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The influence of water, land, energy and soil-nutrient resource interactions on the food system in Uganda

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ABSTRACT

Food Security continues to be elusive in Sub-Saharan Africa (SSA), several decades after the first World Food Summit in 1974. The causes of food insecurity in Sub-Saharan Africa include among others; poverty, economic constraints, agricultural and agronomical challenges, rapid population growth, and the effects of adverse climate change. These causes however, are linked to complex interactions, constraints and dependencies amongst the key physical resources in food systems, namely – *Water, Land, Energy* and *Soil Nutrients* (WLEN). There is limited insight on the combined impacts of the resource nexus, and how this may constrain the performance of food systems in Sub-Saharan Africa. This understanding is essential if the food challenges in the region are to be tackled sustainably.

This study provides a detailed analysis of the Uganda's 2012 WLEN nexus resources vis-à-vis the country's current and potential food demand using calorific-demand analysis and source-to-service resource transformation modelling. The analysis determines estimates of the current resource stresses within Uganda's insufficient food system and the interconnected resource implications for the achievement of food security by 2050. The results are visualised using Sankey diagrams. The inferences highlight evident limits across all four resources. Overall, the analysis helps to inform food security policy and the resource context for the present and future management of Uganda's food system.

Introduction

Food security in Sub-Saharan Africa

Each year, many people in Sub-Saharan Africa (SSA) endure severe famine. According to the United Nations Food and Agricultural Organisation [FAO] (FAO, 2012, p. 10) and the European Union's (EU's) European Court of Auditors [ECA] (ECA, 2012, pp. 9–10) *Annual Reports* on food security, the number of food insecure people in SSA increased from about 219 million in 2003 to 239 million in 2010–12. Proportionally, the percentage of food insecure people in SSA remained stagnant at 27% of the population between 2003 and 2012 – representing little progress towards the 20% population undernourished Millennium Development Goal (MDG) target for the same period (FAO, 2012, p. 10).

Regionally, by 2010 none of the five East African (EA) countries was on track to meet its Global Hunger Index (GHI) targets based on analysis of SSA annual food statistics (ECA, 2012, p. 21). All of them had varying degrees of food scarcity ranging from 'Extremely Alarming' in Burundi to 'Serious' in Kenya and Uganda (ECA, 2012, p. 21). In Uganda, over 700,000 people require direct famine relief annually according to statistics from the World Food Program (WFP, 2012) and the Uganda Bureau of Statistics (UBOS, 2012).

Food security and the interactions between Water, Land, Energy and Soil Nutrients

The European Union's report titled *'Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth'* (EU, 2012) examined the increasing global constraints on the Water, Land and Energy resources, and the connections to food security. They argue that one of the major challenges of existing policy efforts in SSA has been a limited understanding of the holistic resource considerations and interconnections within the food systems (EU, 2012, p. 3). Policy efforts thus far have tended to focus on causal factors such as productivity/agronomic constraints, funding bottlenecks and climate change mitigation.

However interventions in one resource-use sector – for instance using limited energy supplies for large-scale fertilizer production, may have unintended adverse consequences elsewhere – such as irrigation water shortages. While discussing this challenge, the EU (2012, pp. 3–4) proposes integrated resource analysis to help

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Table 1
Aspects of food security (adapted from Ericksen, 2008; Ingram, 2011).

Availability	Accessibility	Utilization
• Food stock (production, distribution, exchange) • Variety • Travel distance • Transportation	• Allocation • Preference • Affordability (price, purchasing power/financial ability)	• Nutritional value • Health and safety • Social value

identify the critical points of interconnected resource stress within SSA's food systems and the impact of different policy options.

In this light, the research reported here adopts a *Food System* approach to analysing Food Security in SSA as proposed in Ericksen (2008, p. 238)'s and Ingram (2011, pp. 420–422)'s Global Environmental Change and Food Systems (GECAFS) framework. The approach proposes system-level analysis across the broad-spectrum of food system components, namely: Production, Processing, Distribution and Consumption. Ingram (2011) and Ericksen (2008) identify nine food 'outcomes'. These nine outcomes are grouped under 3 main components of Food Security namely: *Food Availability* (Production, Distribution, Exchange); *Food Accessibility* (Affordability, Allocation and Preference) and *Food Utilisation* (Nutritional value, Social value, Safety). Definitions of these components as adopted in this paper are as follows:

Availability, is comprised of the net stock of food produced, procured or otherwise received within the country, and the variety of foodstuffs available (Ingram, 2011, p. 420). Availability also includes the measures of physical proximity to food stocks including travel distance, efficacy of transportation. **Accessibility** consists of the drivers of Allocation and Preference (such as market efficiency and socio-cultural factors), as well as Affordability – which includes of the complementary aspects of Food Price and Purchasing Power (financial ability) (Ericksen, 2008, p. 240). Finally **Utilisation** includes both the Health & Safety considerations during production and preparation, and the nutrient content of the food. The social value and access to food are dependent on its physical availability. The three components of Food Security are listed in Table 1.

The scope of this study is limited to understanding the interconnected physical limits of the Water, Land, Energy and Soil macroNutrient (WLEN) resources and their potential impact on functionality and outcomes of Uganda's Food System. The economic trade-offs and other social-political costs involved in translating the physical resource availability into productive application in the Food System are complementary aspects not looked at within the scope of this study. Fig. 1 shows the links between the availability of the WLEN nexus resources and their interconnections with the *Food System* components and the different outcomes of Food Security. The study scope is indicated in the dashed boundary.

Understanding SSA's resource limits

Sub-Saharan Africa faces major challenges with the four resources of the Water, Land, Energy and Soil Nutrient nexus (WLEN nexus). SSA's interconnected WLEN resource stresses and trade-offs are discussed here below.

Water stress

According to FAO statistics (FAOSTAT, 2013), over 90% of the agriculture in Sub-Saharan Africa is rain-fed. This leads to perennial food shortages on account of failing rains, as reported in the USAID monthly surveillance report on emergency food-aid requirements and supply statistics – USAID (2012), and the Australian Office of Development Effectiveness strategic report on food security in SSA, AusAID (2008). The challenge of unreliable rain-fed agriculture points to a need for major shifts towards managed agricultural water use.

Rockström (2003, pp. 1999–2006) analysed 'green water productivity' in developing countries using a combination of evapotranspiration modelling, hydro-climatic modelling, and crop yield modelling assuming different cropping systems. The analysis suggests that consumptive dietary use of water in Sub-Saharan Africa will have to almost *double* by 2030 accounting for changes in land productivity, from 690 m^3/year to 1300 m^3/year, with a modest diet mix of 20% animal protein. This poses a significant water-stress challenge, considering the already formidable water concerns in the region and the likely adverse impacts of climate change.

In addition, there is also a competing demand for water for hydropower production, as evidenced by the increasing tussle between the Nile's riparian countries. McCartney and Girma (2012) analysed the likelihood of water stress as a result of agricultural and hydropower interventions on the Ethiopian Blue Nile, for the projection period 2100. Their analysis was based on a combination of Climate Change modelling (using IPCC climate scenarios),

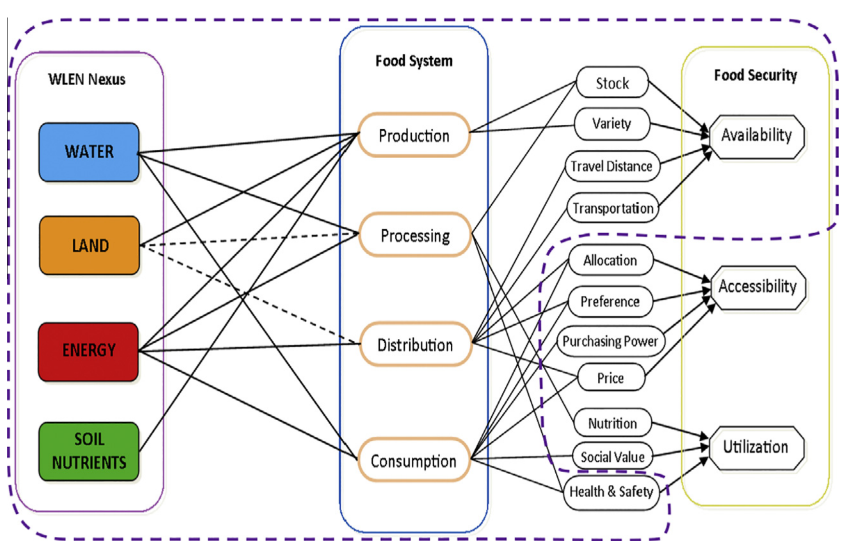

Fig. 1. Food system and WLEN nexus interconnections; scope of the study.