**: Aquaculture is practiced on a small scale mainly in Arua. The River Nile is the source of fish in the West Nile region. However, the good quality semi-permanent /permanent streams in Zombo and Upper Arua provide opportunities for aquaculture.

Based on the scoping mission in October 2019, it is concluded that livestock plays a minor role in the area around the city of Arua. Most farmers own some poultry and a (few) goat(s), but few farmers own cattle (between 1 and 10 cows) or pigs. Cattle is not used for animal traction in crop production. Due to the land scarcity and small farmland holdings, livestock feed production has to "compete" for land with crop production. There is little grazing land and land used for fodder production, leading to low animal numbers. In addition, veterinary services are hardly available. Generally, the available livestock is (a) fed through extensive grazing on communal grasslands, (b) tethered, or (c) left to scavenge. Closer to the Nile (not visited during the field trip in October 2019) more grazing land and livestock appears to be available. Some farmers near the city of Arua own livestock that is managed further away where more land and animal feed is available.

7 Food systems outcomes

7.1 Food and nutrition security

"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). Food security, according to the food systems model presented in Figure 2.1 consists of three components: food availability, accessibility and food utilisation. Utilisation entails the nutritional value, social value and safety of the product; access involves food affordability, allocation and preferences; and availability is about food production, distribution and exchange (Van Berkum et al, 2018).

According to the Food Insecurity Experience Scale, 89% of refugees in Northern Uganda experienced moderate or severe food insecurity against 71% of the households in the host communities (FAO, 2018).

Food availability
For refugees, the World Food Programme provides assistance through two modalities, i.e. food aid or cash. Newly arrived refugees receive full rations for three years; which is than reduced to 50%, and finally phased out after 5 years after which refugees are expected to be self-reliant (WFP Uganda 2016). In 2017, refugee food support saw a reduction in the rationing (of 50-75%), and at some distribution points not all food commodities were provided (sometimes only maize and no beans for example). The current rationing per person (December 2019) consists of 12 kg Maize, 2.5 kg beans, 2 mugs of oil (approx. 1 L) and sometimes salt (some months salt is not provided). These amounts are multiplied by the number of individuals in the household. Refugees who receive cash get 31,000 UGX (approx. €7.50) (pers. com member of the Refugee Welfare council, Omugo Village 2).

Both refugees and host communities rely on food assistance but refugees much more than host communities (Figure 7.1). On average, own food production contributes to around one fifth (20%) of the food consumed by a refugee household. In the case of host communities this is 54% (FAO & OPM, 2018).

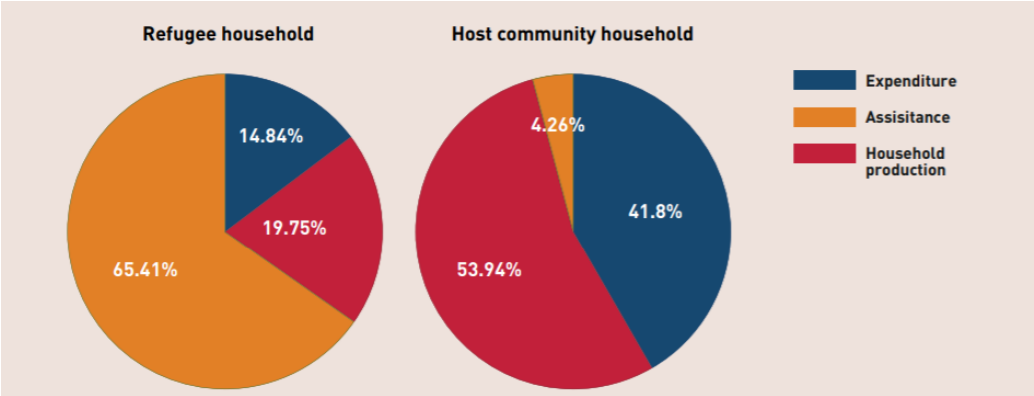


Figure 7.1 *Sources of food consumption, i.e. food aid through assistance programs, own household production and food expenditures (Source: FAO & OPM, 2018).*

Due to the bimodal climate there are two harvest seasons. Most households have enough carryover staple stocks in combination with newly harvested foods to hold out for a couple of months after the first harvest season. As their stocks get smaller, they turn to earning income from agricultural labour, trade or crop sales, and casual labour for cash to be able to access food from the markets.

Food accessibility

A 2016 study by the World Food Programme that looked at the differences between refugees who received cash compared to those who received food rations found that the former, as would logically be expected, purchased about 80% of their food. The latter purchased only 35% of their food (WFP Uganda 2016). Food scarcity among the refugees and the host communities drive prices of essential food items and influence food consumption patterns. Both communities reduced meals and relied on less expensive food items to cope with high food price situations (UNHCR & WVU 2017). Those refugees who receive cash (compared to those who receive food) have higher absolute spending on food and are more likely to purchase pulses, meats, fruits and vegetables, compared to those who received food assistance (WFP Uganda 2016). The 2016 comparison of cash versus food beneficiary recipients found that those who received cash are more likely to be in debt; the main reason for this debt is purchasing food.

Food utilization

UNCHR & WVU (2017) studied food consumption of both refugee and host populations in the Imvepi refugee settlement in Arua district and the Adjumani settlement in the East Nile area. Based on a 24-hours recall period, 60% of the refugee households and 53% of the sampled host community

households consumed on average two meals (for both adults and children). About 25% of the refugee households and 14% of the host community households used only one meal in the last 24 hours.

Refugee households in Arua have lower dietary diversity, out of 12 food groups, their diet consists of 5.9 food groups compared to households in host communities, whose diet consists of 7.6 food groups (Table 7.1). Human nutritional status is the outcome of a complex range of factors, which include food consumption, but which is also influenced by an individual's health (even if nutrients are consumed, if they are not absorbed by the body nutritional status will not improve). Thus, access to health care, clean water and sanitations services are also important in terms of determining an individual's nutritional status. In this regard, refugees have better access to water, hospitals and basic health services compared to host communities, as, especially in the earlier phases of the refugee response, services for refugees were provided without a lot of coordination with the existing structures, which led to jealousy among the host communities (FAO and OPM, 2018).

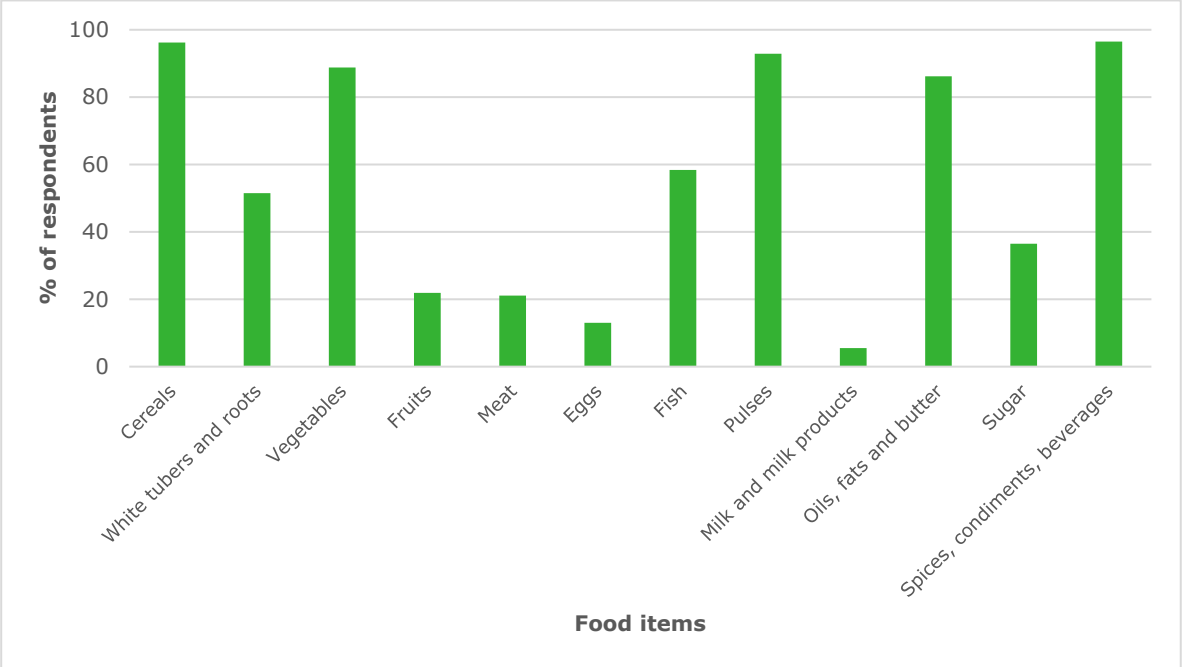


Figure 7.2 *Accessibility to different food items as percentage of respondents in host and settlement communities in Arua (Source: FAO and OPM, 2018).*

Table 7.1 *Food security indicators (mean values) of refugee settlements and host communities in Arua (Source: FAO and OPM, 2018).*

Variable (indicators)	Refugee	Host communities
Caloric intake per capita (Kcal per day)	1588.39	1742.39
Shannon index[2]	0.94	1.16
Simpson index	0.52	0.60
Food Consumption Score[3]	41.26	53.58
Household Dietary Diversity Score (# food groups per day)	5.94	7.65
Monthly food consumption per capita (USD)[4]	12.47	17.41
Monthly food expenditure per capita (USD)	1.25	6.07
Monthly food from own production per capita (USD)	1.40	10.99
Monthly food from aid per capita (USD)	9.96	0.33

[2] The Shannon and Simpson dietary diversity index are both indices for dietary diversity. is computed by considering the shares of the consumed calories by food group (cereals, roots, vegetables, fruits, meat, legumes, dairy, fats and other).

[3] Score calculated using the frequency of consumption of different food groups consumed by the household during the seven days before the survey.

[4] Monetary value (USD) of per capita food consumption, including bought, own-produced, received for free (as gifts or part of a conditional project) and food stored over the last month.

Pulses and nuts, vegetables, roots and tubers, oils and fats, and cereal are the most frequently consumed food groups. Households in Arua, on average, spend 2972 Ugandan shillings (≈ 0.71 EUR [5]) on food per day. In the last 7 days, they consumed, on average 7.65 out of 12 food groups, which is comparable to the national average. The food groups that most people have easily access to are pulses and nuts (92% of the households), vegetables (91%), roots and tubers (90%), oils and fats (83%), and cereals (80%) (Figure 7.2). However, note that these figures do neither indicate the amount of these food items consumed nor the frequency of consumption. Animal products are consumed less frequently, and only 8% of the households in Arua consumed dairy products. In terms of quantities, cassava (both dry as well as fresh) is consumed in large quantities (LSMS, 2014-2015).

Those households in the settlements who receive cash instead of food aid were found to have higher dietary diversity (lowest levels of dietary diversity were found in those receiving no food aid). Those receiving cash were also more likely to consume vitamin A rich foods and haem-iron rich foods. However, consumption of foods high in protein (most commonly beans) is higher in those who receive food assistance. It is hypothesised that this is because these foods are relatively expensive to purchase and are provided as part of the food package.

UNHCR carries out an annual food and nutrition security assessment in all refugee hosting districts in Uganda each year. However, due to challenges with the 2018 data collection resulting in the data not being published, the most recent data is from October 2017. This survey covered six settlements in the West Nile, including Arua. The survey found the highest rates of global acute malnutrition (GAM; a combination of moderate a severe acute malnutrition) in the West Nile compared to the other refugee hosting regions. In Rhino camp, the GAM rate was found to be 10.3%, above the cut-off for a public health emergency (UNHCR et al. 2017).

[5] 1 Euro = 4.15 UGX (January 7, 2020).

7.2 Socioeconomic

About 20% of the households in Arua has children between the age of 6 and 13 that are not enrolled in schools. At the national level, only 9% of the households has children between these ages not enrolled in schools. The level of education of the household heads in Arua does not differ significantly from that at the national level. On average, 12% of the household heads in Arua did not have any education, while 61% only received primary education (LSMS 2014-2015). This is in line with other reports (UNHCR and WVU, 2017) that concluded that about half of the surveyed refugees and residents (44 and 51%, respectively) had a primary level of education only, and 25% of the refugees and 6% residents are illiterate/semi-literate.

The majority of the household heads are farmers (64%) and only a minority (19%) is involved in the labour market (LSMS 2014-2015). At the national level, the share of farmers is lower, and the share of self-employed or unemployed household heads is higher. The engagement in the labour market is higher for males (27%) than for females (12%).

Remittances are one of the major other sources of income for households in both Arua as well as the rest of the country. Remittances are mainly received from elsewhere in the country. Based on LSMS (2014-2015), 29% of the households in Arua received such income. Remittances from abroad are much less common, with only 2% of households receiving such income.

7.3 Environmental outcomes

7.3.1 Resource use efficiency

Crop yields
Although systematically collected yield statistics of Arua are lacking, available information on crop yields in Arua show that crop yields are generally low and associated with the low use of external inputs (Chapter 6).

The Global Yield Gap Atlas (GYGA) estimates for maize and sorghum in Arua the difference between yield potential (Yp) without limitations due to water or other abiotic and biotic stresses (the most relevant benchmark for irrigated systems), and water-limited yield potential (Yw) as the benchmark for rainfed systems, and actual crop yields (Ya). Hence, Yp and Yw estimates are based on an optimal supply of crop nutrients and control of weeds, pests and diseases and are the average of two cropping seasons per year that are possible in Arua. See the GYGA website, www.yieldatlas.org, for details on the used methodology to estimate Yp, Yw and Ya.

Based on GYGA, Table 7.2 shows the yield estimates for maize and sorghum in Arua and the yield gaps between Ya and Yw, between Yp and Ya, and between Yp and Yw. Annual yields and yield gaps are based on the average simulated yield of two crops grown in the same field during the minor rains and major rains.

Table 7.2 *Actual yields (Ya), water-limited yield potential (Yw), yield potential (Yp), yield gap between Yw and Ya, yield gap between Yp and Ya and yield gap between Yp and Yw of maize and sorghum in Arua based on GYGA data (www.yieldatlas.org). All data in tonnes grain at standard moisture content per hectare (Source: www.yieldgap.org).*

	Ya	Yw	Yp	Yw – Ya	Yp – Ya	Yp – Yw
Maize	1.7	7.7	13.7	6.0	12	6.0
Sorghum	1.0	5.4	5.6	4.4	4.6	0.2

The yield gap for irrigated maize produced without other abiotic and biotic stresses (Yp) and current maize yields (Ya) is 12 t/ha. This yield gap is difficult to close by farmers in Arua because farmers lack

access to irrigation water. The yield gap between the water-limited yield potential and actual yields is (Yw – Ya) is 6 t/ha, but requires a perfection in crop management, i.e. the application of the appropriate amounts of nutrients to avoid nutrient stress and an optimal control of yield-reducing pests, diseases and weeds. In the literature, the exploitable yield gap, i.e. 80% of Yp and Yw, is considered the yield level at which average farmer yields in high production situations tend to be pegged (Cassman et al., 2003). In the case of Arua this means that under rainfed conditions farmers should be able to increase current maize yields with about 4.8 t/ha (i.e. 80% of 6 t/ha). An important assumption is that farmers have the knowledge, skills and access to required inputs allowing a perfection of the crop management.

Table 7.2 shows that yield response of sorghum under different production situations is different from maize. Not only Ya, Yw and Yp are considerably lower but also associated yield gaps show less room for yield improvement. Especially, the yield gap between Yp and Yw is small, only 0.2 t/ha, indicating that the production of sorghum under rainfed conditions is not much limited by the amount of rain in Arua. This relates to the more drought resistant properties of sorghum compared to maize.

Water productivity

In GYGA, water productivity (WP) is estimated as the ratio between Yw and crop water availability (potential WP) or between Ya and crop water availability (actual WP). Crop water availability is defined as the amount of water supply available during the crop growing season (from available soil water at sowing and precipitation) after discounting unavoidable water losses through surface runoff, deep drainage and the residual available soil water left in the soil profile at crop physiological maturity. See the GYGA website, www.yieldatlas.org, for details on the used methodology to estimate the potential WP and actual WP.

Table 7.3 shows the water productivity for maize and sorghum under rainfed conditions and actual conditions. In the current situation, water productivity of maize is a bit higher than that of sorghum. However, under perfect crop management the more drought resistant properties of sorghum come to the fore and it produces more grain biomass per amount of water supplied.

Table 7.3 *Potential water productivity (potential WP) and actual water productivity (Actual WP) of maize and sorghum in Arua based on GYGA data (www.yieldatlas.org). All data in kg grain at standard moisture content per mm of water.*

	Potential WP	Actual WP
Maize	14.5	3.3
Sorghum	16.2	2.9

7.3.2 Water pollution

In Arua municipality, the majority of houses do not have access to in-house piped water and rely on non-piped water (for example from boreholes or rivers), pit latrines and open garbage disposal (Kansiime, 2013b). There is indiscriminate disposal of solid waste, and the refuse street bins are not big enough for the generated garbage. Moreover, there are a lot of contaminating activities in the rivers such as vehicle washing, cattle watering, and clothes washing. As a result, most of the non-piped water is contaminated with E-coli (85%), and high organic matter contents (BOD5) and chloride levels have been measured in river water. Most of the non-piped water is therefore not fit for human consumption, even though most of the population in Arua municipality rely on it (especially in the dry season). This has led to residential areas being prone to environmental diseases like cholera, malaria, typhoid, dysentery, and intestinal diseases (Kansiime et al., 2013b).

7.3.3 Deforestation

Amongst the host community, the average wood requirement per person per day is around 2.1 kg. (Table 7.4) Average wood requirement per person in the refugee settlements was around 3.5 kg per day in 2017, but this has decreased to 1.6 kg in 2018. This decrease can be attributed to a shift in diet (from dry beans to more fresh food that cooks faster), the use of drier firewood, and the use of improved cooking stoves (WB & FAO, 2018a). Using an improved cookstove, such as a mud-stove, can reduce fuel use by 15 to 50% compared to the traditional 3-stone fire.

The use of wood as a source of energy has many disadvantages:

- **Deforestation:** With a total refugee population of almost 800,000 in the West Nile region, the wood requirement for the refugee settlements is around 527,000 tons of wood equivalent per year. As the wood is sourced mainly from natural areas, its demand has led to massive deforestation. Between 2014 and 2018, a total of 23,000 ha of woodland and bushland were lost, and 64,000 ha were degraded (WB & FAO, 2018a).
- **Health problems:** The inefficient combustion of the traditional cookstoves in poorly ventilated kitchens pollute the air with a mixture of particulate matter, carbon monoxide, hydrocarbons, formaldehyde, and benzene. This can lead to long term health problems, especially for the cook of the household (Ekouevi et al., 2014).
- **Long distances:** Due to the increasing scarcity of the wood, the women and children who collect it need to walk long distances to do so. Travelling such long distances exposes them to risks, such as being attacked by host communities (in case of the refugees), encountering wild animals, being assaulted or raped, or being arrested by rangers. Moreover, as the task becomes increasingly time consuming, it leads children to missing out on school (WB & FAO, 2018a).

Table 7.4 *Wood and charcoal consumption by hosts and refugees in 2018 in Adjumani and Yumbe, two neighbouring districts of Arua (Source: WB & FAO, 2018a).*

	Population using firewood	Firewood consumption	Population using charcoal	Charcoal consumption
	(%)	(kg pppd)	(%)	(kg pppd wood equivalent)*
Refugees – Total	96.6	1.65	16.7	1.30
Hosts – Total	97.6	2.13	6.0	1.30

* Expressed in firewood equivalent, assuming 20% conversion of firewood to charcoal by weight. Kilogram of firewood pppd is expressed on an air-dry basis.

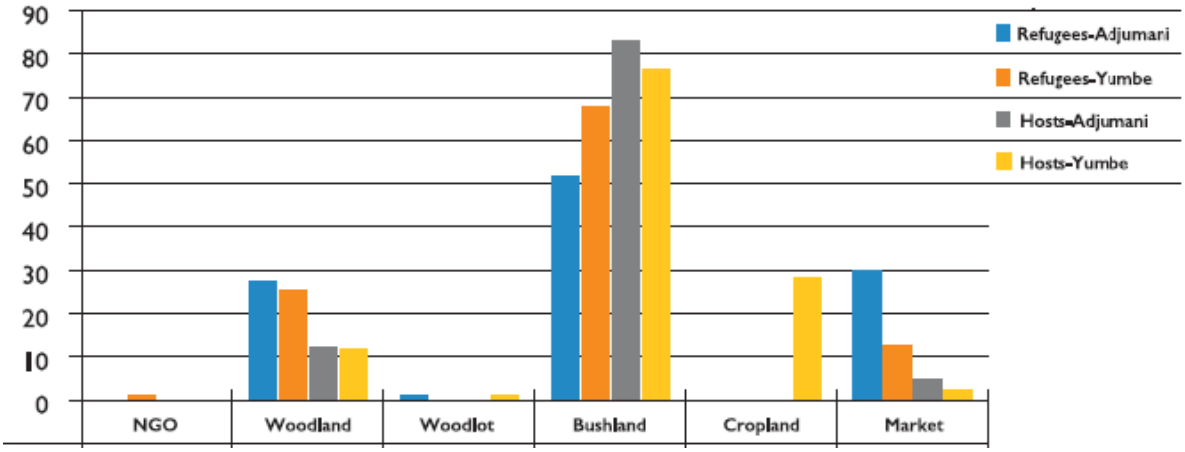


Figure 7.3 *Sources of wood for refugees and hosts from Adjumani and Yumbe districts, bordering Arua district (Source: WB & FAO, 2018a).*

7.3.4 GHG emissions

Uganda's national reporting based on the Tier 1 approach[6] in 2000 states that the three key sources of GHG emissions were N2O from agricultural soils (38%), CO2 from forest degradation (15%) and CH4 emissions from enteric fermentation (12%) (Republic of Uganda, 2014). Information of GHG emissions at lower scales is not available. The national emissions per capita in Uganda are around 1.39 t carbon dioxide equivalents (CO2e), at a rather low end of the global average of 7.99 t CO2e (CIAT: BFS/USAID, 2017). Agriculture has the highest share of total emissions with 22.38 Mt CO2e (46%) of which enteric fermentation and manure left on pasture contributes to 43% and 31%, respectively (CIAT: BFS/USAID, 2017) (Figure 7.4). The emissions are estimated to reach 77.3 Mt CO2e in 2030 (Uganda Coalition for Sustainable Development, 2017). Land use change and forestry, the second largest contributor to the national emissions, is expected to remain a net emitter by 2030 but may have the potential become a major sink by 2025 (USAID, 2015). Because of the limited scale of livestock production in Arua, GHG emissions associated with land use change and forestry are expected to be more important, now and in the future.

[6] Tier 1 is the most basic level, using only regional fixed values does not account for changes in animal productivity and animal production parameters, making it unsuitable if mitigation options are to be assessed.

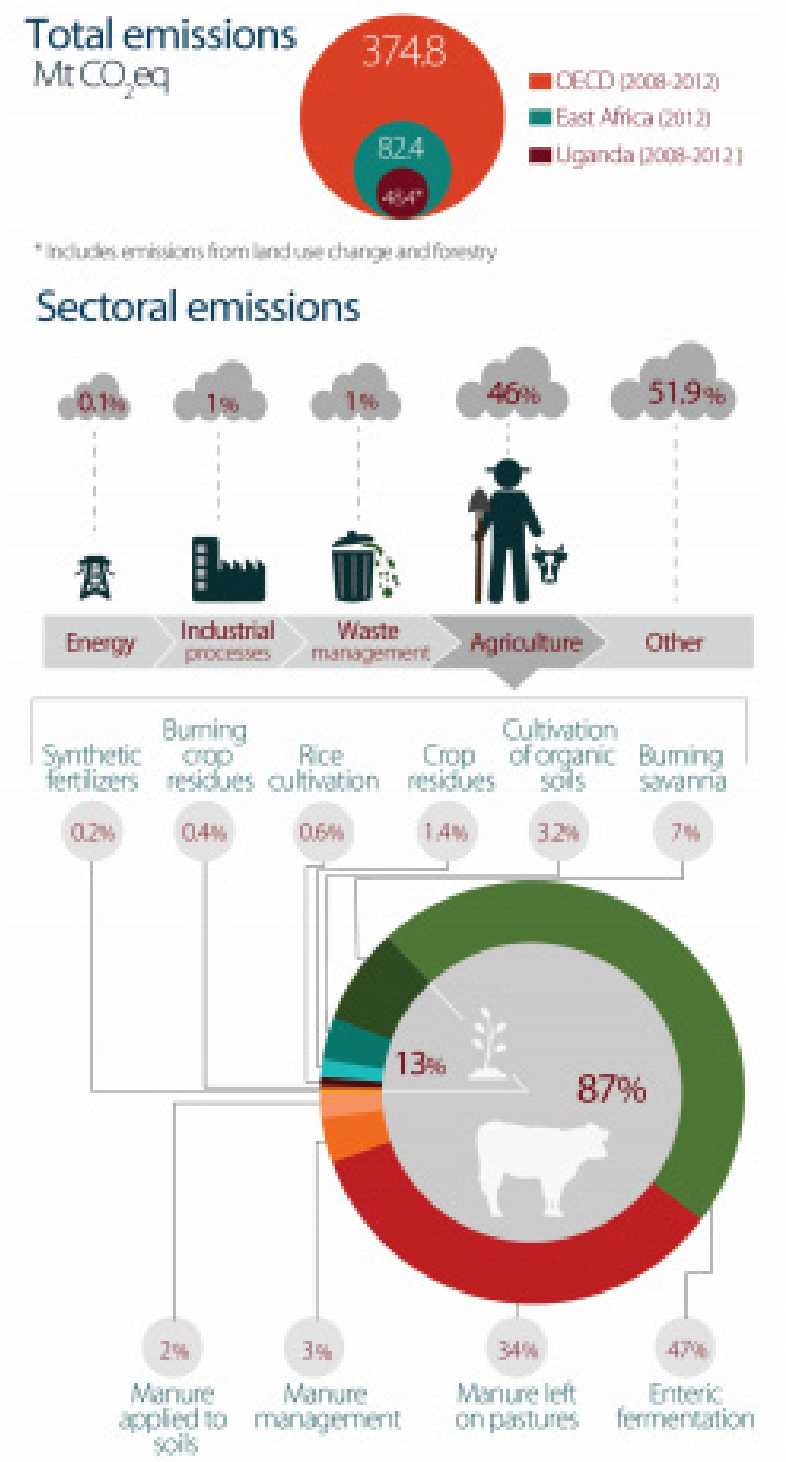


Figure 7.4 *National emissions in Uganda and their sources (Source: FAO (2012) and WRI (2016) in (CIAT: BFS/USAID, 2017)).*

8 Discussion and conclusions

8.1 Not all necessary data are available

The description of the Arua food system from different disciplinary viewpoints has been carried out within a relatively short period and is based on a review of the available, often grey literature, a scoping mission and interaction with stakeholders, unlocking data from the yield gap Atlas and an analysis of LSMS databases. Relatively much information was available in NGO reports on policies and food security outcomes related to refugees and host settlements. Much less information was available on agriculture. Agricultural statistical data such as (time series of) land use, and land and animal production and productivity are lacking. The lack of basic information was confirmed during the scoping mission to Arua in October 2019. Although a scoping mission of a week gives anecdotal evidence at the best, it was extremely useful to validate the results from the literature with stakeholders and to understand the context of the food system. In addition, the scoping mission offered an opportunity to interact with local stakeholders, which is an important aspect of the food systems approach as outlined in Chapter 2. Further analysis of some data sources such as the LSMS databases and the ongoing FAO food security assessments may give additional information contributing to the better understanding of the food system. It is important to note that food system drivers in Arua are changing rapidly as, for example, the influx and outflux of refugees may differ considerably over time. Hence, there is an inherent uncertainty in some of the presented data, which is further aggravated by poor definitions of concepts, different metrics used in different data sources, and changes over time such as the recent change in administrative spatial boundaries affecting the total area of the Arua district. Despite the data limitations, the quick scan of the Arua food system gives a basis for a diagnosis of the food system in Arua during the next step of the R&D process to improve food systems in less favoured areas in East Africa, in this case the Arua food system.

8.2 Preliminary conclusions of the description of Arua food system

A major driver of the food system dynamics in Arua are the demographics, i.e. with an annual population growth rate of about 3% the resident population grows rapidly and is on average very young. The West Nile region has a long history in both being a source of displaced people and hosting displaced people. Also in recent years there has been a large net influx of refugees mainly from South Sudan. Currently, about 25% of the Arua population consists of registered refugees of which most arrived in recent years. The refugee settlements are in less developed and less accessible areas of Arua with less fertile (stony) soils.

The OPM is leading the settlement of refugees and the assistance programs of over 100 NGOs active in Arua. Non-food assistance programs have the obligation to direct 30% of the interventions to host communities. In exchange, OPM negotiates land deals with resident land owners and host communities for refugee settlements. For example, two large refugee settlements in Arua, Rhino settlement and Imvempi, are together over 22,000 ha (UNDP, 2018). Refugee settlements are well organized and the policy to provide refugees with home garden sized plots for food production contributes to the self-reliance and resilience of refugees. In general, policies in Uganda related to refugees are liberal, i.e. refugees are free to move, they have the right to work and to start their own business. The policy to shift from food assistance to cash-transfer programmes is a next step towards enhancing the self-reliance of refugees. However, this will have major consequences for the current food system as refugees will become dependent on poorly developed food markets.

The food system activities in Arua can be characterised as predominantly low-input subsistence agriculture. External inputs such as improved seed/planting material, fertilizers and pesticides are

hardly used. As consequence, the cropping systems are depleting current nutrient soil stocks and crop yields are correspondingly low. Major value chains of food commodities are lacking. Only for tobacco there is a well-functioning value chain in place with impact on the income of farmers. In general, roots and tuber crops in combination with groundnuts are the dominant food crops both from a production and consumption perspective. Refugees tend to consume more cereals such as maize and sorghum than the resident population. Food activity supporting business services and the enabling environment including extension, research and agro-input supply are poorly developed and organized. For example, public extension is severely understaffed and the few agro-inputs stores outside Arua city offer a limited supply of inputs. Labour-saving traction, mechanised or animal-based, is hardly available and used. In addition, animals seem to play a minor role in a large part of Arua district which may be related to the scarcity of good quality land. Rainfall conditions often allow to grow two crops per year, which, in theory, smoothens food supply over the year and limits the duration of typical hunger seasons.

Apart from the increase in various basic services and international support attracted by the influx of refugees, the continuing rapid growth in population also means an increased number of people to be fed. Both refugees and residents are periodically food insecure, although the percentage food insecure refugee households is higher than the percentage of food insecure residents. In addition, natural resources, such as water, arable land and forests are already insufficient or are becoming insufficient to provide for the current population needs (production of food, firewood, clean drinking water, etc.).

8.3 The next step: from description to understanding the food system of Arua

Based on the above description of the Arua food system the main research question is how to improve the performance of that food system - increased supply of more safe and nutritious food, within environmental limits, in an inclusive way - as the food security status of both refugee and host communities is currently unsatisfactory. Answering this question requires a better understanding of the functioning and interrelationships of the different components of the prevailing food system:

1. How does the combination of socio-economic drivers impact the food system activities? How are various food value chains affected, and where do these chains perform well, where not, and why? To what extent is the enabling regulatory as well as business environment conducive for system improvement? How do consumer preference influence the food system activities? What trends in these socio-economic drivers can be identified and how are these expected to influence the development of the food system over the next 20 to 30 years? Vice versa, how does the development of food system activities impact on the socio-economics of Arua?

2. How do the current food system activities impact on the environment? What are the limits of sustainable use, and how are these stretched over the next 20 to 30 years? And vice versa, how are changes and trends in land and soil conditions; use of fossil fuels; biodiversity and forest cover; availability and quality of water resources; climate conditions; and availability of minerals important for food production, affecting food production. Today and over the next 20 to 30 years?
3. How does the interplay of socio-economic and environmental drivers in relation to food system activities influence the current food security in all its dimensions? Where are the major threads, and where the opportunities to improve. How will the current food security status evolve over the next 20 to 30 years given identified trends.
4. What are the aspired food system outcomes as set by either international targets such as SDGs, or by local stakeholders. Setting these targets, and having them validated by stakeholders in Arua is of key importance for answering the main research question regarding the food system in Arua: "how to improve the performance" which cannot be answered without agreed (negotiated) benchmark. Benchmarking is equally important before starting to build future scenarios and explore options for change.

During the next research step research questions need to be formulated to understand the functioning of the individual components of the food systems model, and the interrelationships between these components. Main questions could be inter alia:

1. Considering trends in population growth (including refugees) how much safe and nutritious food is required over time, and how much can be produced and processed in the region?
2. What are key limitations in agricultural production, what the strengths and opportunities for meeting food (future) demand in a sustainable manner?
3. What is the performance of the various food value chains, where are constraints and where opportunities for improvement? What impact do changes have on the food system?
4. What are impacts of increased production on the environment, and how do environmental limitations affect production over time?
5. How will food preferences and consumer behaviour in Arua affect the demand for food over time and what impact does that have on food value chains, food security and the environment?
6. How will increased demand for food in Uganda affect the food value chains in Arua, with accompanying impact on the environment and local food security?
7. How do national and regional relevant policies affect the local food system?

Better understanding the food system of Arua is necessary to move to the third and fourth step in our transdisciplinary research and development framework: exploring options - developing transitional pathways - to increase food availability, utilisation and access in Arua. Without wanting to pre-empt the further diagnosis of the food system one could think of i) increasing land productivity; ii) increasing food supply through less loss and less waste; iii) expansion of agricultural land or use of different land tenure and production systems; iv) production of healthier food and influencing consumer behaviour; v) better integrating local food systems in regional/national/international systems. Each option will involve specific trade-offs, modifications in the enabling environment, behavioural change of actors, environmental implications and will affect the food system outcomes for Arua differently.

"The food systems approach offers not only a means to compare different intervention possibilities but also a framework for systematically analysing the synergies and trade-offs between different policy objectives. Of course it must be said that the most recent literature in this field also recognises that the complexity of the food system makes it extremely difficult to precisely pinpoint the relationships and feedback mechanism between the different parts of the system (and with other systems) and to say what will work in order to improve system outcomes. Nevertheless, the framework does have a number of advantages (see also Ingram, 2011). First, it provides a checklist for the topics that should in any event be addressed in order to improve food security, certainly in relation to other policy objectives, and it identifies the actors and other parties who should be involved. Second, it helps to document the impact of environmental and climate changes on food security by pointing out different vulnerabilities in the food system. In that sense the concept can help in the search for ways of enhancing the system's resilience to climate change. Third, it helps to determine the most limiting factors when it comes to achieving food security, and thereby to identify effective interventions aimed at improving food security" (Van Berkum et al, 2018, p. 24-25).

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Appendix 1 Nutrition and Income generation project (NIGI)

Forced displacement is highly correlated to poor nutrition and food security outcomes. People are forced away from their lands, impacting agriculture and food production systems, and placing an enormous strain on the local resources, jobs and markets for the host community. Ongoing civil war in South Sudan and political unrest in the Democratic Republic of the Congo, have led to over 1.5 million refugees fleeing to Uganda, which has sought to support these refugees with one of the most welcoming refugee strategies in the world, providing refugees with small amounts of land for homes and farming activities. However, in reality, many refugees lack the necessary capacities (human, financial, technical) to produce healthy, nutritious foods for themselves. Additionally, the increase in people living in the area has led to a significant increase in demand for fresh foods, providing a strong potential market for the host community. The NIGI project seeks to improve access to, and consumption of, nutritious crops as well as by increasing income for refugees and hosts communities from production, processing and trade in crops.

The project works through 4 interconnected pillars:

1. Household nutrition - Refugees and host communities are be supported with capacity building on sustainable agricultural practices for vegetable and fruit production as well as awareness raising about the importance of good nutrition. This should lead to increased access and consumption of nutrient rich foods including vegetables/ fruits/legumes/tubers and bio-fortified crops.
2. Commercial vegetable production - Farmers, both host and refugee, with larger plots of land are supported to produce, market and sell vegetables, fruits, legumes, tubers, bio-fortified crops and seeds for commercial purposes, thereby increasing their incomes. Capacities will be built in terms of applying best agronomic practices.
3. Quality seeds - Existing local seed businesses (45), set up by the Integrated Seed Sector Development Project (ISSD) are supported technically to produce and market quality seed to both refugee and host communities. Additional activities will be undertaken to promote the importance of quality seed.
4. System Innovation – Together with local research institutes- the project will develop and test a set of innovative approaches and product packages, seeking to provide solutions to improve availability, access and consumption of nutritious crops in protracted refugee situations.

The KB work will focus on the 4th pillar and seek to provide the project with a better understanding of the project area food system, and what strategies maybe most effective in supporting healthy and sustainable food systems in protracted refugee contexts.

Appendix 2 Woody tree species and their use (*Source: Kindt et al., 2011*)

	English name	Human consumption	Other uses
Butyrospermum paradoxum	Shea butter tree	• Fleshy part of the fruit is consumed • Oil extracted from the seeds	• Soap making
Borassus aethiopum		• Fleshy part of the fruit is consumed • Oil extracted from the seeds • Roots of the young plant are consumed	
Tamarindus indica	Tamarind	• Fruits are consumed (for juice and porridge)	
Balanites aegyptica	Desert date	• Fleshy part of the fruit is consumed • Oil is extracted from the seeds • Young leaves are consumed	• Leaves are used as goat fodder
Ficus natalensis	Fig tree	• Fruits are consumed	
Grewia bicolor		• Young leaves are consumed	
Gardenia ternifolia		• Fruits are consumed • Leaves are consumed	
Ziziphus abyssinica		• Fruits are consumed	
Ximenia americana var caffra		• Fruits are consumed	
Vitex doniana		• Fruits are consumed	
Elaeis guineensis	Palm tree	• Fleshy part of fruit is eaten • Oil is extracted from the seeds • The seed is also consumed	
Moringa oleifera		• Young leaves are consumed	
Anonna senegalensis	African custard apple	• Fruits are consumed	
Ficus sur	Fig species	• Fruits are consumed • Young leaves are consumed	• Leaves fed to cattle and shoats
Lophira alata		• Oil is extracted from seeds	• Oil is also used for soap

Appendix 3 General description of soil types in Arua district

The soils covering most of Arua district are mainly ferralsols, leptosols, arenosols, vertisols (IUSS Working Group WRB, 2015).

Ferralsols are red and yellow weathered soils whose colors result from an accumulation of metal oxides, particularly iron and aluminum (from which the name of the soil group is derived). They are formed on geologically old parent materials in humid tropical climates, with rainforest vegetation growing in the natural state. Because of the residual metal oxides and the leaching of mineral nutrients, they have low fertility and require additions of lime and fertilizer if they are to be used for agriculture. Tree crops such as oil palm, rubber, or coffee are suitable, but pasture is often their main agricultural use after the original forest is cleared.

Leptosols are soils with a very shallow profile depth (indicating little influence of soil-forming processes), and they often contain large amounts of gravel. They typically remain under natural vegetation, being especially susceptible to erosion, desiccation, or waterlogging, depending on climate and topography. Because of continual wind or water erosion or shallow depth to hard bedrock, Leptosols show little or none of the horizonation, or layering.

Arenosols are sandy-textured soils that lack any significant soil profile development. They exhibit only a partially formed surface horizon (uppermost layer) that is low in humus, and they are bereft of subsurface clay accumulation. Given their excessive permeability and low nutrient content, agricultural use of these soils requires careful management.

Vertisols are characterized by a clay-size-particle content of 30 percent or more in all horizons of the upper 0.5 m of the soil profile, by cracks at least 1 cm wide extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying. They are found typically on level or mildly sloping topography in climatic zones that have distinct wet and dry seasons. Vertisols contain high levels of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management. Vertisols are dark-colored soils (though they have only moderate humus content) that may also be characterized by salinity and well-defined layers of calcium carbonate or gypsum.

Most soils are fine texture with loose structures, and they are easily eroded and leached (Arua, 2012). Especially along the valleys (vertisols) and the slopes of the hills (arenosols) soils are fertile thereby promoting small-scale farming. The ferralsols and leptosols on the hill tops have often a limited soil depth making them less suitable for agricultural production. If the soil depth is deeper than 15 cm, as is the case in the relatively flat areas, soils are fairly fertile. This is especially the case for the vertisols along the valleys due to alluvial deposits found along the lower portions of the slopes. Lateritic layers in soils will reduces rooting depth and therefore water and nutrient availability especially when these layers are close to soil surface. Another obstacle to plant production is the acidity of most soils.

Appendix 4 List of workshop participants, 8th of October 2019

Arua food systems mapping workshop, Muni University, 8th October 2019		
Name	**Position**	**Organisation**
Ezuma John	Commercial officer	Arua DLG
Solomon Osakan	Refugee Desk Officer	OPM
Babaru Gertrude	District Agricultural Officer	Arua DLG
Onzimen Georzen	Dean/Principal	IABC Arua
Ayikobua Kennedy	Lecturer	IABC Arua
Drileonzia Simon	P.M.	DCA
Francis Onyiko	Lecturer	Muni university
Pieter Temminck	Teacher	Zone College, the Netherlands
Felix Amabe	Value Chain Expert	GIZ
Herman Fleer	Director	Ecopolis Europa
Anyonzo T. Abbey	ED	PALM
Emmanuel Odama	Scientist	Abi Zardi
Ester Azim	Marketer	Ecopolis Europa
Alfred Andama	Lecturer	Muni university
Chamaji Jerry	Teamleader livelihood	DRC
Kennedy Aygyo	Program Coordinator	CEFORD
Edna Jurugo		UNHCR
Asaah Ndambi		WUR
Thomas Tichar		WUR
Henk van Reuler		WUR
Huib Hengsdijk		WUR
Marlene Roefs		WUR
Marleen Hermelink		WUR

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