Can Africa Feed the World?

Land Acquisitions as a Solution to Global Food Security

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LUCSUS
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Abstract

Ensuring food security for 9 billion people is one of the biggest challenges facing humanity in the 21st century. Crop production needs to double by 2050 to keep up with demand from increasing population and income growth. Through analysis of the GRAIN database detailing land acquisitions in Africa for food production, I answered the question: are land acquisitions a solution to global food security? The main findings of the research were that 53% of the land is acquired for the production of flexible crops (crops used interchangeably for food, fuel and other purposes). The most popular crop groups were cereals and oil crops which together are grown on over 50% of land acquisitions. Oil palm is the largest single crop grown on land acquisitions, with 17% of land designated for its production. Oil palm is produced on an area 1 million hectares larger than for any other crop. The acquisitions of land for cereal production could potentially produce 9-18 million tonnes, which is 7-14% of the current cereal production quantity of Africa. However analysis of the intercrop yield (yield difference between two crops) shows that land acquisitions could increase total calorie production from cereals by 20%, largely by switching from growing wheat and rice in Eastern and Western Africa to producing maize and sorghum. The results show that large proportions of crops that are produced on land acquisitions are not a primary source of calories for diets and are being produced for the highest price. Crops which are grown for the food purposes are likely to be exported out of Africa to meet the demands of investor nations somewhat at the expense of host countries and communities. For these two main reasons land acquisitions are not seen to be reducing food insecurity. This papers uses kcal/ ha as a measure of food supply in agricultural production and I argue that traditional yield indicators only measure agriculture in terms of trade. This paper highlights the importance of finding new agricultural indicators that do not measure agriculture in terms of trade by food supply.

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Table of Contents

Table of Tables ... 8

Table of Figures ... 8

List of Abbreviations ... 9

1. Introduction ... 10

1.1 The problem definition ... 10

2. Background ... 11

2.1 Barriers for food security ... 11

2.2 Challenges for agriculture ... 13

2.3 Land acquisitions as a solution ... 14

3. Theory ... 15

3.1. Productionist paradigm ... 15

3.2 Yield Gap ... 16

4. Methods ... 17

4.1 Research design and methods ... 18

4.1.1 Research Question 1: What is, and where is, the potential for rain-fed agriculture in Africa? ... 19

4.1.2 Research Question 2: Are the crops being produced in land acquisitions those which will contribute for food security? ... 21

4.1.3 Research Question 3: Are land acquisitions making best use of land to contribute for food security? ... 23

4.2 Research boundaries, assumptions and limitations ... 25

4.2.1 Global food system and availability ... 25

5. Results ... 26

5.1 What is, and where is, the potential for rain-fed agriculture in Africa? ... 26

5.1.1 Available arable land ... 26

5.1.2. Increasing crop yields ... 28

5.2 Are the crops that are being produced those which will attribute to global food security? ... 30

5.2.1 Crops grown ... 30

5.2.2 Origins of the investment ... 31

5.2.3 Production quantity for cereals ... 32

5.3 Are land acquisitions making best use of land to contribute to food security? ... 32

5.3.1 Inter-crop yields ... 32

5.3.2 Land acquisitions and inter crop yields ... 34

6. Discussion ... 35

6.1 What is, and where is, the potential for rain-fed agriculture in Africa? 35
6.1.1 Available arable land 35
6.1.2 Increasing crop yields 36
6.1.3 Barriers for land acquisitions 38
6.2 Are the crops that are being produced those which will attribute to global food security? 39
6.2.1 Crops growns 39
6.2.2 Origins of the investments 40
6.3. Are land acquisitions making best use of land to contribute for food security? 41
6.3.1 Calorie yield and Inter-crop yield gap 42
6.3.2 "Mismanagement" of resources 42
6.4.3 Food security or securing food supply 43
6.3.4 Agribusiness, Finance and Speculation 47
6.4 Are land acquisitions providing a solution to global food security? 48
6.4.1 Food, fuel and the rest 48
6.4.2 Changing diets 48
6.4.3 Food security for everyone but the most in need 49
6.5 Limitations 51
7 Conclusion 52
8 References 54
9 Appendix 61

Table of Tables

TABLE 1 COMPONENTS OF FOOD SECURITY. 12
TABLE 2 COMMON FACTORS THAT CONTRIBUTE TO YIELD LOSSES IN FARMER'S FIELDS. 17
TABLE 3 RESEARCH OVERVIEW 18
TABLE 4 TERMINOLOGY, DEFINITIONS AND SOURCES FOR AGRICULTURAL CALCULATIONS 24
TABLE 6 CORRECTION FACTOR FROM HARVESTED YIELD 25
TABLE 5 BACK CALCULATION FOR CALCULATING KCAL/T 25
TABLE 7 POTENTIAL LAND AVAILABLE IN AFRICA 27
TABLE 8 QUANTITY OF CEREAL CROP PRODUCED ON LAND ACQUISITIONS 32
TABLE 9 AVERAGE POTENTIAL CALORIE YIELDS SUMMARY 34
TABLE 10 AREA OF LAND ACQUIRED FOR EACH CROP BY REGION SUMMARY 34
TABLE 11 S ANALYTICAL ANALYSIS OF COUNTRIES ACQUIRING LAND FOR CEREAL PRODUCTION. 44
TABLE 12 GRAIN DATABASE METHODOLOGICAL ASSUMPTIONS FOR ANALYSIS. 61
TABLE 13 INDEX OF PRODUCT CLASSIFICATION FOR GRAIN DATABASE. 61
TABLE 14 INDEX OF PRODUCT GROUPING FOR GRAIN DATABASE 62
TABLE 15 ADDITIONAL PRODUCT GROUPING 63
TABLE 16 FOOD PRODUCTION FOR EACH CROP WITHIN EACH COUNTRY IN AFRICA: FULL VERSION 66
TABLE 17LAND ACQUISITION ALLOCATED FOR EACH CROP WITHIN EACH COUNTRY IN AFRICA: FULL VERSION 67
TABLE 18 USES OF MOST POPULAR CROPS PRODUCED BY LAND ACQUISITIONS. 69

Table of Figures

FIGURE 1 REGIONS IN AFRICA USED THOUGHOUT THIS STUDY 20
FIGURE 2 VISUALISATION OF FOOD SECURITY. 26
FIGURE 3 POTENTIAL AVAILABLE LAND IN AFRICA COMPARED TO THE CURRENT ARABLE LAND. 28
FIGURE 4 POTENTIAL YIELD VS OBSERVED YIELD 29
FIGURE 5 DIVISION OF LAND ACQUIRED FOR FOOD PRODUCTION 30
FIGURE 6 PERCENTAGE AREA OF LAND ALLOCATED TO EACH CROP IN AFRICAN LAND 31
FIGURE 7 A SPATIAL REPRESENTATION OF POTENTIAL CALORIE YIELD OVER AFRICA 33
FIGURE 8 IMPACT OF PROJECTED FOOD PRICE 45
FIGURE 9 PREVALENCE OF UNDERNOURISHMENT 46
FIGURE 10 EXAMPLE OF PRODUCTION CLASSIFICATION FOR THE GAMBIA LAND ACQUISITION. 63
FIGURE 11 HECTARES ACQUIRED BY COUNTRY TO GROW CEREAL 65
FIGURE 12 HECTARES ACQUIRED BY COUNTRY TO GROW OIL PALM. 65

List of Abbreviations

FAO - Food Agricultural Organisation

FDI **-** Foreign Direct Investment

GAEZ - Global Agro-Ecological Zones

ha - Hectares

IAASTD- International Assessment of Agricultural Knowledge, Science, Technology Development

IIASA **-** International Institute for Applied Systems Analysis

Kcal - 1000 calories

NGO - Non-governmental Organisation

OECD - The Organisation for Economic Co-operation and Development

t - Tonnes [metric]

UN - United Nations

WB - World Bank

WHO - World Health Organisation

1. Introduction

1.1 The problem definition

Ensuring global food security in the future is one of the biggest challenges facing humanity today (UNEP, 2012). This has global impacts because food underlines all economic, social and human development and is integral to the future of humanity (Misselhorn et al., 2012; The Montpellier Panel, 2012). Despite the developments and advancements made, we face the same predicament unearthed by Thomas Malthus some 200 years ago: how do we feed a growing population?

Projections for food demand estimate that crop production will need to double to meet the needs of an increasing population with growing incomes, while the portion of arable land per person is decreasing (Alexandratos, 2009; Bruinsma, 2009; Foley et al., 2011; Tilman et al., 2011). The difficulty of this challenge is compounded by the threats of water scarcity, energy restrictions, climate change and biodiversity loss which are likely to undermine agricultural practices as they currently stand. Concurrently, food production has to compete for limited land resources with urbanisation, energy production and conservation of biodiversity (Bruinsma, 2009).The FAO defines food security as the condition in which "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" (FAO, 2002).

Some claim that Africa is the solution to the problem of global food security (OECD-FAO, 2009; World Bank, 2009; Tran, 2011; Kearne, 2011). This Africa-centric solution to food shortages has surfaced within popular debate, propelled not least through publications by the OECD, FAO and the World Bank. The large potential lies in the abundant areas of land suitable for rain-fed cultivation. Africa has low level of yield attainment and has an abundant supply of underused agricultural land. There are opportunities to increase crop significantly by making use of the large available rural labour force and by increasing the application of fertilisers[1] (The Montpellier Panel Report, 2012). African politicians are increasingly keen for their countries to be seen as a solution in this context, "rather than a problem" (Aljazeera, 2009). However Kanayo Nwanze, president of the International Fund for Agricultural Development, reiterates that investment is key (Tran, 2011).

Investment has taken the form of land acquisitions, finance and aid. The French Inter-Ministerial Food Security Group (2010) claimed that large-scale foreign investments in farm land has the

[1] Fertilisers are used very sparingly across Africa, the average rate of fertilisers in Africa are 11kg/ha compared to 154kg/ ha in India and 468kg/ha in China. Africa has the potential to source rock phosphate fertiliser from within the continent at affordable costs (The Montpellier Panel Report, 2012 pp 9).

potential to reduce food insecurity at the global or local level, build infrastructure, generate jobs and wealth, facilitate the transfer of technology and preserve areas of ecological interest. These investments have occurred in Asia, Latin America and the Caribbean, and Eastern Europe, but the heaviest investments have been primarily in Africa (Deininger et al., 2011; Borras et al., 2011). In sub-Saharan Africa alone, 29 million ha of land have been considered for investment in one year (Deininger et al., 2011). As one investment method and acquisitions are driven by the desire to ensure food security and supply (Cotula et al., 2009). Foreign investment in land acquisition is growing fast, with multinational companies and countries, with low domestic production potential and high economic wealth, purchasing or leasing areas of land for food and fuel production (Beddington, 2010).

In this thesis I explore the claims, as they are made, that Africa can feed the world, by looking at the role of land acquisitions in Africa. Using a database of land acquisitions for food production in Africa (GRAIN, 2012) I present a macro level analysis for whether land acquisitions are increasing global food supply to contribute for food security. This thesis will analyse the potential of land acquisitions in an increasingly global food supply and contribute to the discussion of how global food security is framed.

2. Background

2.1 Barriers for food security

One billion people are currently malnourished, despite enough food being produced globally to supply each person with their necessary calories and nutrition (Foley, 2011). This is because food security is not solely an issue of adequate global food supply but is composed of adequate access, availability and utilisation (Dibden et al., 2011; Wu et al., 2011). There are challenges associated with each of these components (Table 1).

Access and utilisation are significant barriers for food security. Problems of distribution, pricing and waste leave people hungry. The higher food prices of 2007-2008 pushed an additional 40 million people into hunger as prices rose (Daniel, 2010). However there are serious concerns that with the forecasted increases in population and consumption, agricultural production will not be able to meet these growing demands, causing more people to go hungry (Foley et al., 2011; Rosegrant and Cline, 2003). Therefore the net production of food is one of the most pressing issues for future food security (Godfray et al., 2010; Foley et al., 2011; Misselhorn et al., 2012).

Various projections predict that crop production needs to increase by approximately double to cope with increasing population and changing income, which change dietary demand (FAO, 2002; 2006; Bruinsma, 2009; Foley et al., 2011; Tilman et al., 2011). One estimate made by Bruinsma (2009) makes the claim that agricultural production would need to increase by 70% by 2050 to be able to provide enough food. This means that in 2050 there will need to be an additional one billion tonnes of cereal and 200 million tonnes of meat produced annually by 2050[2] (Bruinsma, 2009).

The majority of this expected increase is set to take place in developing countries; with incomes rising, households will have more disposable income to spend on luxury protein-based food (Bruinsma, 2009; IAASTD, 2009; Lobell et al., 2009; Ciera and Masset, 2010). Demand for food is also rising as the global average intake of calories is predicted to be 12% higher in 2050 than 2001 levels (Alexandratos, 2009).

Table 1 Components of food security. The components of food security and the role of land acquisitions for food security. Compiled from WHO, 2005; pg 35; Dibden et al., 2011

Components of Food security	Challenges	Claims of land acquisition proponents
Availability	◦ **Is there enough food available through domestic production or imports to meet needs?** ◦ **Are the distribution systems effective in reaching low-income and rural communities?**	**Land acquisitions promise:** **Closing yield gap; new seed varieties, new farming techniques etc.** **Building infrastructures, strengthening local markets, creating jobs**
Accessibility	◦ **Do the vulnerable in society have the purchasing power to attain food security?** ◦ **Can they afford the minimum basic diet of 2100 calories per day required for an active and productive life?**	**Increased yields will lead to lower prices.**
Utilisation (Adequacy)	◦ **Does the food supply provide for the differing nutritional needs, i.e. a balanced diet, offering the necessary variety of foods at all times?** ◦ **Is the food properly processed, stored and prepared?**	**Nutritionally enhanced crops, e.g., Golden Rice, will meet the nutritional needs of “the poor” in developing countries**

[2] 2050 demand compared to 2005/2007

2.2 Challenges for agriculture

The demands facing food production have come at a time when crop yields are stagnant and food reserves are the lowest they have been in 35 years (Rosengrant and Cline, 2003; OECD-FAO, 2009; Premanandh, 2011). Over the last 20 years global focus has moved away from agricultural production and its role in ensuring food security. There has been a decline in investment in research and infrastructure and advancements in technology have decelerated (Rosengrant and Cline, 2003). Agricultural development has been neglected and is now set to face its biggest challenges.

The global demands on freshwater resources are great and with the growing population this demand only increases. Agriculture is the largest user of freshwater, totalling 85% of global consumptive use[3] (Gleick, 2003). Freshwater resources are used in irrigation and fertilisers and have become vital to achieving the level of crop yields that have become expected in industrial agriculture. The sustained use of freshwater resources by agriculture has reduced flows of rivers and streams and lowered water tables, reducing the available water for future production (Foley et al., 2005). This is a limiting factor for food production particularly in China and India where agriculture relies heavily on irrigation. In addition, agricultural activity degrades the quality of water resources. Pesticides and insecticides commonly used in agriculture pollute water resources. Sediment load and nutrient enrichment remove large volumes of water from use, further decreasing the availability of a limited resource (Foley et al., 2005; Premanandh, 2011). These difficulties will be compounded by climate change, which predicts more intense rainfall and longer dry periods and disrupted weather patterns. This will affect all types of agriculture (Premanandh, 2011). It is projected that product yield will drop 5-15% for each degree Celsius increase in climate temperature. This means that potentially, average yields of crops (e.g. maize, soybean and cotton) on existing farmland could decrease by up to 46% in the next 90 years (Premanandh, 2011).

Since 2008, groups from national governments, international organisations, trans-national companies and academia have renewed their interest in the issue of agricultural production and long-term food security. The 2007-2008 food crisis put the future of agricultural production and global food security back on the agenda. The crisis which was characterised by huge price spikes, food shortages and riots has served as a reminder that although humanity is more technologically advanced than ever before, agriculture is still central for our existence (Wu et al., 2011). In 2008 the FAO, World Bank and G8 all called for the renewed investment in agriculture directed at improving and expanding agricultural productivity and production (OECD-FAO, 2009). The World Bank report

[3] in which the water is not returned to its watershed

(2009) highlights the global availability of agricultural land and the potential for improving production, particularly in areas with low agricultural development, such as Africa.

A consensus appears to be forming that “underutilised” land in developing countries can be the key to long-term global food security, whether this is through the introduction of new farmland or the closing of yield gaps (OECD-FAO, 2009; The World Bank, 2009; Foley et al., 2011; Kearney, 2011; Tran, 2011). Investing in the farming sectors of developing countries will increase productivity to a larger degree than possible in Europe or the US, where agricultural potential is very close to maximised and soil quality is now degrading (Beddington, 2010). This investment in policies, infrastructure, science and technology is required to access the potential productivity from Africa’s land and resources (Rosengrant and Cline, 2003; The World Bank, 2009). The logic is that investment in developing nations, which are currently only achieving a small amount of their agricultural potential, could contribute to future global food security.

2.3 Land acquisitions as a solution

Land acquisition and land grab are terms often used to describe the purchase or long-term lease of areas of by foreign investors typically for period from 50-99 years (Mann and Smaller, 2010). Land acquisitions in Africa are a controversial topic. They are currently being viewed as anything from a development opportunity to neo-colonialism (Robertson and Andersen, 2010).

Land acquisitions are displayed as a solution to the underuse of agricultural resources by African farmers (Daniel, 2010). There are many economic, environmental and social constraints to agriculture, both in general, and more specifically related to Africa. These challenges have been described in Section 2.2[4]. Land acquisition and outside investment into land typically encourage the use of practises employed and developed by large-scale agriculture (De Schutter, 2011a). The limiting factors affecting yield, such as water availability and nutrient lacking soil, have easy technological fixes which African farmers may not be able to afford, such as irrigation systems or the application of fertilisers (Collier, 2008; Beddington, 2010). Large-scale commercial agriculture is also more suited to supply markets, attracting investment and adapting to regulation better than small hold African farmers (Collier, 2008). Foreign investors bring with them a wealth of knowledge about increasing

[4] A more comprehensive discussion can be found in Rosengrant and Cline, 2003; FAO, 2006; IAASTD, 2009; Foley et al., 2011

yields and producing a greater output of food (Collier, 2008). It is with these practices that land acquisitions can overcome challenges of food security (Table 1).

Opponents of acquisitions (or grabs) believe that such investment will provide little benefit to local people and may destroy livelihoods through dispossession of land and relocation to marginal land (Zoomers, 2010). The use of the term grabbing originates from the concern that the land acquired is often from poor developing countries, by food-insecure but income-rich countries and private trans-national companies for use in export (Borras et al., 2011; Daniel, 2011). There are many accusations levied against land acquisitions in light of the code of conduct, corruption, transparency, compensation and failure to carry out claims of rural development (Borras et al., 2011; De Schutter, 2011a; De Schutter, 2011b). There is disagreement about the competency of the countries being approached, to manage the investment to help facilitate poverty alleviation (De Schutter, 2011a). In addition land acquisitions and large-scale farming put pressure on land resulting in environmental degradation (De Schutter, 2011; Deininger et al., 2011).

I chose to focus my research on land acquisitions due to the controversy surrounding the nature of such actions, as well as the reported consequence of social and environmental degradation. I wish to look at the arguments put forward by proponents of land acquisitions and look at its role in increasing food production to help feed the world.

This thesis looked at the following questions:

Main RQ: Are land acquisitions in Africa providing a solution to global food security?

1. *What is, and where is, the potential for rain-fed agriculture in Africa?*
2. *Are the crops that are being produced those which will attribute to global food security?*
3. *Are land acquisitions making best use of land to contribute for food security?*

3. Theory

3.1. Productionist paradigm

Productionism paradigm (Lang and Heasman, 2004) is characterised by the move from local small-scale production to mechanised, commercial, mass production of food commodities. It hails from the time after the Second World War and the industrialisation of agriculture. The food supply chain is lead by the quantity of food and all progress is directed to increasing this output. The productionist model of farming is typically monoculture, this type being especially conducive to the high input of energy, pesticides, and fertilisers (Lang and Heasman, 2004). The productionist paradigm influences how policy is made and where investment is directed, favouring particular types of farming methods and production. It is through this paradigm that land acquisitions have been seen as a solution.

High input large-scale farming has, for a long time, been the dominant agricultural practice (Delininger et al., 2011b, p.3). It is partly because of the productionist paradigm that African governments are willing to open up their local markets to foreign investment. Due to the surplus stock caused by high production rates and strong regional economies could undermine local markets in developing countries by selling their stock at undercut prices (Lang and Heasman, 2004).

Lang and Heasman (2004) predicted the decline of the productionist paradigms and the emergence of two paradigms concerned less with production and more with integrated ecology or life science. However, economic stability, food prices and demand for arable land has changed since the time they wrote their book. Like the period after the war, in 2008 the globe was suffering from food shortages; prices rose and many countries experienced riots. These events have reaffirmed the dominance of the productionist paradigm for a little while longer.

3.2 Yield Gap

Reaching higher yields is part of the strategy for achieving food security while protecting the natural environment (Lobell et al., 2009; Foley et al., 2011).The potential for closing the yield gap has been claimed as the most important factor in improving agriculture in Africa (Finger, 2011). It is preferable to expanding agriculture land (Lobell et al., 2009; Foley et al., 2011). By closing yield gaps and not expanding cultivated land you can protect areas of biodiversity such as forests and natural ecosystems from being converted into crop land

Yield gap is a term which has been used extensively in literature to highlight African farmland as a region which is underused (Godfray et al., 2010; Deininger et al., 2011; Foley et al., 2011). It is a term referring to the difference between the potential and actual crop yield (production per hectare) of a given area of land, assuming the best technology and agricultural practises are available (Lobell, et al., 2009; Godfray et al., 2010; Foley et al., 2011). The biophysical and socioeconomic factors that inhibit yields are listed in Table 2. The gap between the *potential yield* and actual yield is considered, by Widawsky and O'Toole (1996) for example, as a loss in production that is yet to be realised. Yield gap is used often in reference to the gap being closed and identifying how to "fix" them.

The yield gap theory is placed within the productionist paradigm. There is an understanding that land is not worth anything until it is utilised for production. The *potential yield* is calculated using all the known agricultural technology and management, and therefore it is assumed that this should be adopted as the method on the ground.

In the World Bank report (Deininger et al., 2011) yield gaps are perceived in respect to investment opportunities (Borras et al., 2011). A large yield gap is defined as an attractive quality for investment due to the possibilities for easy increase in yield (pp. xxxvii). Land acquisitions are thought to bring investment in fertilisers, pest management, irrigation, improved seed varieties, knowledge of farming practises and mechanised practices (Table 2). However, large yield gaps can be an indicator of problems that land acquisitions cannot easily solve such as political problems. As such, when investment has already been made in the land, sustained large yield gaps are a negative sign as it implies that there are constraints that are difficult for investors to overcome (pp. 55).

Table 2 Common factors that contribute to yield losses in farmer's fields. Adapted from Lobell et al., 2009

Biophysical factors	Socioeconomic factors
Nutrient deficiencies and imbalances (nitrogen, phosphorus, potassium, zinc, and other essential nutrients)	Profit maximization- law of diminishing return
Water stress	Risk aversion
Flooding	Inability to secure credit
Suboptimal planting (timing or density)	Limited time devoted to farming because of household commitments, health of population
Soil problems (salinity, alkalinity, acidity, iron, aluminium, or boron toxicities, compaction, and others)	Lack of knowledge of best practices
Weed pressures	
Insect damage	
Diseases (head, stem, foliar, root)	
Top heavy crop, fall over (from wind, rain, snow, or hail)	
Inferior seed quality	

4. Methods

This thesis applies a deductive approach, in testing the hypothesis that land acquisitions in Africa provide a solution to future global food security. I seek to contribute to research on land acquisitions by linking this question into the wider debate on the legitimacy of land acquisitions. The research design is based on a quantitative study of the potential production capacity of Africa and the analysis of current land acquisitions. I aim to address the ad hoc, case by case approach by which individual land acquisitions have been examined (de Shutter, 2011b) by providing macro level research into a claim used by proponents to justify land acquisitions in Africa.

4.1 Research design and methods

Three sub research questions guide the research (Table 3):

1. *What is, and where is, the potential for rain-fed agriculture in Africa?*
2. *Are the crops that are being produced those which will attribute to global food security?*
3. *Are land acquisitions making best use of land to contribute for food security?*

Table 3 Research Overview. This table explains how the Main Research Question will be answered and what methods and cases will be used to do so

Main Research Question: Are land acquisitions in Africa a solution to global food security?				
Research Questions	**Sub questions**	**Methods**	**Crops chosen**	**Source**
1. What is, and where is, the potential for rain-fed agriculture in Africa?	**1.1 How much agricultural land is available in Africa?**	Literature review, agricultural calculations	Maize, wheat, soybean and oil palm	Fischer and Shah (2010) "Farmland Investments and Food Security"
	1.2 How much can crop yields be increased?	Agricultural calculations of observed yields and potential yields	Maize, rice, soybean and wheat	Observed yields for 2010 from FAOSTAT; Production; Crops; Yield (FAOSTAT, 2012) and Potential yields from GAEZ v 3.0 (IIASA and FAO, 2012)
2. Are the crops that are being produced those which will attribute to global food security?	**2.1 What crops are being grown?**	Catalogue production	Crops analysed varies by country	GRAIN land acquisition database (GRAIN, 2012)
		Comparison of hectares allocated for crop group and individual crop		
	4.2.2 What is the potential production of cereals from these land acquisitions?	Agricultural calculations; using potential yield and ha to calculate production	Barley, maize, rice, sorghum and wheat	GRAIN land acquisition database (GRAIN, 2012) and potential yield from GAEZ (IIASA and FAO, 2012)
	2.3 Where do investments originate from?	Created spreadsheet to compare land area acquired per country for crop	Cereals, oil palm	GRAIN land acquisition database (GRAIN, 2012)
3.Are land acquisitions making best use of land to contribute for food security?	**3.1 Where are the highest yields of cereal crop to be made?**	Calculating kcal per hectare using optimal yields from database	Barley, maize, rice, sorghum and wheat	Potential yield from GAEZ (FAO and IIASA, 2012) and kcal/t from Conte (2009)
		Plotted kcal per hectare on map		
		Compared country and inter-crop, calorie yield		
	3.2 Are land acquisitions producing cereal where production is high?	Create table of location and total area of cereal land acquisitions	Barley, maize, rice, sorghum and wheat	GRAIN land acquisition database (GRAIN, 2012)
		Compare to location of highest yields		

4.1.1 Research Question 1: What is, and where is, the potential for rain-fed agriculture in Africa?

Potential land available

Based on figures in Fischer and Shah (2010) I calculated the *potential land available* in Africa for production of four major food crops: cassava, oil palm, rice and wheat. I chose these because they were used in the Fischer and Shah (2010) Farmland Investments and Food Security, upon which the World Bank report Rising Interest in Farmland (Deininger et al., 2011) based many of its findings. The crops indicate the availability of arable land and the *potential yield* of the land.

Potential land available (Table 4) refers to grassland/woodland or forest land ecosystems that can achieve no 60% maximum yields for rain-fed agriculture, that is not protected or being used for crop production (Deininger et al., 2011 pp. 93). For all calculations using ”potential” values I will assume rain-fed agriculture, as this is more suitable for long-term agriculture with the threat of water scarcity and the reduced future water availability associated with climate change.

Throughout the analysis Africa will be divided into regions (Figure 1) to assist in identifying patterns within and between different areas. Africa is a large and heterogeneous region with regards to social, environmental and economic aspects. It is has different social and political boundaries and many different ecological zones of which sub-Saharan Africa is most suitable for rain-fed agriculture.

I have chosen to study the whole continent of Africa and not a specific region, because various claims made regarding Africa’s potential for agricultural development refer either to the whole region or different sub regions which sometimes overlap. Therefore I have chosen the whole continent to be able to encompass this. In addition by only choosing the most productive regions in Africa for my study I would be excluding many land acquisitions in Africa and I believe this would provide a limited picture.

Figure 1 Regions in Africa used thoughout this study

The values for *potential land available* are calculated using the total area of Africa for each crop. This assumes that none of the other crops are being grown. Therefore the totals cannot be added together to produce total area of land available as it would mean counting the same area of land as available more than once. I chose to calculate four major crops individually referencing which crop is suitable for production. Without specifying which crop is suitable for agriculture, results can be misleading; for example, large areas of North Africa can be considered potentially available for agriculture despite only being suitable for cultivation of olive trees (Brunisma, 2009).

I compared the potential available land for each crop to the total land in each African region, as well as the arable land in Africa and arable land in the whole World. The land values were taken from FAOSTAT (2012). Arable land refers to "land under temporary agricultural crops...temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years)" (FAO Statistical Division, 2012).

Increasing crop yields

The amount that yields can increase has been identified by looking at the gap between *potential yield* and *observed yield* (Table 4). *Potential yield* is sourced to the nearest t/ha, whereas *observed yield* is given to 4 decimal places.

Potential yield has been created using the assessment of agro-climatic conditions, with reference to thermal climates, temperature profiles, and temperature and moisture growing period characteristics (IIASA and FAO, 2012). I have calculated the *potential yield* for crops under industrial farming conditions using rain-fed agriculture in 2050 with the occurrence of climate change (Table 4). I chose to use this particular prediction for *potential yield* for two reasons, firstly, because 2050 is benchmark used for food security targets and secondly because of current and future water scarcity issues (Foley et al., 2005). I wanted to test the potential of rain-fed agriculture alone, as this method of farming is more sustainable for long term use and a prediction for agricultural potential assuming irrigation is not a realistic vision of future water use. This does not suggest that there will be no irrigation, or that land acquisitions do not irrigate but that I should assume no more than rain-fed agriculture. There is a time factor in this calculation. The *observed yield* is from current practices in 2010 whereas the *potential yield* is taken from predictions of rain-fed agriculture in 2050.

I plotted the *potential yield* vs. *observed yield* for each African country which produced one or more of these for four major crops; maize (N=51), rice (43), soybean (49), and wheat (34). Each data point refers to a different country. Countries were not plotted if both values were zero, as this means the land is not suitable for production. I added a line "100 yield" which represents where *observed yield* is equal to *potential yield*. This graph is not a real scatter plot as the data is interval rather than continuous.

In this section I altered the study crops. In order to emulate the study by Fischer and Shah (2010), which I used previously to look at maize, oil palm, soybean and wheat. However there was no data for *observed yield*s for oil palm so I substituted oil palm with rice in the second half of this research question.

4.1.2 Research Question 2: Are the crops being produced in land acquisitions those which will contribute for food security?

Research questions 2 and 3 are answered through analysis of a database that lists land acquired for food production in Africa. The database has been compiled by GRAIN and most of the information has been collected from the website farmlandgrab.org (GRAIN, 2012).

I used the database to identify the type of crop grown on land acquired and the number of hectares allocated to each crop. I calculated the hectares used for each crop and catalogued the data on "products" (crops). I excluded 27 of the 174 total entries which did not contain values for hectares or production.

Crops grown

I catalogued the products based on FAO and GAEZ groupings of commodities. The total hectares for land acquired were divided by the number of products grown. This provided me with the number of hectares for each crop. I added the hectares for each product to find the total number of hectares that each product was grown on. The products were then grouped into "food", "flexible" "fodder" and "other". The next classification was based on the crop type "cereal", "oil crop", "sugar crop" etc. (categorisation index can be seen in Appendix: Table 13 and 14 and a full example of one classification is in Appendix: Figure 10). I looked at all the crops that were mentioned in the database as being produced by land acquisitions. I analysed the crops being grown to see which crop or groups of crop are grown on the greatest area of land. This indicates the most popular crops grown on land acquisition in Africa.

The information in the database was limited to the total number of hectares acquired and a list of products grown. In order to calculate the number of hectares for each crop I made some assumptions in my study. The database does not provide details of production area of each crop. Instead it lists the size of the land acquisition and crops for production. I calculated the number of hectares (ha) allocated to each crop assuming that all land acquired was used for harvesting. Each commodity listed for production was divided equally by the number of ha of land acquired in each case. This provided the number ha for each crop. However this is likely to be a slight overestimate in general as a proportion of the land acquired may be used for agricultural infrastructure. The assumption that the total area of land acquired was used for harvesting overestimates the area that crops are grown on. Additionally, I assumed that the land acquired for multiple crops is divided equally between all crops grown. This creates an underestimate in hectares for bulk commodities which are most likely to be grown on a larger portion of the farm.

There was no information on what the products were used for, and some classification decisions were at my discretion for example whether to include "sunflower" as a seed or an oil crop. In these instances I opted to include the crop in the broader definition, for example, choosing to list sunflower as an oil crop. The full list of assumptions for the GRAIN database is in Appendix Table 12. The term flexible crop was used to highlight which crops were being produced that have a variety of significant uses. This does not mean that the products will not be used for food, but refers to the fact they can be used interchangeably for food, fuel or other materials depending on demand. The flexible crops have been identified in this study as those which are most commonly and easily used for different purposes (sugar crop, oil crop and maize).

Origins of the investment

Each land acquisition in the database has a country where the investor is "based". I have used this information to help me to draw conclusions in my discussion about the global patterns emerging. This information may give additional insight into the uses of a crop.

I have added together the area of production for each major crop and attributed them to the base country of origin. I have plotted this to identify which countries are the largest actors in land acquisitions for which crop. I have compared the actors investing in different crops.

Potential production quantity for cereals

After looking at the range of crops produced by land acquisitions, I now focus on cereal production to quantify *potential production quantity*. I focus on cereals as they are the most important source of food in the world (Kearney, 2010).

I calculated how many tonnes of cereals could be produced with land acquisitions. I used a simple uncertainty analysis by calculating *potential yield*s at two intervals, 50% and 95% of *potential yield*, which reflect an average and very good crop yield respectively (Moffat, 1982) (Table 4) and the hectares of land acquired in each country for each crop (ha). The calculation was specific to country and crop. For example 3,000 ha were acquired for rice production in both Mali and Sierra Leone. However Mali has a *potential yield* of 3 t/ha for rice whereas Sierra Leone has a *potential yield* of 8 t/ha. Therefore the *potential production quantity* for these acquisitions differs so Mali could produce 90,000 t, whereas Sierra Leone will produce 240,000 t.

I calculated the total *potential production quantity* for each crop. This figure quantifies the cereal production that can be produced on areas acquired by foreign investors for food production. This is not an additional amount to food that is already produced, because many of the farms may have previously produced a proportion of the crops that is calculated in the *potential production quantity*. To find the significance of this *potential production quantity* with respect to observed African production I calculated the *potential production quantity* as a percentage of both total African production quantity and as a total production quantity based on the country the acquisition was made by, for each crop in 2010 sourced from FAOSTAT database; Resources; Land; Arable land (2012).

4.1.3 Research Question 3: Are land acquisitions making best use of land to contribute for food security?

I have chosen to calculate the calorie yield (kcal/ha) for 5 cereal crops (barley, maize, rice, sorghum and wheat) grown in Africa. I chose this measurement, as opposed to the traditional measure of yield (t/ha), as it provides a better assessment, for food, than t/ha which does not represent what can be consumed nor the benefit of consumption. For example the measure of t/ha includes the parts of the crop that cannot be consumed which in the case of maize 20% of this is lost when shelled (Murphy, 1993).

Table 4 Terminology, definitions and sources for agricultural calculations

Term	Definition	Components	Source
Potential land available	Land suitable for expansion of crops	Grassland/woodland or forest land ecosystems that can achieve 60% maximum yield for rain-fed agriculture, that is not protected nor being used for crop production (Deininger et al., 2011 pp. 93)	Author's calculations from Fischer and Shah, 2010
Observed yield	Harvested production per unit of harvested area for crop products (t/ha)	Using figures for the year 2010	FAOSTAT (2012) Production; Crops; Yield
Potential Yield	The mean agro-climatically attainable yield for (High input level) Rain-fed (2050s) using H3B2 Climate Model for each crop in each country (t/ha)	High input refers to advanced management market oriented farming techniques. Typical of those land acquisitions would use.	Global Agro-ecological Zones (GAEZ v3.0) (IIASA and FAO, 2012)
		Potential yield assumes only rain-fed production	
		This has been calculated for the year 2050 taking into account climate change predictions, using the climate scenario H3B2	
Potential Production Quantity	The amount of crop produced	=Potential yield (t/ha) * land acquisition (ha)	Author's calculation
Calorie Quantity	The amount of calories per tonne of crop (kcal/t)	calories total/ production total	Author's calculations based on (Conte, 2009)
Potential calorie yield	The amount of calories per ha of land	Kcal/ha =potential yield (t/ha) x Calorie quantity (kcal/t)	Author's calculations

I calculated the potential calorie yield for each crop in each country using the calculation listed in Table 4. I made a simplistic calculation of kcal/t based on Conte (2009) result for production total and calories total (Table 5). Conte (2009) used the "production total" from FAOSTAT, to calculate the "calories total" based on USDA Nutrient Database. From this I have calculated an estimate of the value kcal/t for each crop. I used kcal/t as a constant for each crop and multiplied it with the potential yield for each crop in each country. In this calculation potential yield needed to multiply by a correction factor for the weight lost for maize and sorghum when removing the non edible parts (Table 6) (Murphy, 1993). I have assumed 100% of other cereals can be eaten.

The potential calorie yield indicates optimal planting areas for each cereal crop in Africa. From this I can highlight what I have identified as the inter-crop yield gap . The inter-crop yield gap refer to the gap in production (whether kcal or t output) between growing different crops. Inter-crop yield refers to the gain or loss in productivity made by planting crops which are suitable for the region. For example if X crop has a calorie yield of 10 million kcal/ha, and Y crop calorie yield of 5 million kcal/ ha then by choosing Y crop you are not maximising productivity of the land. This information is then used to compare what crops land acquisitions are producing in within these areas.

Table 5 Back calculation for calculating kcal/t "Production Total" and "Calories Total" from Conte (2009)

kcal/t = calories total/ production total			
Staple Crop	Production Total (metric tonnes)	Calories Total (total billion kcal)	Calorie (kcal/t)
Barley	157,644,721	557500	3536433
Maize, shelled corn	822,712,527	2974000	3614871
Rice	685,013,374	2356000	3439349
Sorghum, grain	65,534,273	237600	3625584
Wheat	689,945,712	2421000	3508972

Table 6 Correction factor from harvested yield to what can be consumed (Murphy, 1993)

Correction factor	
Maize, shelled	**0.8**
Sorghum, grain	**0.9**

4.2 Research boundaries, assumptions and limitations

4.2.1 Global food system and availability

"Even if we solve ... food access challenges, much more crop production will probably be needed to guarantee future food security." **(Foley et al., 2011)**

I have chosen to focus on one aspect of food insecurity, "the challenge of ensuring sufficient availability of food globally". I focused on the issue of availability primarily through demand and supply of food crops. The assumption is that the higher demand needs to be met with a higher supply, if this is not the case then there is food insecurity.

There are limitations associated with this choice as it has long been understood that availability and production are not the primary driver of food insecurity (Devereux, 2009). Food security is more recently categorised by having sufficient availability, access and utilisation (Table 1) (Wu et al., 2011). Each of these is dependent on the others. If one is missing there will be food insecurity. If, for example, there was an abundance of grain, and the facilities in a community to grind and make bread with it, but there was no means of transporting the grain, access would be missing and there would be food insecurity. Similarly, if there are no means of turning raw ingredients into edible food then an abundance of crops and transport will mean nothing; there will still be food insecurity. Recent articles have inferred however that availability is the most essential factor, and a scarcity in crops undermines access which in turn undermines utilisation. This understanding from papers has visualised in Figure 2 illustrating that availability of crops is the primary challenge facing humanity (Bruinsma, 2009; Godfray et al., 2010; Foley et al., 2011).

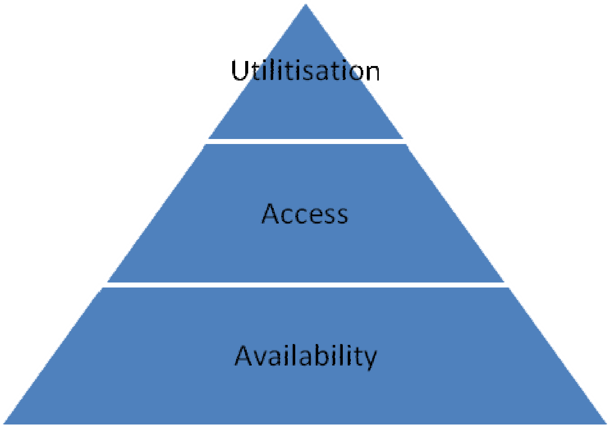

Figure 2 Visualisation of Food Security. Availability undermines access and access undermines utilisation. Created by the author from understanding in current literature

5. Results

5.1 What is, and where is, the potential for rain-fed agriculture in Africa?

5.1.1 Available arable land

There are at least 365,162,000 ha of land suitable for expansion of crop production in Africa (Table 7) namely unprotected forest land and grassland/ woodlands that are not currently being used for cultivation.

If land is potentially available for production of more than one crop the land is counted twice, for example it is possible that the area suitable for maize is also counted as suitable for soybean. Therefore the total amount of additional land is not a sum of the potential in this table as the figures in places will assume potential growth on the same land.

Twelve per cent of total land in Africa is *potential land available* for the production of soybean and 11 per cent for maize, which makes these two the most suitable crops in Africa. To put this into context, there is an area larger than the whole land area of India, which is not currently being cultivated, but is suitable to grow maize and soybean. The area of *potential land available* for oil palm amounts to the area of Venezuela and wheat which, although not as suited to African climates as the other crops, has a potential planting area equivalent to an area larger than Finland's land area.

The most *potential land available* is in Eastern and Central Africa. Twenty three percent of land is potentially available for maize production in Eastern Africa or soybean production in Central Africa (Table 7). There is very little potential available land in Southern and Northern Africa.

Table 7 Potential land available in Africa. Potential land available in unprotected grassland/ woodland and forest land ecosystems for rain-fed production. The figures have been calculated by the Author based on Fischer and Shah (2010). This table shows the area, in ha and as a percentage of total land area, in each region of Africa which is suitable for each crop. Table has been colour coded to match regions in Figure 1

Region	Total Land (1000 ha)	Potential land availability in unprotected grassland/woodland and forest land ecosystems for rain-fed production of different crops -Area 1000 ha (%)			
		Maize	Oil Palm	Soybean	Wheat
Eastern Africa	842,692	197,585 (23)	587 (<1)	167,855 (20)	24,347 (3)
Central Africa	649,682	67,347 (10)	84,260 (13)	150,701 (23)	1,917 (<1)
Western Africa	605,682	49,028 (8)	5,110 (1)	37,241 (6)	4 (<1)
Southern Africa	265,205	6,301 (2)	0	9,365 (4)	3,635 (1)
Northern Africa	600,439	0	0	0	2,786 (<1)
Africa Total	**2,963,700**	**320,261 (11)**	**89,957 (3)**	**365,162 (12)**	**32,689 (1)**

If this land was converted into arable land it would contribute significantly to the world total arable land for all crops. Arable land in Africa is 224 million ha and currently accounts for 16% of the world total of arable land (Figure 3). However if soybean was produced on all suitable land in Africa, this would more than double the arable land in Africa. If put into production the *potential land available* for soybean would amount to a 26% increase in the world's total arable land for all crops (Figure 3). There is a large possibility of increasing arable land in Africa as if the potential land for wheat only, which is 10% that of maize was brought into production that would be an increase of 15% on the current arable land in Africa.

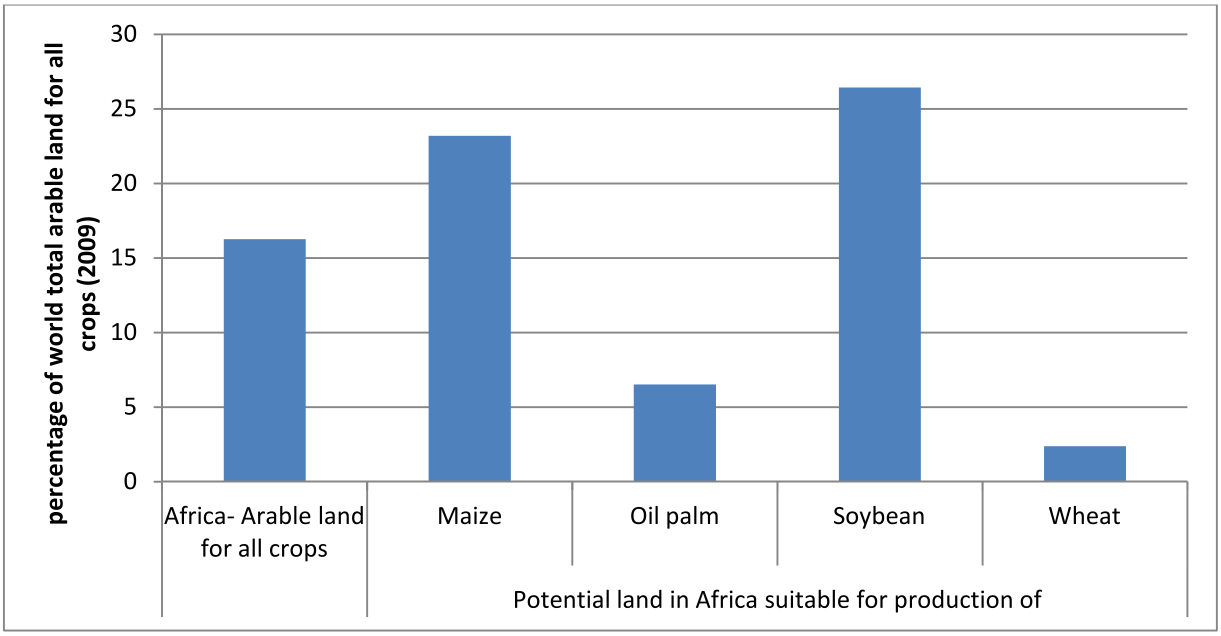

Figure 3 Potential available land in Africa compared to the current arable land and as a percentage of world total. Arable land figures are for 2009 and have been taken from FAOSTAT (2012). Potential land area in Africa suitable for production may refer to the same areas of land and therefore are not cumulative.

5.1.2. Increasing crop yields

I have plotted *potential yield* against *observed yield* for four major crops in Africa (Figure 4) to investigate the margin by which crop yields can be increased. Data points below the 100% yield line indicate a low yield ratio, as the potential is much higher than is actually being achieved. On the other hand, points above this line indicate what is actually being achieved is greater than the potential. This figure tells two stories, firstly that observed crop yields are generally very low across Africa and secondly that the limitations on future potential yields will cause a large drop in yields in some areas.

A great number of the yield ratios for these four crops in Africa are very low. With further analysis I can ascertain that most of the data points show low yields. Only 8% of countries achieve at least 50% of *potential yield* for soybean, and this situation is similar for all crops, with 11% of countries achieving at least 50% for maize, 25% for rice and 29% for wheat. The grouping of data points close to the X axis shows that many observed yields are close to zero despite the *potential yield* being higher than this. The largest potential for increase in production comes from maize and then rice as this is where there are the highest potential values but lowest observed values.

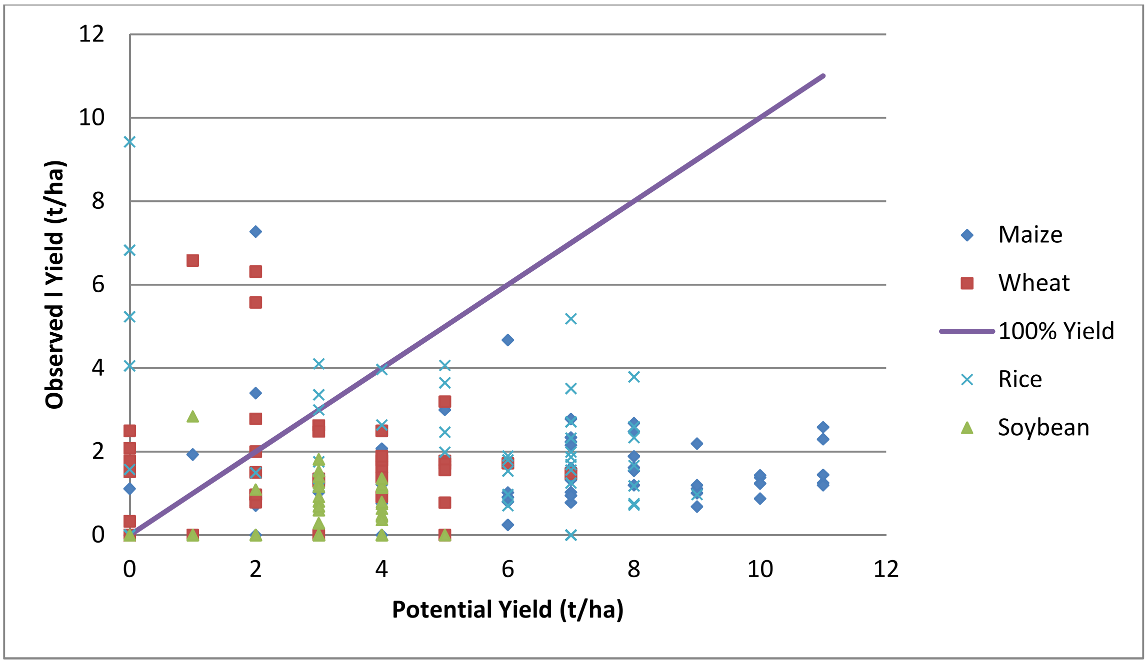

Figure 4 A scatterplot to show potential yield vs observed yield. The 100% yield indicates where observed yield and potential yield are equal. The data points below this line indicate cases where yield gap is high. Observed yield is sourced from FAOSTAT figures for yield 2010. Potential yield is from GAEZ (Table 4) (IIASA and FAO, 2012)

The second story evident is the number of cases where the *observed yield* actually exceeds that of the *potential yield* (Figure 4), this was less expected. This can occur because the *potential yield* has been limited to rain-fed agriculture in 2050, whereas the observed production is taken from the 2010 production figures, which include irrigation.

For all four crops there has been a case where there is a greater *observed yield* than *potential yield*; however this occurrence is most noteworthy for wheat and rice[5]. A greater proportion of data points for wheat occur above 100% yield. Rice has five cases where there is an *observed yield* whilst the *potential yield* is zero. Regionally this phenomenon occurs mainly in North Africa, and to a lower degree in Southern Africa, where observed yields most often outperform the potential yield. North Africa, despite having very low potential yields, has some of the highest crop yields throughout Africa. The three African countries with the highest *observed yield* for rice[6] are shown to have zero yields in 2050 under rain-fed condition. The highest observed yields for rice occur in Egypt and Morocco where potential yields are zero. Egypt and Algeria have the first and third highest observed yields for maize. The highest observed value for wheat occurs in Namibia which is over 6 times that of its potential.

[5] This occurs only 3 times for maize, in Algeria, Egypt and Libya and once for soybean in Egypt
[6] Egypt, Morroco and Mauritania in that order

What these two findings tell us is that there are many countries with high yield gaps, which represents a possibility for substantially increasing production output. However on the other hand there are a few highly productive countries, mainly in North and Southern Africa that will potentially lose the majority, if not all of the crop producing capacity if they move to producing using rain-fed agriculture in 2050.

5.2 Are the crops that are being produced those which will attribute to global food security?

5.2.1 Crops grown

Of the land acquired for production for food, only 42% is allocated to grow crops that are solely used as a food source, with 53% of the land growing flexible crops, which leaves 5% of the land growing non food products[7] (Figure 5). For a full list of classification of food, flexible and other crops please see the appendix Table 13 & 14.

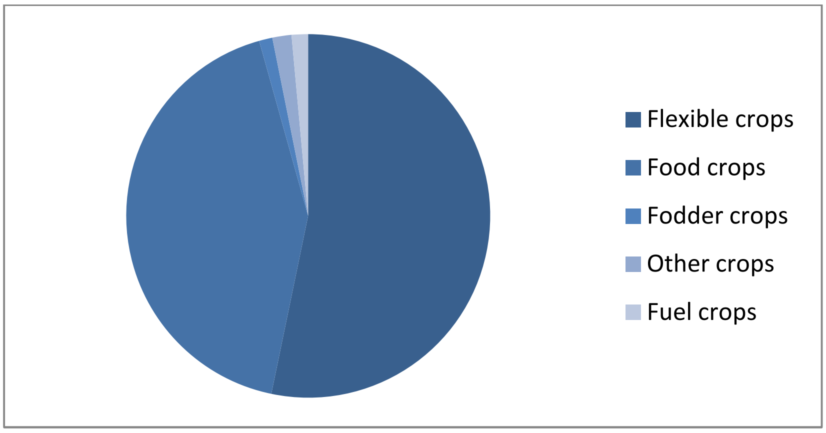

Figure 5 Division of land acquired for food production by use (flexible [53%], food [42%], fodder [2%], fuel [1%] and other [2%]). Other refers to fibre and horticulture.

Over half of the area acquired in Africa is being used to grow cereal and oil crops. Cereal and oil crops have the largest area of land for production. Twenty six percent of land in Africa is being used to grow cereals, and 25% for oil crops. Land acquired for palm oil is almost as large as land acquired for all oil crops making oil palm by far the biggest oil crop and even the single biggest commodity[8]. Oil palm is produced on over 2 million ha of land, 17% of the total land acquired in Africa (Figure 6). The land area acquired for growing oil palm in Africa is equivalent to the land area of Israel. Wheat has the second most land allocated for production and is most popular out of all the cereal followed by rice and then maize. There are 9 percentage units less land dedicated to wheat production than

[7] Non food products refers to; bio-fuels, fodder, cotton and flowers. The non food products are as a result of multiple items have been grown on some farms
[8] In terms of amount of ha of land

there is for oil palm. Production of other cereals such as barley, sorghum, teff and unspecified cereals is minor. Sugar cane is also a crop of significant production; it is being produced on 700,000 ha of land which is 5% of the total land acquired. The remaining half of land acquired produces a variety of crops on smaller portions of land for example nuts, seeds and herbs.

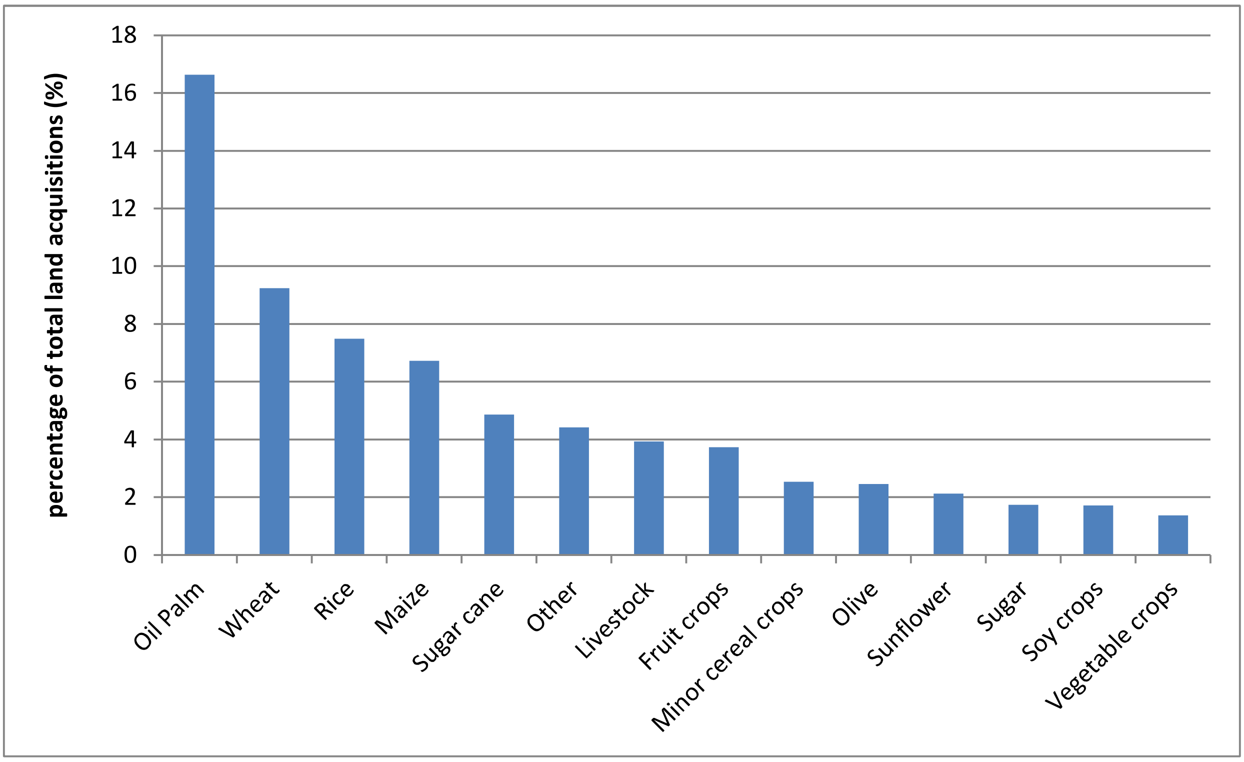

Figure 6 Percentage area of land allocated to each crop in African land acquisitions from the GRAIN database. Some smaller crops have been grouped for example vegetables, whereas crops which are significant on their own such as oil palm have been separated. "Other" refers to crops which make up <1% such as herbs, minor oil crops. Full list of classification in Appendix; Table 15.

5.2.2 Origins of the investment

The majority of countries producing cereals and oil palm are Asian and Gulf States and to a lower degree European nations and the USA. The countries of investment origin for cereals are different from oil palm. Egypt and South Korea make up 57% of hectares acquired to grow cereal, and additional investments from UK, India, Saudi Arabia and USA account for 33% (Appendix Figure 11). Alternative 70% of land for oil palm is acquired through the three Asian countries Malaysia, Singapore and India, with an additional 10% from the UK (Appendix Figure 12). Land acquisitions with investors based in Egypt grow more cereal than any other country, which acquires nearly 1,200,000 ha for production of cereals.

The origin of investment for cereal production is concentrated to a few countries. There are 63 individual land acquisitions which produce any cereal crop and these come from 20 different countries. This means that the same 20 countries repeatedly act as bases for companies investing in land for cereal. In comparison land acquisitions for the production of oil palm were few but generally much larger. There were 31 land acquisitions for the production of oil palm from 15 different base countries and in the majority of cases oil palm was the only crop being produced.

5.2.3 Production quantity for cereals

Africa could potentially produce 9-18 million tonnes of cereal, which is 7-14% of the current production quantity of Africa (Table 8). The largest production quantity total is from maize and rice. However the production of maize is not as large a proportion of existing African production as rice and wheat. Maize production at 95% yield is 10% of what Africa produced in 2010, however the smaller production quantity of rice, is 26% of rice produced in Africa. The production of barley and sorghum by land acquisitions is minimal, both in terms of total production and as a percentage of what Africa produced. The total production of the cereals is not an addition to food that is already produced, because many of the farms may have previously produced a proportion of the crops.

Table 8 Quantity of cereal crop produced on land acquisitions (tonnes) assuming 50% and 95% of potential yield. This table shows the *potential production quantity* as a percentage of African production for the same crops in 2010.

Crop	Potential Production Quantity from Land Acquisitions		Potential Production Quantity as Percentage of African Production Quantity 2010	
	95% yield	50% yield	95% yield	50% yield
Maize	6,192,794	3,259,365	9.6	5.1
Rice	6,088,385	3,204,413	26.6	14
Wheat	5,684,551	2,991,869	25.8	13.6
Sorghum	379,096	199,524	1.8	1
Barley	14,169	7,457	0.2	0.1
Total	**18,358,995**	**9,662,629**	**13.5**	**7.1**

5.3 Are land acquisitions making best use of land to contribute to food security?

5.3.1 Inter-crop yields

There is a wide variety of *potential calorie yield*s between crops and countries in Africa. Calorie output can be as much as 11 times more or less depending on which in country land is acquired[9]. Alternatively depending on which crop is grown, the calorie yield per hectare could be seven times different[10] (Figure 7: for full numbers see Table 16).

[9] In Libya 3 million kcal/ha for maize production where Tanzania is 33 million kcal/ha
[10] If Botswana produced sorghum (22 million kcal/ha) and not barley (3 million kcal/ ha)

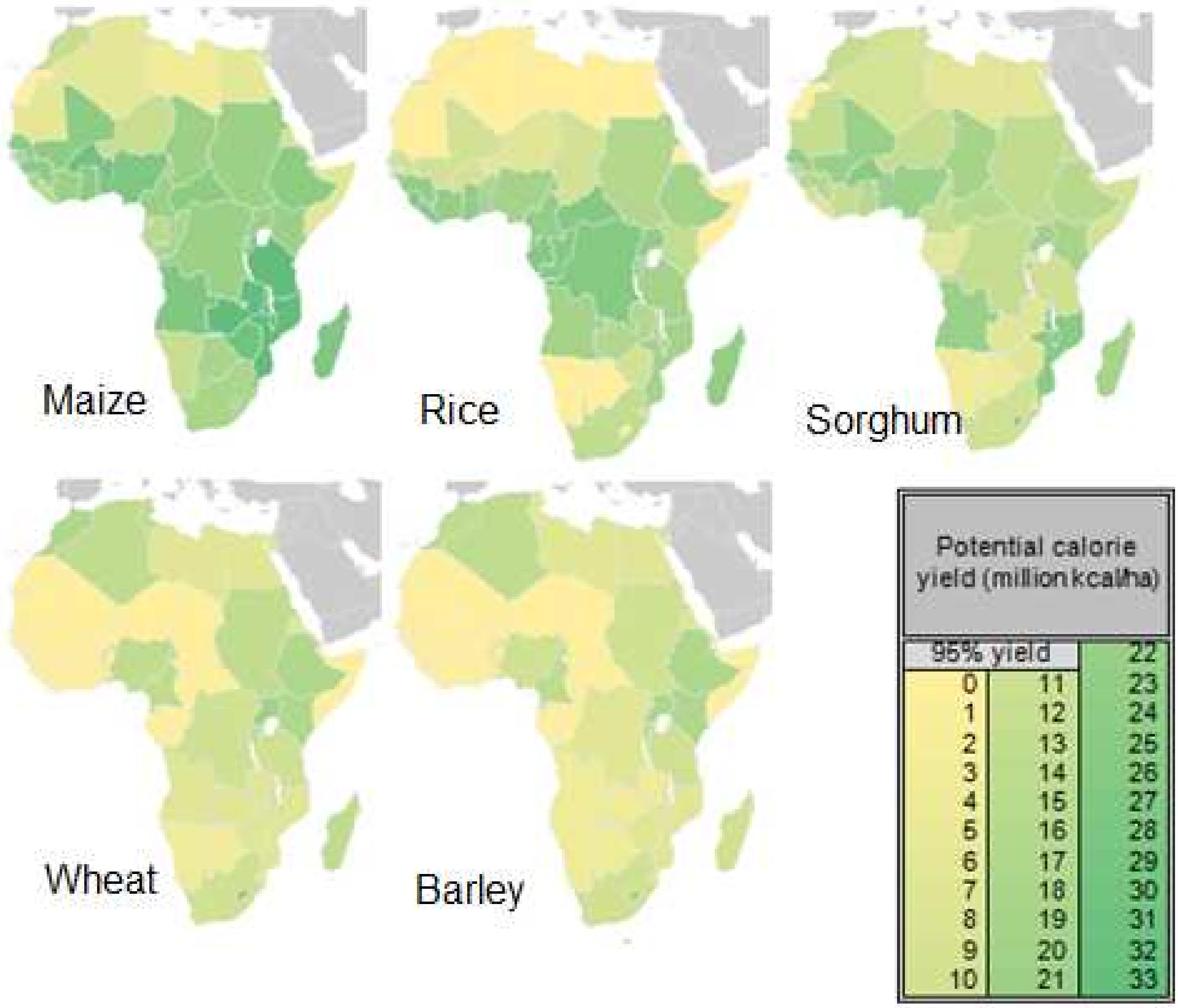

Figure 7 A spatial representation of potential calorie yield over Africa for 5 cereal crops; barley, maize, rice, sorghum and wheat. The darker green means higher return of kcal/ ha

Maize, sorghum and rice have the potential to produce the highest return of kcal/ha (Figure 7). Within a region there are significant differences in average kcal output depending on which crop is produced and there is potential to double or triple output by producing maize and sorghum instead of rice or wheat (Table 9). The highest calorie yield is for maize in Western and Eastern Africa and rice in Central Africa (Table 9). The majority of countries in Western and Central Africa have zero potential calories yields for barley and wheat (Appendix; Table 16).

Potential calorie yield shows Eastern Africa, closely followed by Western Africa, to be the most productive region over all crops (Figure 9). North Africa is the least productive region with the most productive crop being 20 million kcal/ha less than the most productive crop in the other regions. In addition, although maize, sorghum and rice are by and large the most productive crops overall in Africa, barley and wheat are the most productive crops in Northern Africa (Figure 7).

Table 9 Average potential calorie yields (million kcal/ha) across region. This shows the most productive crop for each region and the most productive region. This table is a summary of Table 16 in appendix

	Average potential calorie yield (million kcal/ha) by region)				
	Barley	Maize	Rice	Sorghum	Wheat
Northern Africa	9	6	0	7	9
Western Africa	1	23	17	17	1
Central Africa	3	19	23	11	4
Eastern Africa	10	23	16	17	11
Southern Africa	9	19	5	18	9

My calculations indicate that an average of 23 million kcal can potentially be produced from one hectare of maize grown in East Africa, however this figure can be up to 33 million kcal in some countries. The average world diet consumes 1,289kcal of cereal per person per day (FAOSTAT, 2012). Therefore 1 ha of land used to grow maize in Malawi, Mozambique, Tanzania or Zambia can produce enough to provide up to 70 people with their cereal intake for a year[11].

5.3.2 Land acquisitions and inter crop yields

The land acquisitions in Africa do not match the optimal planting model (Figure 7). The largest area of land, over 1 million ha, has been acquired to grow wheat in Eastern Africa (Table 10). There are 30% more hectares acquired to grow wheat in Eastern Africa than any other crop in another region. Wheat has the second lowest *potential calorie yield* in Eastern Africa with a *potential calorie yield* less than half of Maize (Table 9). The largest acquisitions of land for rice production are in Western and Eastern Africa despite Central Africa having an average *potential calorie yield* of 6 million kcal/ ha larger. Sorghum despite being a high calorie yielding crop throughout Africa is only produced in minimum amounts in Eastern Africa.

Table 10 Area of land acquired for each crop by region. This table is a summary of Table 17 in appendix

	Hectares dedicated to each cereal				
	Barley	Maize	Rice	Sorghum	Wheat
Northern Africa	0	5,000	0	0	36,250
Western Africa	0	96,541	657,900	0	0
Central Africa	0	3,333	93,167	0	0
Eastern Africa	4,971	844,265	308,869	33,841	1,276,104
Southern Africa	0	7,133	2,500	0	2,500

[11] 1289 kcal per day is the global average intake of cereal is 470485 kcal per year which sums up to 70.14 people.

The largest number of hectares for one country has been acquired to grow wheat in Sudan (Appendix; Table 17). However, using that land for maize or sorghum would produce 40% more kcal. Another example is that if the rice farms in Nigeria grew maize instead of rice then the same area of land could produce an extra 2408 billion kcal (if achieving 95% yield). For these land acquisitions, there is a loss of 20% kcal by not selecting the most optimal crops within countries. The 15 million more kcal that could be produced with optimal planting is equivalent of just over the cereal intake for a year of 32 million people. This could largely be made by switching from growing rice in Eastern and Western Africa to producing maize or sorghum.

The same area of land could be producing higher output of calories if land was acquired in the countries with the highest potential. The same area of land producing wheat in Namibia could be producing 7 times the number of kcal if land was acquired in Lesotho. This is true for other cases; rice production in Guinea-Bissau could have an output of 2.3 times than in Gambia where it has been acquired, and even more if production of rice was to move to Central or Eastern Africa.

6. Discussion

6.1 What is, and where is, the potential for rain-fed agriculture in Africa?

My results show the ability for the majority of crop yields to increase by 50% and agricultural land to expand by at least 26%. This discussion will draw attention to other factors that will impact upon these findings.

6.1.1 Available arable land

The results confirm the claim that Africa has large areas of land for arable expansion. The potential area for expansion of soybean or maize alone is larger than the arable land that currently exists in Africa. However, the land which is considered suitable for crop expansion may not be available in reality. Assessments of land suitability are based on statistics and satellite images which are ignorant of changes in land degradation. Additionally such imagery ignores customary community claims on the land, which may mean that despite not being currently cultivated, it is often in rotation and in use (Cotula and Vermeulen, 2011). Land has not been considered potential available land if it is not protected or currently being cultivated, however a better definition for unused land should go beyond this. It should look at the multiple functions, goods and services of the land (Backhaus et al., 2012).

The classification in Section 5.1.1 of land as available does not take into account the supporting, regulating and provisioning ecosystem services of the land, including aesthetic, spiritual, historical, recreational or scientific use (de Groot, 2002). This categorisation says nothing of the people who already use and have access to the land (Backhaus et al., 2012). Sir Gordon Conway, chair of The Montpellier Panel report, stated that much of the land that is being claimed as unused already has people who claim ownership to it, and the notion that there is empty land, other than the land of the rainforests, is untrue (Rowlatt, 2012).

6.1.2 Increasing crop yields

Yields for maize, wheat, rice and soybean, are considerably low as 65% of cases achieve less than 50% potential yield. This statistic is, however, an underestimate of how poor yields are in Africa, as many of the cases achieving above 50% yields are a result of the limitations of potential yield in this study. Values for potential yield are constrained to rain-fed agriculture to provide a suitable solution for agriculture which is facing increased water scarcity in the future. Potential yield calculations also factor in climate change effects on agriculture in 2050. This is predicted to reduce yields and the amount of suitable arable land. These two potential yield-limiting factors mean that the *observed yield*, which do not face or overcome these constraints, can be seen to be performing better than if they were compared to - current potential yields, achievable under the same conditions.

The benefit of calculating *observed yield*s as a percentage of potential yields (with the constraints of rain-fed agriculture and climate change), is that the results reiterate the challenges facing agriculture. The three African countries with the highest *observed yield* for rice[12] are shown to have zero yields in 2050 under rain-fed conditions. This raises the question: does the benefit of irrigation, in order to produce high crop yields in these areas, and so increasing availability, outweigh the consequences of water scarcity?

If irrigation is attractive, then foreign investment through land acquisitions may provide the capital to provide irrigation. Considering the negative effects of climate change on agriculture, which threatens to reduce production potential in Africa, and reducing the availability of food, do land acquisitions represent a solution for climate adaptation? As with the question of yield gap, the answer lies in the potential. Land acquisitions provide knowledge and infrastructure, the ability to weather market fluctuations, take risks and innovate (Collier, 2008), thus representing a potential for climate adaptation solutions which increases production and food availability.

[12] Egypt, Morroco and Mauritania in that order

However, without the input from land acquisitions, millions of small farmers in western Sahel have adopted their own climate change adaptation technique. A system entitled “farmer managed natural regeneration” protects crops from the heat and droughts associated with climate change, and allow farmers to increase the area of agricultural land by rehabilitating degraded land (Hertsgaard, 2012). Therefore foreign investment and land acquisitions are not the only means for innovation adaptation and improvements in agriculture productivity.

There are consequences for closing crop yields that must be considered. The predictions for future agriculture as shown in Section 5.1.1 do not take into account degradation from continued use of the land. The high input farming that is required to achieve the highest yields will degrade the soils and pollute water supply. Reaching high yields in the short term could undermine productiveness in the long-term (World Bank, 2009). Therefore, long-term production needs to focus more on sustainable agriculture and sustainable yields and not on achieving unnaturally high yields.

The use of potential yield and yield gap itself provides an unrealistic assessment of land productivity. The potential crop yield of the land is not a real figure which has been attained by a farm, but an estimate of the production capacity of a given location. The potential crop yield assumes perfect conditions in every aspect, other than solar radiation, air temperature, and rainfall in rain-fed systems which are specific to the location. Uncertainty of yield potential is high when working on the scale of global agriculture, because the coarse grid used in calculations generalises and blurs spatial variations on the ground (Lobell et al., 2009). Often, potential yield is calculated mathematically, assuming that all conditions (other than the location specific conditions mentioned above) are perfect, and with an understanding of plant physiology to find out the maximum net primary productivity (Lobell et al., 2009). Best in practice is usually impossible to ever achieve potential yield because it is also impossible to achieve perfection in nutrient level, management, seed population and protection against diseases and pests. It is also neither practical nor advantageous to attempt to do so (Lobell et al., 2009).

The concept of yield and yield gap is biased towards large-scale commercial farming. When production is calculated as output per area for a specific crop, there is a predisposition in favour of highly technological, high input farms which strive for the highest output on the smallest area of land. Despite multi-cropping[13] farming being considered to be agriculturally preferable (Tilman et al., 2002), these techniques will not be considered preferable when looking at yield data, as they produce less of each crop on a specific area and therefore the yield is lower (Licker et al., 2010). In

[13] Growing more than one crop on the same land

addition, other beneficial techniques like adopting buffers to help with soil erosion and borders for pest control are seen to produce a lower yield as that area of land is not producing crops.

6.1.3 Barriers for land acquisitions

Land acquisitions have been posed as a solution to many of the existing agricultural constraints (as mentioned in Section 2.3), for example nutrient poor soils and lack of infrastructure (Deininger et al., 2011). However this section will now discuss the constraints which stop land acquisitions from achieving the potential laid out above.

Limited fuel

The limited availability of fossil fuels and the subsequent increase in price will have a negative effect for land acquisitions achieving the high yields set out in the results. Land acquisitions are an example of modern agriculture which is reliant on fossil fuels. Modern mechanised agriculture input over three times more energy to achieve the same energy output in grain (Harding and Peduzz, 2012). This is through use of fossil fuels in synthesising fertilisers, planting and harvesting and transportation.

Economic incentives

For land acquisitions to achieve large output in food production there needs to be an economic incentive in place. A law of diminishing return reasons that it at some point the input will be larger than the subsequent output, for example it is relatively inexpensive and easy to reach 50% yield, but to reach every extra 10% becomes disproportionately costly. Adding twice the amount of fertiliser or pesticide, or doubling your workforce will not double the yield, and the cost of this method becomes untenable near the higher percentages.

Farms will produce high yields and expand agriculture because of the money they receive for selling the produce. If there is no demand for such produce on the global market or if there is not adequate access to markets to sell the produce, farms will not strive to produce large outputs. Furthermore the investment required in Africa to achieve this growth will only surface if there is sufficient reward for doing so. Increasing supply to match demand will cause low global food prices, which is not beneficial for farmers (Collier, 2008) and therefore unlikely to happen unless there are sufficient policies in place that provide additional incentives.

Political

The controversial nature of land acquisition makes them vulnerable to political changes and civil disorder. Africa in general has been a region which has for a long time seen political insecurity (Kieh, 2009). If governments change, then the foreign ownerships of land acquisitions are vulnerable to land expropriation (Rowlatt, 2012). The World Bank does provide financial insurance to investors for losses made from political unrest (Rowlatt, 2012), however this does not secure a steady food supply. The vulnerability of land acquisition to political changes means that they are not a stable solution to long-term global food security and are not legitimised if people are opposed to them.

6.2 Are the crops that are being produced those which will attribute to global food security?

6.2.1 Crops growns

My findings show that cereal and oil crops are the most popular crops produced by land acquisitions. Sorted by production size, these are followed by sugar crops, livestock, fruit and then vegetables. Out of these crop groups, oil crops, sugar crops and maize have been identified as flexible crops. Although many crops have different uses (Appendix Table 18), flexible crops are identified as more commonly used for purposes other than food. Many of the crops are processed and different components are used for different purposes (Singh, 2010).The total of these flexible crops amounts to 53% of the land acquired.

Cereals

The results of this paper show that land acquisitions in Africa could potentially produce 9-18 million tonnes of cereal, which is 7-14% of the current production quantity of Africa. The highest estimate only amounts for 1.8% of the one billion tonnes of cereal needed to meet demand in 2050 (Bruinsma, 2009). However, if all the land acquired in Africa were used to produce cereal, this figure would be approximately four times larger with a top estimate of 72 million tonnes.

Cereals make up the approximately half of the average global diet (FAOSTAT, 2012) and are considered the primary source of food. This study identifies that they are produced on 26% of the acquired land in this study. However, oil crops, despite accounting for less than 2% of the global average diet, are produced on 25%.

Oil crops and oil palm

Land acquisitions in Africa have assigned 3.5 million ha of land to oil crops. Oil crops are a source of energy for diets, providing a healthy alternative to animal fats (Cahoon et al., 2010). It is predicted that by 2050 demand for edible oil will be twice what it is today (Corley, 2009). The increased consumption of oil crops has helped increase food security in developing countries[14] by increasing the availability of food kcal per capita per day. Edible oils provide a low cost food to help populations reach their recommended fat requirements (Rae, 1992). The significance of edible oils in developing countries is predicted to increase (Kearney, 2010).

Oil palm is the highest produced crop on acquired land in Africa. Oil palm is grown on 17% of all land acquired. This amounts to 1 million more ha dedicated to oil palm than the second most popular crop; wheat. In 2007, one quarter of oil palm produced was being diverted to non food products, mainly bio-fuel (Murphy, 2012). The diversion of edible crops for bio-fuels is being encouraged by government policies, particularly in Europe, which aim to increase bio-fuel use and reduce green house gases. This diversion increases prices of food, by increasing competition for the diverted resource, and by diverting arable land towards that crop. In the USA, the push for maize as bio-fuel caused civil disorder in Mexico as it increased maize price. The allocation of more land to maize also limited the production of soy, wheat and barley, increasing the prices of those crops (Eggleston et al., 2010). The diversion of edible oil crops is predicted to increase prices by 18-44% (Murphy, 2012). The increase in price is problematic for populations in poorer countries as it reduces access to food.

6.2.2 Origins of the investments

The countries of origin for cereal crops and oil palm are both somewhat focused. The base countries for cereal and oil palm investment saw 30% overlap of between the two products. Many cases showed one country acting as a base for multiple investments for either cereals or oil palm. Therefore despite the fact that investments are not so clearly attached to a country due to market globalisation, I do believe the origin of the investment can be a basis to suggest that the actors who producing cereal and oil palm are different.

The investment into oil palm is very concentrated with 70% originating from three countries. Investments originating from Malaysia acquired the most land for production of oil palm despite Malaysia itself being one of the largest producer and exporters of oil palm in the world (Jayed et al., 2011). This is a sign that large agribusinesses in Malaysia are expanding oil palm production overseas rather than production for export back to home countries. The few concentrated countries that

[14] China, Brazil and India

invest in large amounts of oil palm production indicate that it is done so for large export onto the global market.

Egypt, Brazil and Malaysia appear in the list of base countries that acquire land in Africa for cereal or oil palm production, however they too are targets for land acquisitions. This pattern could represent these countries trying to acquire land elsewhere to compensate for the losses of their own land, or again large countries investing for production to the global market.

Contribution to global food security

A study of the crops produced by land acquisition in Africa[15] shows that the prevalence of a crop does not reflect the significance of each crop in global diets. The results show a large proportion of crops being produced are not those which contribute to global food security. The acquisition of land for oil crops and sugar crops and others do not contribute to food security as they are meeting demands of increased food consumption. Additionally the production of crops which do not contribute to food security reduces the area of land available for crops which do. The increased competition will increase prices on food crops. Nonetheless, 26% of land is dedicated to cereal production which could potentially produce 18 million tonnes of cereal[16]. However this figure is only a quarter of what could be produced if all land acquisitions focused on cereal production. The results have highlighted that three of the top five crops produced: oil palm, maize and sugar cane, are commonly used for non-human consumption as a bio-fuel. The choice of crop leads me to believe that attaining global food security is not a primary driver for the majority of land acquisitions. However the lack of staple food crops now does not mean there will not be a shift in the future which sees land acquisitions producing only cereal crops.

6.3. Are land acquisitions making best use of land to contribute for food security?

There is a large difference in potential calorie yields between countries and crops in Africa. Maize is the most productive crop in Eastern and Western Africa, followed by sorghum and rice. The location and type of cereal crop grown has a marked difference on the amount of calories that can potentially be produced. The results show that land acquisitions are not acquiring land in the areas, nor growing the cereal varieties, which provide the largest amount of calories per hectare (Table 9 & Table 10). The results show that despite potentially closing crop yields, land acquisitions leave inter-crop yield gaps [17].

[15] Only including those which produce edible crops
[16] Assuming 95% of potential yield
[17] I use inter crop yield to refer to the gain or loss in productivity made by planting crops which are suitable for the region.

6.3.1 Calorie yield and Inter-crop yield gap

Using *potential calorie* yield and *inter-crop yield* gap for my analysis allowed me to identify the crops most suitable in each region for increasing calorie availability. Calorie yield is useful for analysis or agriculture in relation to food security as it gives the results in energy for consumption and not tonnes. Tonnes are a practical measure for trade of crops, as purchases will be made by weight, however it is less relevant for food security. Whereas the *inter-crop yield* gap builds on the traditional yield gap which shows that there is not only a gap in production output for one crop, but also across crops. This analysis shows that achieving maximum output is not just dependant on how you grow a crop (fertilisers, irrigation, seed management), but which crop is chosen.

Despite the relevance of these concepts for analysing agriculture for food security, neither appeared within my literature search. Conte (2009) looked at kcal/ sq m for the global average yield to compare the crops globally, however this was the only source. That these two concepts are neglected for traditional yield and yield gap shows agriculture (and by extension land acquisitions) is still focused on profit and not food security. The adoption of agricultural indicators which focus more on purpose rather than price would help to focus the agricultural production towards a better end goal. The intention of this measure is not to suggest that all of Eastern Africa should be planted with maize, but to identify which crops are more suited to which regions so to reduce the inputs needed for each output of cereal.

6.3.2 "Mismanagement" of resources

By making sub-optimal choices regarding cereal type and location, land acquisitions are mismanaging agricultural resources. For example sorghum is neglected by land acquisitions despite being a staple crop for traditional farming. Sorghum out performs wheat on *potential calorie yield* in almost every country in Africa however; it is being produced on very small areas of land in comparison. Land acquisitions only contribute to 1% of sorghum production in Africa (Table 7) in comparison to wheat which is 26%. This indicates that land acquisitions are not focusing on producing food for local people in Africa but satisfying the demand for crops overseas. This notion is reaffirmed from looking at the origins of the investment for wheat in Sudan (Box 1).

The large areas of land acquired for production in Eastern Africa rather than Northern and Southern matches to the potential available land (Table 7). However Central Africa which has large areas of potential available land has not been targeted for production of cereal with Western Africa being favoured instead.

Box 1: Wheat production in Sudan

The largest area acquired for cereal production in Africa has been for wheat production in Sudan (incl. South Sudan). This is not the optimal crop for production in Sudan where wheat has the second lowest *potential calorie yield* ratio of all the cereals and therefore can be considered as above a ”mismanagement” of resources. To contribute for food security it would be more fruitful to produce maize, sorghum or rice on this land. This supports the claim that the choice to grow wheat is not based on achieving high calorie yields or even crop yields, but to satisfy the demand for export. The production of wheat in Sudan is a result of six land acquisitions, three with investors based in Egypt, and one based each in United Arab Emirates, Saudi Arabia and South Korea. These are countries with limited capacity for production and are water scarce (UNEP, 2008; Zoomers, 2011). All four nations are in the top 20 percent of highest wheat importing countries, with Egypt having the tenth largest import quantity in the world (Based on FAOSTAT: Trade:Import Quantity (2009)) (FAOSTAT, 2012). These cases represent a land acquisition phenomenon where richer nations acquire land in poor nations such as Sudan for consumption back home, or as it is alternatively known: offshore farming (Zoomers, 2011).

6.4.3 Food security or securing food supply

I have developed a table to group the countries that have acquired land in Africa to produce cereal (Table 11). The countries have been grouped based on the impact of increasing food prices (Figure 8) and the prevalence of undernourishment (Figure 9). I assume that a negative impact of increasing food prices is an indicator for an import dependent country. From this analysis four groups emerge.

Group 1 identifies countries which are both import dependent and food insecure. This group is considered by the FAO to have “moderately low” to “moderately high” undernourishment (Figure 8) and are considered “moderate” to “large losers” from the trade imbalances from 2007-2008 food price spike (Figure 9). This group is made up of Asian and Gulf States that predominantly produce crops for export to home markets (Mann and Smaller, 2010). The nations in group 1 are predominantly soil poor and water stressed and land acquisitions in Africa provide a means of assuring food security (GRAIN, 2008). This group contains countries which are themselves a target for land acquisitions[18]

[18] Egypt, South Africa, Philippines, Mauritius, and West Africa are themselves targets for land acquisitions

Table 11 Analytical analysis of countries acquiring land for cereal production. Shows the 20 countries which are a base for companies acquiring land to produce cereals in Africa. The countries have been organised by import dependancy and undernourishment. Countries have been listed in order of the size of acquisitions, largest first.

Countries acquiring land for cereal production		
	Prevalence of undernourishment	No prevalence of undernourishment
Import Dependent	**Group 1:** Egypt, South Korea, India, Saudi Arabia, Libya, South Africa, China, UEA, Philippines, Mauritius, West Africa[19] collaboration and Djibouti	**Group 2:** UK, Portugal, Spain, Germany and Singapore
Not Import Dependent	**Group 3:** Brazil	**Group 4:** USA

Group 2 are mostly European countries. These are countries which do not have prevalence of undernourishment, but are reliant on imports. These four countries are densely populated with little and degrading available farmland per person (Beddington, 2010). Group 2 nations are relatively wealthy nations and the negative trade imbalances will be unlikely to lead to widespread food insecurity. In Germany, for example, the average person spends ten percent of their income on food in comparison to developing countries which spend 80% of their income on food (Oxfam Deutschland, 2012). Group 2 are gaining control of resources not to provide for the immediate problem, but in order to become less reliant on the market imports and subsequent price volatility (Robertson and Andersen, 2010). It is more likely that production by Group 2 countries could be end up on the global market.

[19] West Africa has been names as the base country for investment. I assume this refers to a coalition of different West African countries

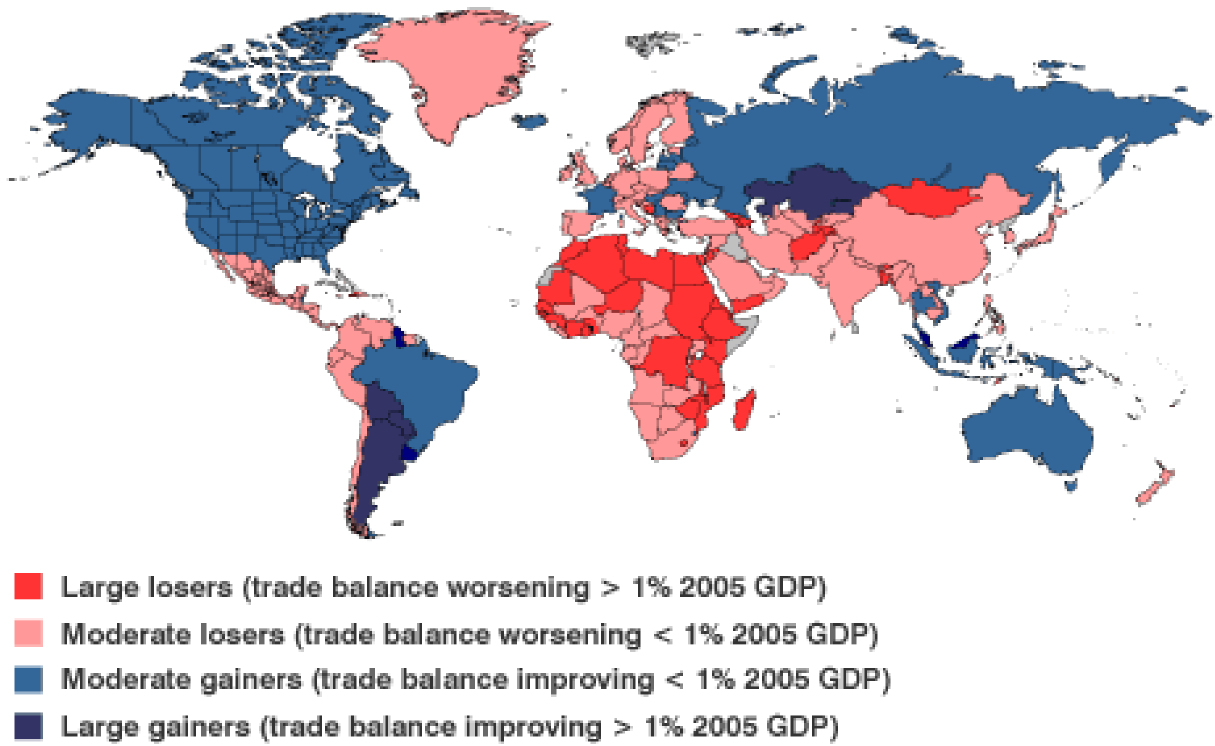

Figure 8 Impact of projected food price (2007-2008) increases on trade balances. Source: Holmes, 2008

The third group are countries which are not import dependant but are food insecure. This group contains just Brazil. Brazil has a moderate level of undernourishment but benefits from the rise in food prices as it is an exporter of produce. From this I infer that the prevalence of undernourishment in Brazil comes from access issues and not the availability of food. Therefore investment in Africa to increase availability of food is not likely to be a solution to Brazil's food security problem nor is it a strategy by the government to do so. Therefore this investment could be merged with Group 4; the last group, made up of the USA. This country has neither a prevalence of undernourishment nor is dependent on imports. I believe these two groups reflect acquisitions made solely for the purpose of export onto the global market to whoever commands the highest price (Mann and Smaller, 2010).

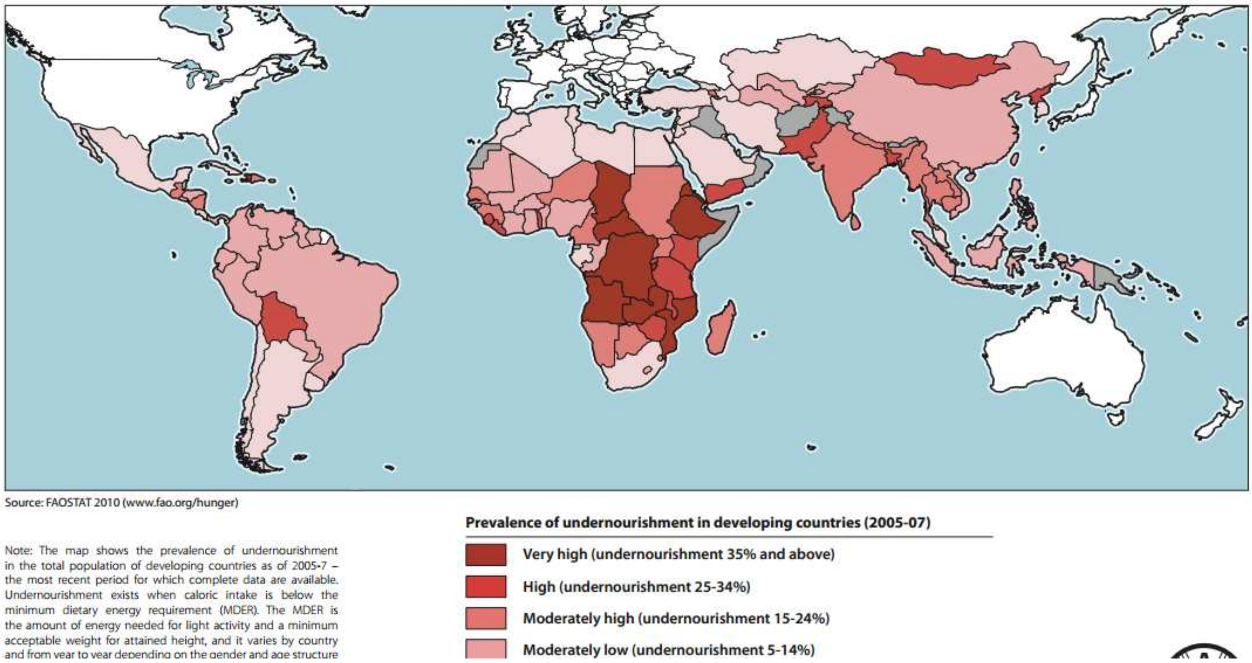

Figure 9 Prevalence of undernourishment 2005-2007. Source FAO, 2010

The three groups reflect the different driving forces behind acquiring land for cereal production whether it be for food security (Group 1), securing food supply (Group 2) or producing food for the highest bidder (Group 3 and 4). However I do not rule out that some land acquisitions do provide food to domestic markets. Group 1 shows countries that do not have sufficient resources to provide food for civilians are producing food in more resource rich countries. China could be a cross over country that might better fit within group 2 as it is largely self sufficient with food, however with a large, developing water poor country the actions seems to be to assure long term food security. I would define Group 2 as securing food supply. This group is differentiated from Group 1 by the fact that the populations are not undernourished and the primary concern in acquiring land for cereal is to protect home nations from rising prices. The largest proportion of land being acquired for cereal production is through Group 1 and 2 countries. Land acquisitions in Group 3 and 4 represent production for the global market exchange. Neither countries are resource deficient and are both major exporters. It would appear that the driving force for these acquisitions comes from within the agribusiness and finance sector.

6.3.4 Agribusiness, Finance and Speculation

The investments from USA, Brazil and Malaysia in Africa have been highlighted in the section above as a few of many examples where land acquisitions are being driven by large international trade. This section looks at origin and involvement of these sectors in land acquisitions.

"We could be moronic and not grow anything and still make money over the next decade."

Goldman Sachs employee from Vince (2012)

As a result of the 2008 economic crisis, troubled investors lost faith in the market (GRAIN, 2008). The commodity market shifted from "hard" to "soft" commodities, and investment in agricultural production became an attractive investment option (Cotula et al., 2009; Daniel, 2010). This means that there are new investment opportunities in shares of companies holding land, fertiliser manufactures and other upstream agricultural activities. Additionally, the trend of rising land prices makes the legal rights to the land a valuable product to speculate on (Cotula et al., 2009). Speculators who bet on rising prices of land can make big profits (Oxfam Deutschland, 2012). This means actual investment in agricultural growth and infrastructure can be a secondary investment, supported by the attitudes implied in the quote above. A study by the World Bank revealed that it is not unusual for companies to acquire land and leave it unused. In Mozambique a 2009 audit showed that of the 2.7 million ha that were transferred only 50 percent was being used and this pattern is reflected in the larger scale with only 21% of land acquisitions globally being cultivated (Delininger et al., 2011). As more investments are made prices of land increases and the demand grows (GRAIN, 2008). Increased speculation, which is reinforced by the claim debated in Section 5.1 that Africa is resource abundant, is increasing prices of land. This means not only do food prices increase so businesses can sustain a profit (Lord, 2011), but also that small-scale farmers are priced out of the market, whether or not the land is ever acquired (De Schutter, 2011a).

Contribution to global food security

Land acquisitions are not making the best use of the land for food security as they are not producing cereal crop types in the correct location to maximise overall kcal output. This means there is a 20% of potential calories are lost. I have argued that this is because land acquisitions are not driven by the aim of supply food for food security but are being driven by dietary demands from home countries as well as market demands. The introduction of new indicators for agriculture based on value for food security and not trade could help to shift the focus of agriculture (and land acquisition) to look at how to maximise calorie yield and not just traditional tonne yield.

An analytical study into the country of origin of cereal investors helps identify 3 types of investment; land acquisition for food security, land acquisition for securing food supply and land acquisition for profit. These groups are not completed but can be basis for further analysis. Only one of these groups is considered to be investing in land in Africa for securing food security and the other two are for control and profit.

6.4 Are land acquisitions providing a solution to global food security?

6.4.1 Food, fuel and the rest

The results indicate that land acquisitions grow crops for a mixture of different uses. Although many ha of land are assigned to grow cereals, many more are not. Nonhebel and Kastner (2011) distinguish between the requirements for developing countries, which need extra cereal; transition countries, which require animal feed and luxury food; and developed countries which require biomass to meet ”clean” energy targets. The production of crops for animal feed, luxury crops and biomass indirectly lead to higher prices of staple food prices as a result of competition.

6.4.2 Changing diets

Trends show that there has been a global increase in energy intake and a “substitution” in transition countries from staple crops like cereals, roots and tubers to vegetable oils, animal products and sugar (Kearney, 2010; Satterthwaite et al., 2010). The rise in demand for edible oil crops is commonly associated with luxury consumption[20]. In “western” diets 40% of edible oils that are consumed come from cakes, cookies, crackers, pies etc. and consumption levels are above the optimal dietary intake (Corley, 2009).

As income grows there is an increase in the demand for meat (Ciera and Masset, 2010). The increase in meat consumption means greater demand of fodder for livestock. Many food crops grown on the land acquisitions are crops which can be directed to livestock. Demand for soybean in particular is driven by use as fodder as it is a high source of protein (Corley, 2009). Typically 78% of a soybean bushel is processed for soybean meal which is used for livestock (North Carolina Soybean Producers

[20] Palm oil is a major component of margarine, ice cream, and in processed foods such as crisps, chips, instant noodles, pastry, chocolate, instant soup and other snack foods .

Association, 2007). Meat consumption accounts for the demand of cereal, as more than 35% of cereal production is used as fodder (Nonhebel and Kastner, 2011), which is inefficient, as large amount of energy is lost by the animal converting fodder into muscle and biomass (Tscharntke et al., 2012). Not only is the food diverted away from people to animals, to provide luxury food, but it uses up available land.

A large proportion of land acquisitions are seemingly producing food to meet the changing diets in transition countries. There is an emergence of a “middle class” in countries specifically in Asia, which is changing demand (Khras, 2010). This may not be strictly contributing for food security, as defined by the FAO (2002) (see section 1 Introduction), but raises some complicated questions about global equality. As with climate change it seems that there are not enough global resources for all nations to adopt western lifestyles and dietary habits.

The results indicate that land acquisitions grow crops for a mixutre of different uses. Although many ha of land are assigned to grow cereals, many more are not. Nonhebel and Kastner (2011) distinguish between the requirements for developing countries, which need extra cereal; transition countries, which require animal feed and luxury food; and developed countries which require biomass to meet ”clean” energy targets. The production of crops for animal feed, luxury crops and biomass indirectly lead to higher prices of staple food prices as a result of competition.

6.4.3 Food security for everyone but the most in need

”...land grabs and exclusive deals that meet the food needs of the rich but not the poor ”

Kofi Annan (FAO, 2011)

The extent to which land acquisitions contribute to food security is at a minimum. The export of cereals to food insecure countries is an example of where land acquisitions can contribute for food security. However if we introduce the concept of distribution it is clear that there is a separation of cost and benefit of the gain in food security.

Increasing national food security through land acquisition is done at the expense of the world’s most poor and vulnerable nations and people (Daniel, 2010). Food insecure nations are investing to produce cereals in Africa to re-import. However, Africa is the world’s most famished continent that struggles to feed itself and these land acquisitions are producing food for the export market (Rice, 2009). In all Group 1 (Table 11) cases, the country in which land is acquired has a higher prevalence of under nourishment than the country in which the investor is based[21].

In addition, the necessity for Egypt to "offshore farm" for cereals may be exacerbated by the large areas of land being acquired in Sudan and Ethiopia. Sudan and Ethiopia have had a large area of land acquired (Appendix: Table 17) and the desire for these land acquisition to irrigate using the Nile is affecting the water supply reaching Egypt (Brown, 2011). The largest volume of water from the Nile is allocated to Egypt however the lobbying power of foreign governments and agribusinesses are hoping to overturn this. This would give the land acquisitions in Sudan and Ethiopia a larger water supply to irrigate crops from (Brown, 2011). Irrigation for crops is not a long-term solution for agriculture and food security as it reduces the water table.

The displacement of small-scale farms exacerbates food security in Africa. Vast areas of land are leased to foreign investors because rural land rights have never been formalised for local and indigenous populations (Robertson and Andersen, 2010). Even countries that have progressive land laws, such as Mozambique, are relaxing them to allow for more investment. Although intergovernmental organisations try to implement a code of conduct for land acquisitions without the formal land rights in place land acquisitions continue to displace local and indigenous populations (Deininger et al, 2011; Borras and Franco, 2012). Subsistence farmers rely on land for food security and small-scale farmers supply local markets. When local African farmers are displaced from the land they become dependent on markets for their food and local African markets are disrupted. For the farmer there is no surplus of industry or services jobs to support this population which is now reliant on a wage to purchase food from the market (De Schutter, 2011a). In addition the distribution to the local food chain leaves regions reliant on high priced food imports.

An interview with Neil Crowder[22] by the BBC revealed that in some cases supplying food for local African markets in Central Africa is more profitable than sale on the local markets. This is because Africa is reliant on food imports which drive the food prices high (Rowlatt, 2012). In effect foreign investors are acquiring land in Africa thereby reducing the capacity of African farms to supply to local markets. This in turn raises food prices due to reliance on imports which means the said foreign investors can sell the products with Africa at a larger profit than they could elsewhere.

[21] Group 1 cases have a claim at contributing to food security, however this pattern is true for all the land acquisitions in Table 11
[22] the chief executive of Chayton Capital

6.4.4 The problem with the new "global food security"

Since the 2007-2008 food price crisis there has been a new surge of interest in food security. It has become the top of the agenda for many intergovernmental bodies (OECD-FAO, 2009) and has resurfaced within academia. The majority of the literature used in this thesis which reference "food" or "food security" has been published after 2008[23]. However the framing of food security since 2008 has changed. It has gone from being seen as a local or national problem, associated with developing countries, to being an issue of immediate global importance with global solutions.

The framing of food security as a global problem masks the regional disparities involved, as food security is still very much a regional problem littered with inequalities. "Global food security" tends to combine and equate the demand for luxury protein-based crops for transition and developed countries, with developing countries needs for staple cereal crops (Nonhebel and Kastner, 2011). The projections that crop production needs to increase by approximately double by 2050, does not distinguish between the increase to cope with increasing population, and that which is attributed to the change in dietary demand (FAO, 2002; 2006; Bruinsma, 2009; Foley et al., 2011; Tilman et al., 2011). Population growth is at 30-40% therefore to sustain the status quo production needs to increase by that amount by 2050. Therefore the 60-70% required increase in crop production is attributed to changing diets and non food uses. A recent study by Oxfam say that only 1% increase in production is needed to ensure food security for the 13% of population (Raworth, 2012).

The framing of the crisis allows developed and transition countries to shift their own crisis to other, more vulnerable areas. The narrative of an immediate global crisis has allowed actors to invest in land and commodify these land and their resources. If the regional aspect was reintroduced back into the framing of global food security it would be clear that land acquisitions were causing a net loss of food security in Africa to achieve marginal gains in food prices elsewhere.

6.5 Limitations

This research, like the majority of research on land acquisitions, is limited by the lack of data on land acquisition (Cotula et al., 2009). Typical of land acquisitions is that the formal information on paper is not a reflection of the situation on the ground (Borras and Franco, 2012). T GRAIN database used as a basis for my analysis has not been subject to ground truth-ing however I have assumed it is accurate.

[23] All papers except three

A major limitation in my results is that I do not know what proportion of land is allocated to each crop. For this paper I have divided the number of crops by the land acquired. However this is likely to be quite limited. This gives a bias of my results to large commodities where the whole area of land has been dedicated to single crop production such as rice, wheat, maize and oil palm. It also bias' small products like herbs which would be unlikely to have an equal share of land when being produced by the same company that produces vegetables. The products which are likely to be underestimated is the land dedicated to livestock which is would require a larger area than herbs and products like vegetables which are often planted alongside other commodities.

Despite the lack of information in this database it is very important to get a global picture of land acquisitions. Much literature on land acquisitions and the associated impacts is written using grounded theory and does not provide a picture of the whole landscape.

7 Conclusion

This thesis analysed the claim that, with investments from land acquisition, Africa can feed the world. Land acquisitions are justified in part by the contribution to food security (Daniel, 2010; The French Inter-Ministerial Food Security Group, 2010). As land acquisitions provide a solution to the low agricultural output in Africa in order to increase food production (Cotula et al., 2009; Delininger et al., 2011). I tested this claim by investigating the potential for African agriculture to be increased by expanding farmland and closing yield gaps. I analysed the current land acquisitions in Africa to see if the crops and locations of production were in keeping with the goal of food security and calculated *potential production quantity* for cereals. My study concludes that despite Africa's large potential for increasing food production, the acquisition of land by foreign investors will not see that this potential is directed to producing food crops for the food insecure. This paper took a different approach to analysis of land acquisitions, on the macro level, to see how they could be used for contribution for food security, and to a large extent the results of this paper confirm the assessment of land acquisitions in literature.

From studying the crops produced by land acquisition in Africa I found that land acquisitions are not producing food crops which contribute for food security. This study identifies that cereals which account for half of the global average intake of calories are produced on 26% of the acquired land, while oil crops, accounting for less than 2% of the global average diet, are produced on 25%. Land acquisitions are producing crops to meet the demand of changing diets in transition countries to more luxury protein-based crops, and not the needs of the malnourished that require cereal products (Nonhebel and Kastner, 2011). However, while meeting the food demands of transition countries land acquisitions reinforce food insecurity in Africa.

Using *potential calorie yield* and *inter-crop yield* gap for my analysis allowed me to identify the crops most suitable in each region for maximising calorie availability. The results show that land acquisitions are not acquiring land in the areas, nor growing the cereal varieties, which provide the largest amount of calories per hectares. Land acquisitions could increase total calorie production from cereals by 20%, largely by switching from growing wheat and rice in Eastern and Western Africa to producing maize and sorghum. The crop choice does not reflect highest calorie output because investment is being lead by market forces. Investors are meeting demands from home nations for certain products, such as wheat for Egypt, and not focusing on producing calories for food security. I believe that more research is required into new indicators for agriculture as a move away from traditional measures of yield in tonnes toward measuring yield in calories would change the focus away from production for trade towards production for food security.

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9 Appendix

Table 12 GRAIN database methodological assumptions for analysis.

GRAIN data classification				
With reference to		Definitions	Rationale	Limitations
1	Removal from analysis	Ambiguous entries, not enough data	If there was not sufficient data with regards to production then these entries have been excluded from my study	In this there are X cases listed as food crops and X cases which list cereal or grain. These have been excluded from my study however they would contribute for food security
2	"Hectares"	The area of land that was acquired	I assume all the land acquired is used for harvesting	A proportion of the land may be used for agricultural infrastructure and therefore the land used for crops is an over estimate
3	"Production"	Classification of production	I catalogued the production based on the FAOSTAT and GAEZ classification	Discretion as to where I class some groups does "sunflower" fit under "seed" or "oil crop". I classified it as an oil crop.
4	"Production"	Production crop	I assume that farms are growing what they said they will produce	It is possible that there may be a difference in what each farm is proposed to produce and what it actually produces.
5	"Production"	Production of multiple crops by one land acquisition	I assume an equal area for production of multi crops produced by the same farm.	Assuming that land acquired for multiple crops is divided equally is an underestimation in hectares for bulk commodities which are most likely to be grown on a larger portion of the farm.
6	"Production"	Rice	In my study I assume production of wetland rice	Namibia and Mauritania had 0 yield wetland therefore I assumed they produced dry land rice
7	Flexible crops	Flexible crop refers to a crop which can be used for food, fuel or other materials	Oil crops, Sugar crops and Maize are counted as Flexible crops	Cassava and other cereals not incl.

Table 13 Index of product classification for GRAIN database. This classification has been used to analyse what crops are being grown on land acquisitions in Africa. The numbers refer to the number of land acquisitions which stated each crop for production

Classification	Sub classification	No. of land acquisitions
Not stated	Not Stated	15
	Crops	11
	Mixed farming	1
	Food crops *	3
Animal produce	Livestock	4
	Beef cattle	6
	Poultry	1
	Milk	1
Cereal	Barley	1
	Cereals (unspecified)	9
	Maize/ Corn **	19
	Rice	41
	Wheat	14

	Teff	1
	Sorghum	4
Fruits	Fruits (unspecified)	7
	Citrus	1
	Pineapple	3
	Banana	3
Herbs	Generic herb	1
	Alfalfa	1
	Dill	1
Nuts	Nuts (unspecified)	1
	Peanuts	1
	Almonds	1
Pulses	Pulses	3
Roots and Tubers	Cassava **	5
	Potatoes	4
Oil crops	Soy	1
	Soybean	8
	Sunflower	6
	Canola	1
	Coconut oil	1
	Castor oil	1
	Olive oil	1
	Olive	1
	Oilseed	8
	Palm oil	32
	Vegetable oil	1
	Date Palm	1
	Pongamia pinnata	1
Seed	Seeds	1
	Sesame	2
Sugar crops	Sugar	4
	Sugar cane	27
Vegetables	Vegetables	7
	Sweet corn	1
	Asparagus	1
	Squash	1
	Tomato	1
Bio-fuel crops	Bio-fuel crops	2
	Jatropha	2
Fibre crop	Cotton	5
Fodder	Fodder	4
	Hay	1
Flowers	Flowers	1

Table 14 Index of product grouping; food, fodder, fuel, flexible, fibre, flowers. Table shows number of data entries for each

Grouping	Classification	No. of land acquisitions
Food crops TOTAL	Food crops*	3
	Animal produce total	11
	Cereal total	89
	Fruit total	15
	Herb total	3
	Nuts total	3
	Pulses total	3
	Roots and tubers total	9
	Seeds total	3
	Vegetables	11
Fodder crops TOTAL	Fodder total	5
Fuel crops TOTAL	Bio-fuel crops total	4

Flexible crops TOTAL	Oil crops Total	62
	Sugar crops total	31
	Maize**	19
Fibre crops TOTAL	Fibre crops totals	5
Flower crops TOTAL	Flower totals	1
Not Stated TOTAL	Not Stated	15
	Crops	11
	Mixed farming	1

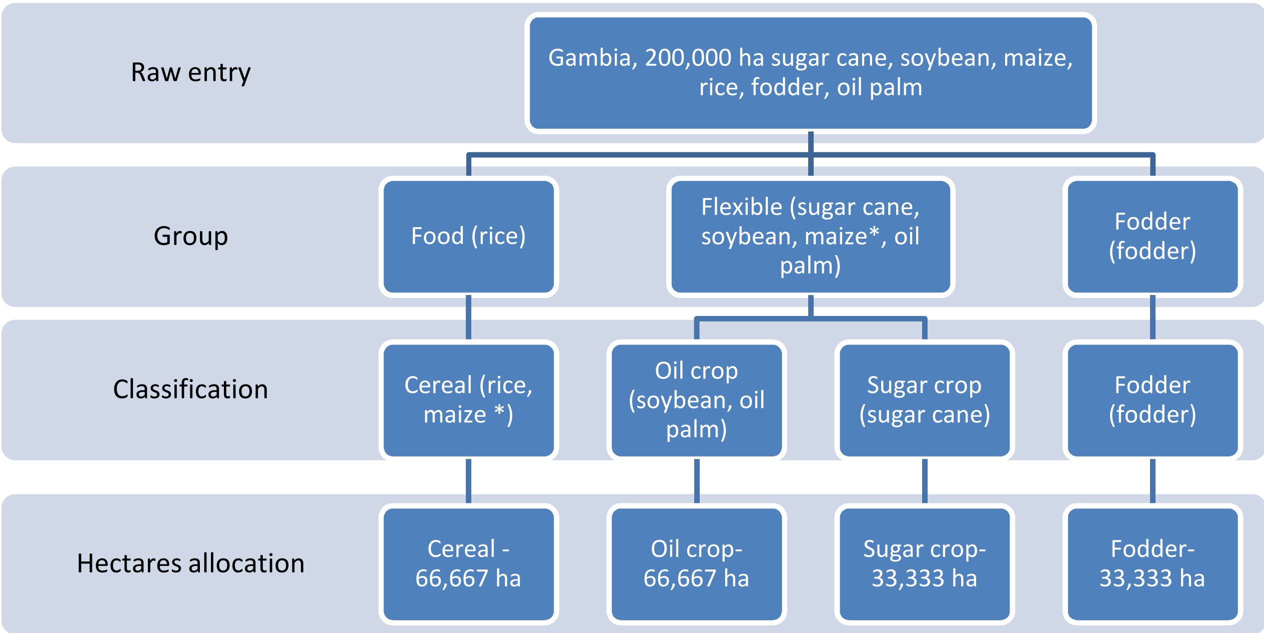

Figure 10 Example of production classification for The Gambia land acquisition. Flow chart shows the process by which to sort and assign number of hectares to each crop

Table 15 Product grouping additional for Figure 6. This table gives a full list of how the bar chart in Figure 6 was organised and what "other" refers to

Palm oil	
Wheat	
Rice	
Maize	
Sugar cane	
Livestock	Beef Cattle
	Livestock (unspecified)
	Poultry
Fruit crops	Citrus
	Fruits (unspecified)
	Pineapple
	Banana
Other	Oilseed
	Fodder
	Cotton

	Flowers
	Sesame
	Cassava
	Coconut oil
	Alfalfa
	Pongamia pinnata
	Vegetable oil
	Castor oil
	Peanuts
	Potatoes
	Pulses
	Olive oil
	Milk
	Nuts (unspecified)
	Dill
	Generic herb
	Hay
	Canola
	Almonds
	Date Palm
	Seeds
Minor cereals	Cereals (unspecified)
	Sorghum
	Teff
	Barley
Sunflower	
Olive	
Sugar	
Soya	
Vegetable crops	Vegetables
	Tomato
	Seeds
	Sweet corn
	Asparagus
Bio-fuel crops	Bio-fuel crops (unspecified)
	Jatropha

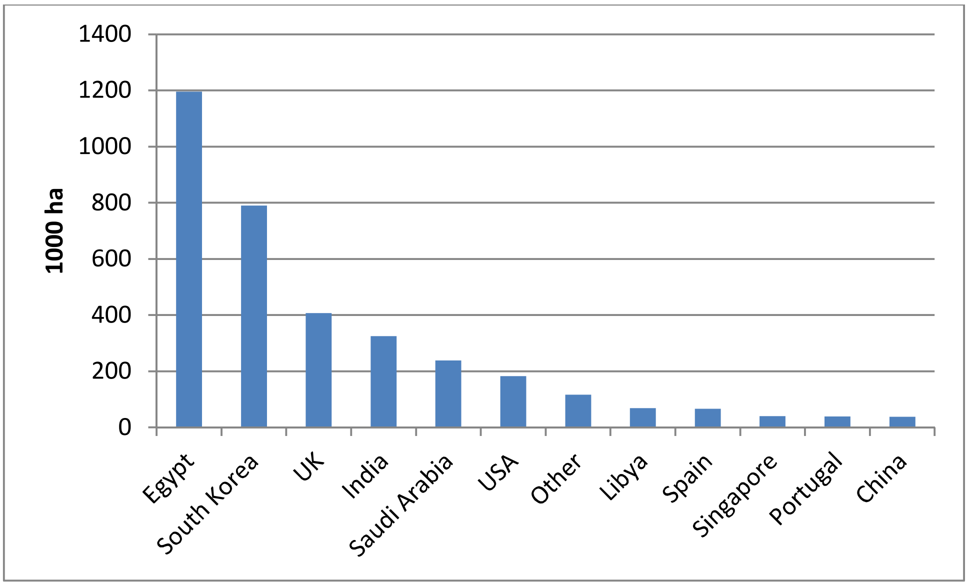

Figure 11 Hectares acquired by country to grow cereal. All land that has been allocated to grow cereal has been added together and plotted by country.

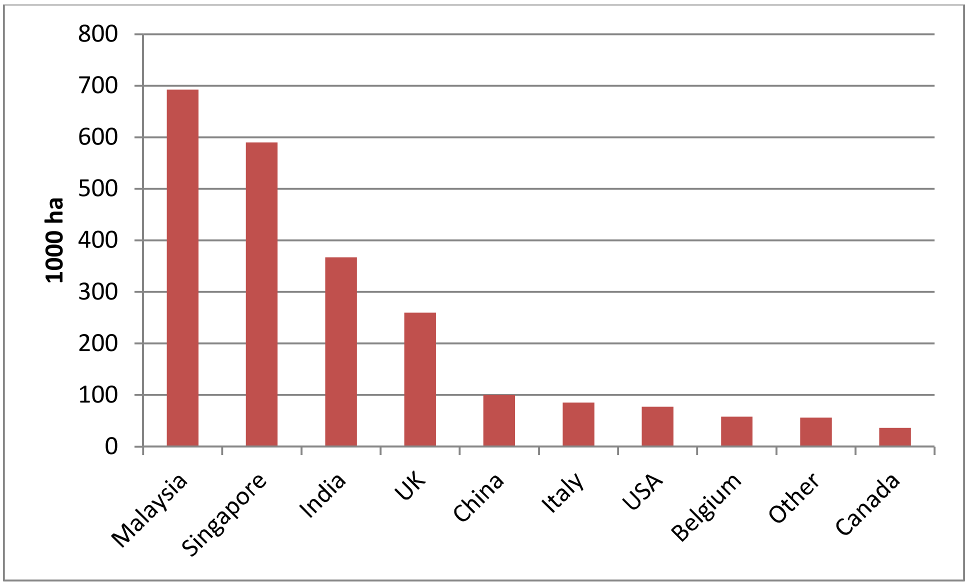

Figure 12 Hectares acquired by country to grow oil palm. All land that has been allocated to grow oil palm has been added together and plotted by country. From this you can see the countries which invest in oil palm production and the area of land

Table 16 Food production for each crop within each country assuming at 95% yield (million kcal/ha). This table shows the productivity of land in terms of kcal output per hectare. The darker green indicates areas where the highest kcal/ ha production can potentially occur. This table has been compiled assuming a 95% yield for all crops[24].

		million Kcal/ha				
		Barley	Maize, shelled	Rice	Sorghum, grain	Wheat
Northern Africa	Algeria	13	6	0	9	13
	Egypt	7	6	0	6	7
	Libyan Arab Jamahiriya	7	3	0	6	7
	Morocco	13	12	0	12	17
	Tunisia	13	6	0	9	13
	Western Sahara	0	0	0	0	0
Western Africa	Benin	0	30	16	22	0
	Burkina Faso	0	30	10	25	0
	Cote d'Ivoire	0	21	23	12	0
	Gambia	0	33	10	28	0
	Ghana	0	24	23	15	0
	Guinea	0	24	23	15	0
	Guinea-Bissau	0	21	23	12	0
	Liberia	0	15	26	6	0
	Mali	0	24	10	22	0
	Mauritania	0	6	0	12	0
	Niger	0	12	7	12	0
	Nigeria	10	27	20	22	13
	Senegal	0	24	10	22	0
	Sierra Leone	0	18	26	9	0
	Togo	0	27	23	19	0
Central Africa	Angola	3	27	20	22	7
	Cameroon	13	21	23	12	13
	Central African Republic	0	24	26	15	0
	Chad	0	21	10	19	0
	Congo	0	18	26	6	0
	Dem Republic of the Congo	7	21	26	12	10
	Equatorial Guinea	7	12	23	3	10
	Gabon	0	15	26	6	0
	Sao Tome and Principe	0	15	23	6	0
Eastern Africa	Burundi	13	27	26	19	17
	Comoros	13	21	29	9	17
	Djibouti	0	0	0	0	0
	Eritrea	7	9	0	12	7
	Ethiopia	17	24	20	15	17

[24] The intercrop, inter country pattern would appear the same if I had chosen a 50% yield.

	Kenya	17	21	13	19	17
	Madagascar	10	27	23	19	13
	Malawi	7	33	16	28	10
	Mozambique	7	33	20	25	7
	Rwanda	17	21	23	9	17
	Somalia	0	6	0	9	0
	Sudan	10	21	16	19	13
	Uganda	17	21	23	9	20
	United Republic of Tanzania	10	33	20	25	10
	Zambia	3	33	16	28	7
	Zimbabwe	7	30	10	28	7
Southern Africa	Botswana	3	18	0	22	3
	Lesotho	20	18	0	12	23
	Namibia	3	12	0	15	3
	South Africa	10	18	13	15	10
	Swaziland	7	30	10	25	7

Table 17Land acquisition allocated for each crop within each country in Africa (ha). Colour coded on a yellow-orange scale to indicate the size of land, orange is the largest The table is organised by region and colour coded so that the darker orange colour signifies where more land has been acquired. The blank squares are countries and crops that have not been invested in.

Hectares dedicated to each cereal by land acquisitions						
		Barley	Maize	Rice	Sorghum	Wheat
Northern Africa	Algeria					
	Egypt		5,000			36,250
	Libyan Arab Jamahiriya					
	Morocco					
	Tunisia					
	Western Sahara					
Western Africa	Benin					
	Burkina Faso					
	Cote d'Ivoire					
	Gambia		33,333	33,333		
	Ghana		10,000	106,000		
	Guinea		53,208			
	Guinea-Bissau					
	Liberia			23,500		
	Mali			78,317		
	Mauritania			2,000		

	Niger					
	Nigeria			344,000		
	Senegal					
	Sierra Leone			70,750		
	Togo					
Central Africa	Angola			26,500		
	Cameroon		3,333	3,333		
	Central African Republic					
	Chad					
	Congo			26,667		
	Dem Republic of the Congo			36,667		
	Equatorial Guinea					
	Gabon					
	Sao Tome and Principe					
Eastern Africa	Burundi					
	Comoros					
	Djibouti					
	Eritrea					
	Ethiopia		101,083	107,083		6,000
	Kenya			7,000		
	Madagascar		150,000			
	Malawi					
	Mozambique		13,078	31,977	15,000	
	Rwanda					
	Somalia					
	Sudan	4,971	179,266	18,841	18,841	869,266
	Uganda		400000			400,000
	United Republic of Tanzania			143,968		
	Zambia		838			838
	Zimbabwe					
Southern Africa6	Botswana					
	Lesotho					
	Namibia		2,500	2,500		2,500
	South Africa		4,633			
	Swaziland					

Table 18 Uses of most popular crops produced by land acquisitions. This table details the different uses (food, fuel and other) of the most popular crops grown on acquired land. Source: North Carolina Soybean Producers Association, 2007; Corley, 2009; Eggleston et al., 2010; Singh, 2010; Murphy, 2012; Nonhebel and Kastner, 2011

Food group	Uses		
	Food	Fuel	Other
Animal produce	Consumed as raw materials	Slaughter house waste is used for biogas	Clothes and accessories
	Used in processed food		
	Used as cooking oil		
Cereal	Primary food source	Cereals can be converted into biogas.	Cereals are used as fodder
		Maize and wheat can be converted to bio ethanol for use as bio-fuel	
Fruit	Consumed as raw materials	Can be used as ethanol but not common	
	Component of alcoholic beverages		
Oil Crops	Vital edible oil for consumption	Main sources for biodiesel	Cosmetics
	Component of many luxury processed foods		Manufacturing plastics
	Soybean used in soy foods for example in tofu, edamame, soymilk, soy sauce		Majority of soybean is used for soybean meal for livestock. It is also used for fish food and pet food
	Source of cooking oil		Industrial uses in printers , releasing agents, sprays
Sugar crops	Raw sugar	Converted into bioethanol to use as bio-fuel	Chemistry
	In beverages and drinks	Heat and electricity	
Vegetables	Consumed as raw materials	Vegetable oil can be used for bio-fuel	