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Food Security and Food Sufficiency in Ethiopia and Eastern Africa

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Abstract

Food insecurity is a major problem in the developing countries of the world, where Sub-Saharan and Eastern Africa is some of the most affected areas. With rapid population growth and lack of means to adapt to a changing climate, the region is in the danger zone for famine.

The aim of this paper is to examine the food situation in Ethiopia today, and how the climate change is predicted to affect the food security and food sufficiency in Sub-Saharan and Eastern Africa in the future. Six scenarios are presented with changes in cereal production in Eastern Africa, indicating food sufficiency by domestic cereal in 2030 and 2050. In the later part of the paper, solutions to achieve food security and food sufficiency are presented.

Ethiopia is of particular concern when it comes to food security. With repeated famines during the 1990´s and 2000´s the country is particularly vulnerable for climate change and population growth. The agriculture is highly dependent on precipitation, only about 1 percent produced food comes from irrigated land, and with a projected increase in rainfall at fewer events in the future, the risk of drought is of major concern. The main cause of food insecurity is poverty; around 80 percent of the population is working in the agricultural sector in Ethiopia, and in years with insufficient precipitation, the workers are out of work. Early Warning System that forecasts drought and famine is when working a beneficial way to prepare a region for food insecurity and drought. But lack of communication and data exchange between different units in the management of Early Warning System has caused the food aid to come to late.

Scenarios developed indicates a increase of 5 percent per year in cereal production to achieve food sufficiency for Somalia, Ethiopia, Eritrea, Sudan, Kenya and Uganda in 2050, if every person of the population have access to 15 kg of cereals each month. To achieve food sufficiency, there are a variety of solutions suggested e.g. rainwater harvesting, irrigation, usage of more drought resistant crops, using manure as fertilizers, agroforestry and establishment of a well working Early Warning System for both famine and drought.

Keywords: Geography, Physical Geography, Food Security, Food Sufficiency, Ethiopia, Eastern Africa.

Sammanfattning

I många utvecklingsländer globalt är svält och undernäring bland befolkningen ett stort problem. Två av de mest drabbade områdena är Afrika söder om Sahara och östra Afrika, och i framtiden förväntas problemet förvärras av global uppvärmning och kraftig befolkningsökning. Temperaturhöjning och förändrad nederbörd kommer att minska produktionen i området, och med detta tillgången av mat samt övrig produktion som kunnat exporteras för att öka den nationella inkomsten, för att sedan importera mat.

Etiopien är extra känsligt, då en ökande befolkning och oförmåga att anpassa sig till nya förhållanden på grund av ekonomiska hinder, ökar sårbarheten för förändringar i klimatet. Dessutom är jordbruket i Etiopien mycket beroende av nederbörd, då endast 1 procent av den producerade maten kommer från konstbevattnat jordbruk. Nederbörden förväntas öka, men kommer att falla vid mer sporadiska tillfällen, vilket kommer öka risken för torka i området.

Målet med uppsatsen är att undersöka matsituationen i Etiopien idag och hur den ökande befolkningen kommer påverka tillgången av mat. Detta görs genom sex scenarier som visar hur stor del av befolkningen som den inhemska spannmålsproduktionen kan försörja, om varje person har tillgång till 15 kg spannmål varje månad. Scenarierna tillämpas på länderna Sudan, Etiopien, Eritrea, Somalia, Kenya och Uganda.

Scenarierna indikerar att länderna behöver öka sin produktion med 5 procent eller mer årligen fram till 2050 för att kunna försörja sin befolkning med inhemskt producerat spannmål. Föreslagna åtgärderna för att uppnå självförsörjning av spannmål är bl. a. vattenskydd och insamling av regnvatten, odling av torkresistenta grödor, bruka djurspillning som gödsel, trädjordbruk och utveckla väl fungerande varningssystem som kan förutspå skörden samt förutse torka. Men det finns många hinder innan detta kommer att bli verklighet. Dagens bristfälligs system för att förutspå svält saknar kommunikation mellan de olika instanserna som har till uppgift att förutse dessa händelser då de inte samarbetar. Insamlingen av nödvändig data görs av olika organisationer, utan något utbyte av information emellan dem. Men viktig att komma ihåg är att det inte finns en metod att uppnå matsäkerhet och självförsörjning för hela Afrika söder om Sahara, utan varje land måste utveckla sin egen lösning efter sina behov och ekonomiska möjligheter.

Nyckelord: Geografi, Naturgeografi, Matsäkerhet, självförsörjning av mat, Etiopien, Östafrika.

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Many people have helped me in my work with this paper, and there are some persons I would like to give a special thank to. My supervisor Jonas Ardö at Lund University for giving me ideas and getting me on the right track when I had to many ideas. To all my classmates for all the fun things we have done together, and all the moments of frustration that we have shared. Finally, I would like to thank Henrik for his patience and encouragement.

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1. Introduction

Food insecurity is a major problem in developing countries all over the world, and with an increasing global population that are expected to be over 9 billion people in 2050, compared to todays population of 7 billion, the problem may become even worse than today (U.S. Census Bureau, 2011a). Food insecurity is when the people do not has access to enough food to meet the dietary need, and food insufficiency is when not enough domestic food is produced to reach food security (Thompson et al., 2010; Pinstrup-Andersen, 2009).

Sub-Saharan Africa (SSA) and Eastern Africa is especially affected of malnutrition and food insecurity, due to several reasons, e.g. the geography of Africa with no easy access to the interior, poverty and lack of good quality seed and environmental friendly fertilizers. The population in SSA is today 870 million with a rapid growth of 2.36 percent per annum (2011) and in 2050 it is expected to be almost 2 billion people (U.S. Census Bureau, 2011b)

Ethiopia is particularly famine prone due to its agricultural system that relies on precipitation and severe environmental degradation has a negative impact on agricultural production (Riley et al., 2002). Ethiopia has the potential to become self sufficient in food, there are crops, e.g. cereals that has increased in production, even though the over all food production has decreased.

If Ethiopia and Eastern Africa was to achieve food security many lives will be spared, and the reliance of food relief would decrease. This would have large economical benefit for the region, where large efforts are made to feed the population, preventing economical growth and development in other sectors that otherwise might have increased the income of the region. When the focus is not only on something as fundamental as food, the population also has the health to work and produce more goods and increase their income and bringing the country into prosperity.

The aim of this paper is to examine the food situation in Ethiopia and Eastern Africa today, how much cereals are produced, and solutions to increase the production in the future in SSA and Eastern Africa.

Six scenarios are presented with both increasing and decreasing cereal production for the countries Sudan, Eritrea, Ethiopia, Somalia, Kenya, and Uganda, indicating if the countries can become food sufficient until 2030 or 2050.

1.1 Definition of Food Security and Food Sufficiency

There are many different definitions of food security; one of the shorter definitions comes from Thompson et al. (2010):

"*all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*".

According to Riley et al. (2002) the most common definition is the one that the World Bank developed in 1986;

"*access by all people at all times to enough food for an active, healthy life. Its essential*

elements are the availability of food and the ability to acquire it. Food insecurity, in turn, is the lack of access to enough food. There are two kinds of food insecurity: chronic and transitory. Chronic food insecurity is a continuously inadequate diet caused by the inability to acquire food. It affects households that persistently lack the ability either to buy enough food or to produce their own. Transitory food insecurity is a temporary decline in a household's access to enough food. It results from instability in food prices, food production, or household incomes and in its worst form it produces famine" (World Bank 1986).

Food and Agriculture Organization of the United Nations (FAO) definition from 1983 states:

"Ensuring that all people at all times have both physical and economic access to the basic food that they need" (FAO 2006).

Food sufficiency is very much like food security, but is the *national food security*, i.e. the mean of self-sufficiency (Pinstrup-Andersen, 2009). It is unclear if food sufficiency can be accomplished by food import, or if the food needs to be domestic, but in this report the term food sufficiency is when a country is self sufficient in domestic food.

1.2 Aim

The aim of this paper is to make a review of the existing literature on food security and agriculture in SSA and Eastern Africa with a particular focus on Ethiopia as a case study. There are seven questions that are ought to be answer, four about Ethiopia and three about Sub-Saharan and Eastern Africa;

- How much cereal is produced in Ethiopia today?
- How large part of the population in Ethiopia is dependent on food relief today?
- How is the population expected to change in the future in Ethiopia?
- Has the agriculture in Ethiopia changed during the later part of the 20th century (crops, harvest, etc.)?

- How do scenarios project future food sufficiency for the countries Somalia, Ethiopia, Eritrea, Sudan, Kenya and Uganda?
- How is climate change predicted to affect the production of food in Sub-Saharan and Eastern Africa?
- What different kinds of solutions are available to increase food security in Sub-Saharan and Eastern Africa?

1.3 Scoop of the Study

This is mainly a literature review that has been performed during ten weeks. Due to the limitation in time, the focus of the production scenarios for the region chosen is the cereal production of the countries Sudan, Eritrea, Ethiopia, Somalia, Kenya and Uganda. Worth mentioning is that no consideration has been taken to the countries export and import sector, but only to domestic cereals production. There are other goods that are produced in the country, exported and contributing to the national income to e.g. import food. In the case

of Ethiopia, coffee is the major crop exported, even though the businesses has been going slow recent years, see section *2.4.1 Export* (FAO/WFP, 2010).

The section about climate change (section *3.3 The Impact of Climate Change in Sub-Saharan and Eastern Africa*) and ways to achieve food security (*4. How to Achieve Food Security and Sufficiency in Sub-Saharan and Eastern Africa*) has focus on SSA and Eastern Africa, when there are few articles about this subject available for Ethiopia specifically.

All scenarios are based on one population scenario, and this is the one produced by the U.S. Census Bureau (2011c).

Humans need more than cereals to be able to assimilate all nutrition's needed to be able to live a healthy and productive life, but in this study, the focus is on how a country can become self-sufficient if every person acquire 15 kg of cereals each month.

1.4 Method

The paper is divided into two main chapters; the first one is about Ethiopia and the food security in the country and reasons behind the lack of food, and the second part widens the aspect into mainly Eastern Africa and in some aspect SSA.

In the second chapter and section *3.2.1.The Future of Cereal Production in Eastern Africa*, six scenarios about future cereal production in Sudan, Eritrea, Ethiopia, Somalia, Kenya and Uganda is presented. The scenarios are;

- An increase of 1 percent per year, a scenario that is, according to Döös and Shaw (1999) a logical increase of food production.
- An increase of 3 percent per year, based on the increase of annual crop production of 2.8 percent during the Green Revolution in the 1960´s to 1980´s, (Kendall and Pimentel, 1994).
- An increase of 5 percent per year, as a very optimistic scenario.
- A decrease of 1, 3 and 5 percent. The average agricultural production trend for SSA has been an annual decline of 1 percent since 1970, but future scenarios for the agricultural production is highly uncertain (Myers and Kent, 2001; Döös and Shaw, 1999).
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The production scenarios have been based on the average annual yield for the years between 1980 and 2009, with data from FAOSTAT (2011). The amount of cereal that every person is assumed to need is 15 kg per month. This is based on the amount of cereals a person is allocated during famine from food relief, even though scientists says that this is an inadequate amount of food with lack of vitamins and animal proteins (FAO/WFP, 2010; Kaluski et al., 2002).

The population growth has been the same for the six scenarios, which makes the population for 2030 and 2050 the same in all scenarios. The population data comes from U.S. Census Bureau (2011c).

2. Ethiopia

2.1 Food in Ethiopia

About half of all Ethiopians in 2002 lived below the food poverty line (Riley et al., 2002). This means that about 50 percent of the population has access less than 2200 calories per day but the average Ethiopian calorie intake for an adult is 1810 kcal per day (Riley et al., 2002; Bryan et al., 2009). This is one of the lowest in the world, and one third to half of all Ethiopians do not get enough calories to live a healthy and productive life (Bryan et al., 2009). During recent years, the number of people in need of food assistance has continued to increase, from 2.2 million people in January 2008 to 6.5 million people in May 2010 (FAO/WFP, 2010). This was an effect of insufficient precipitation (FAO/WFP, 2010).

An area of major concern for the major food donors and the Ethiopian Government is the usage of large amounts of temporary emergency food relief to deal with chronic causes of widespread food shortage (Riley et al., 2002). When food security fails, the resources that otherwise could make a great macro-economic growth possible are now instead drained when to focus is on food security (Riley et al., 2002). Ethiopia is one of a few developing countries where the food security issue remains a focus for donors such as the European Union, the World Bank and USAID, as well as for federal and regional governments in Ethiopia.

Poverty exists in both rural and urban areas; 47 percent and 33 percent of the population lived in poverty in the respective area in 2000 (GOE, 2000). Out of the total population, 85 percent lives in rural areas making poverty mainly a rural problem.

More than half of the rural population in Ethiopia cannot produce enough food to support themselves (GOE, 2000). This is a consequence of decades of misuse of human and natural recourses. Even during years with favorable conditions, while using existing cultivation practice and available land and water, households are unlikely to reach food security (GOE, 2000). In a good year, Ethiopia is capable to reach food sufficiency and to feed the population at an acceptable level.

Chronic food insecurity in Ethiopia is the consequence of several long-term contributing factors (Riley et al., 2002);

- Poverty
- Large variations in annual and seasonal precipitation
- Water shortage for people, crops and livestock
- High population density in the highlands and midlands
- Environmental degradation
- Lack of education
- Lack of alternative employment opportunities in rural areas
- Lack of productivity enhancing products
- High business costs due to bad infrastructure and inefficient markets
- High levels of infant and maternal malnutrition (contributing factor of disease and mortality)

The severity and extent of the food insecurity varies greatly among the regions and the causes may vary (Riley et al., 2002). Several factors are characteristics of most food insecure regions of the country, and all of the factors are long term and affect food security during a

long time span.

The yearly agricultural production is low as a result of these factors (Riley et al., 2002). The continued use of traditional agricultural methods, the trust in precipitation rather than irrigated agriculture, farmer's failure to get access to improved seeds, fertilizers, pesticides, herbicides, effective gear and enough draft animals contribute to the low production.

The food challenge for Ethiopia is very similar to this global challenge- the need to increase food production and at the same time increase income and employment, and this needs to be based on agricultural growth (Riley et al., 2002).

2.2 Background of Ethiopia

Ethiopia is located in the northeastern part of Africa, with borders to Eritrea in the north and northeast, to Djibouti in the east, Somalia in the east and southeast, to Kenya in the south and Sudan in the west (Sjöberg, 2011a). The capital is Addis Abeda with a population of 3.3 millions (2010).

2.2.1 Terrain and Geology

The country is located in the fault fissure of Africa, which makes the landscape diverse, and can be divided into three major topographical regions; *the rift valley, the western highlands* (Ethiopian Highlands) and *the southeastern highlands* (east of the Shawa Plateau), see Figure 1 (Behrens, 2011a). The rift valley is a part of the east African rift system, a valley created by tectonically movements that penetrates the country lengthwise. It separates the other topographical regions and also includes the major part of the coastal region toward the Red Sea. The region is old sea floor that has through plate tectonics been removed from its old location next to the Arabian Peninsulas southwest edge.

The western highland is located to the west of the rift valley and has an altitude of between 2400 and 4000 meters above sea level and large mountain massive, plateaus and deep canyons constitutes it (Behrens, 2011a). The area is constructed of horizontal tuff- and basalt layer from the tertiary.

The southeastern highlands lie to the east of the rift valley and tertiary basalt is predominant in the area (Behrens, 2011a). Toward the Somali border, large flat areas spread out over the landscape, known as *Ogaden*.

The main soil in Ethiopia is volcanic with nutrient rich basalt and alluvial soils in the river valleys, making the soil fertile (Riley et al., 2002; Behrens, 2011a). The soil gets easily sticky when wet, and cracks when dry, which makes it hard to cultivate (Ofcansky and Berry, 1991).

2.2.2 Climate

The country is located in the tropical zone, but due to the regions location with its high altitude, the climate is highly heterogeneous, and in some regions, the climate is temperately (Behrens, 2011b). The highlands has a annual average temperature of 16°C and the lowlands average temperature is 31°C. The daily temperature amplitude in the highlands are as high as 32°C. The warmest month is in general May and the coldest December.

Figure 1: Map over Ethiopia with the major cities Addis Abeba and Dire Dawa marked in the map. The major topographical regions are also marked. Based on map from NE, 2011.

The precipitation in Ethiopia has a high variability and has in general two rainy seasons (Behrens, 2011b). The winds brings rainy weather and the rain starts when the air rises over the mountains in the southwestern parts of the country. The rain period reaches from June until September with a precipitation around 2500 millimeter per annum. During winter, a heavy precipitation falls during thunderstorms along the Red Sea coast after the dry season.

2.2.3 Flora

The cool and moist highlands in the west with an altitude of 3000 to 3500 meters above sea level were before deforestation caused by humans covered with forest. The warmer and drier lowland in the east is covered with more sparse vegetation on the Savannahs and deserts (Gärdenfors, 2011). The mountain forests natural vegetation is on lower altitudes tree savannah and forest, and deciduous forest grows on the volcanic soil. On higher altitudes, the deciduous forests are replaced with coniferous forest and on altitudes above the tree line the forests are replaced with grassland.

2.2.4 Agricultural History of Ethiopia

During the 1950´s, large economical investments in industry were made in Addis Abeba together with some other cities (Rubenson and Holmertz, 2011). The cotton- sugar- and coffee plantations made few people rich and the bad social circumstances began to get attention.

Crop failure, famine and oil crises resulted 1974 into a strike and commotions in Addis Abeba (Rubenson and Holmertz, 2011). Major changes were made in the country's governance, and the land was nationalized (the land is owned by the state), reforms in a more socialistic direction were introduced and the monarchy was revoked.

Eritrea, that had been a part of Ethiopia since 1952, became independent in 1993 when the civil war that started in the early 1970´s came to an end in 1991 (Rubenson and Holmertz, 2011). During the war, a large part of the population suffered from malnutrition (Kiros and Hogan, 2001). The map of Ethiopia was redrawn at the same time with administrative borders according to ethnical groups (Rubenson and Holmertz, 2011).

Despite the new federal ruling of Ethiopia the country was characterized by disputes between the different ethnical groups in Eritrea and Ethiopia (Rubenson and Holmertz, 2011). After a currency change by Eritrea the relationship between the countries became worse, when it hardened the foreign trade for Ethiopia, since a large part of the trade was through the harbors of Eritrea. A dispute over the borderline led to a war in 1998 that lasted until 2000. The war is estimated to have cost over 100 000 lives and made 350 000 Ethiopians homeless and during the same period a dry spell affected the agricultural production, costing many additional lives (Rubenson and Holmertz, 2011; Howe, 2010). Both countries received great criticism from international organizations that while spending tremendous amounts of money on the military, millions of civilians suffered from famine. The borderline dispute has remained tense since the end of the war.

2.2.5 Infrastructure

The size and topography of Ethiopia is to the country's disadvantage when it comes to infrastructure, and is one of the weak links in the economy (Sjöberg, 2011b). The road net is sparse even though large investments have been made to improve it.

The only railway in the country reaches from Addis Abeba to Djibouti, and was for a long time the dominating way for foreign trade, but are today in great need of maintenance.

The lack of infrastructure in the country has contributed to the food insecurity in the region, and the high costs of transportation have made it difficult to transport goods and crops to markets to a competitive price (UN Millennium Project, 2005).

2.3 Ethiopia's Population- Today and in the Future

Ethiopia has a population just more than 90 million (July 2011, estimation) and an average population of 75 persons per square kilometer (2010) (CIA World Factbook, 2011a; Sjöberg, 2011c). The population lives mainly in the highlands, as seen in Figure 2, and estimations show that around two thirds of all inhabitants live in areas with an altitude more than 1800 meters above sea level (Sjöberg, 2011c). The country has a high population growth, with an annual increase of 2.6 percent (see Figure 3) (FAO/WFP, 2010). It is also estimated that 50

percent of all Ethiopians are under the age of 20 and more than two thirds are have not yet reached the age of 30 (Sjöberg, 2011c).

2.3.1 Social situation in Ethiopia

Around 85 percent of the Ethiopian population lives in rural areas under difficult circumstances (GOE, 2000). One out of four lives under the poverty line, which means less than a dollar a day (Sjöberg, 2011d).

Healthcare is badly prioritized; in 2001 only 45 percent of the population had access to formal health care and there were only one doctor per every 30 000 inhabitants (Berhane et al., 2001; Kaluski et al., 2002).

Only 42 percent of the population has access to clean water and parasites in the water are a common cause of death (Sjöberg, 2011d). The situation is somewhat better in urban areas, but they have a high shortage of housing and expanding slum areas. The unemployment is very high and it is only persons with formal work whom have the right to pension and some social benefits, but for the major part of the population, this is not the reality. In 2008 the life expectancy for men was 48 years and 51 years for women, but people rarely dies as a direct consequence of hunger; it is more common that they perish from diseases that are strongly accelerated by malnutrition (Myers and Kent, 2001).

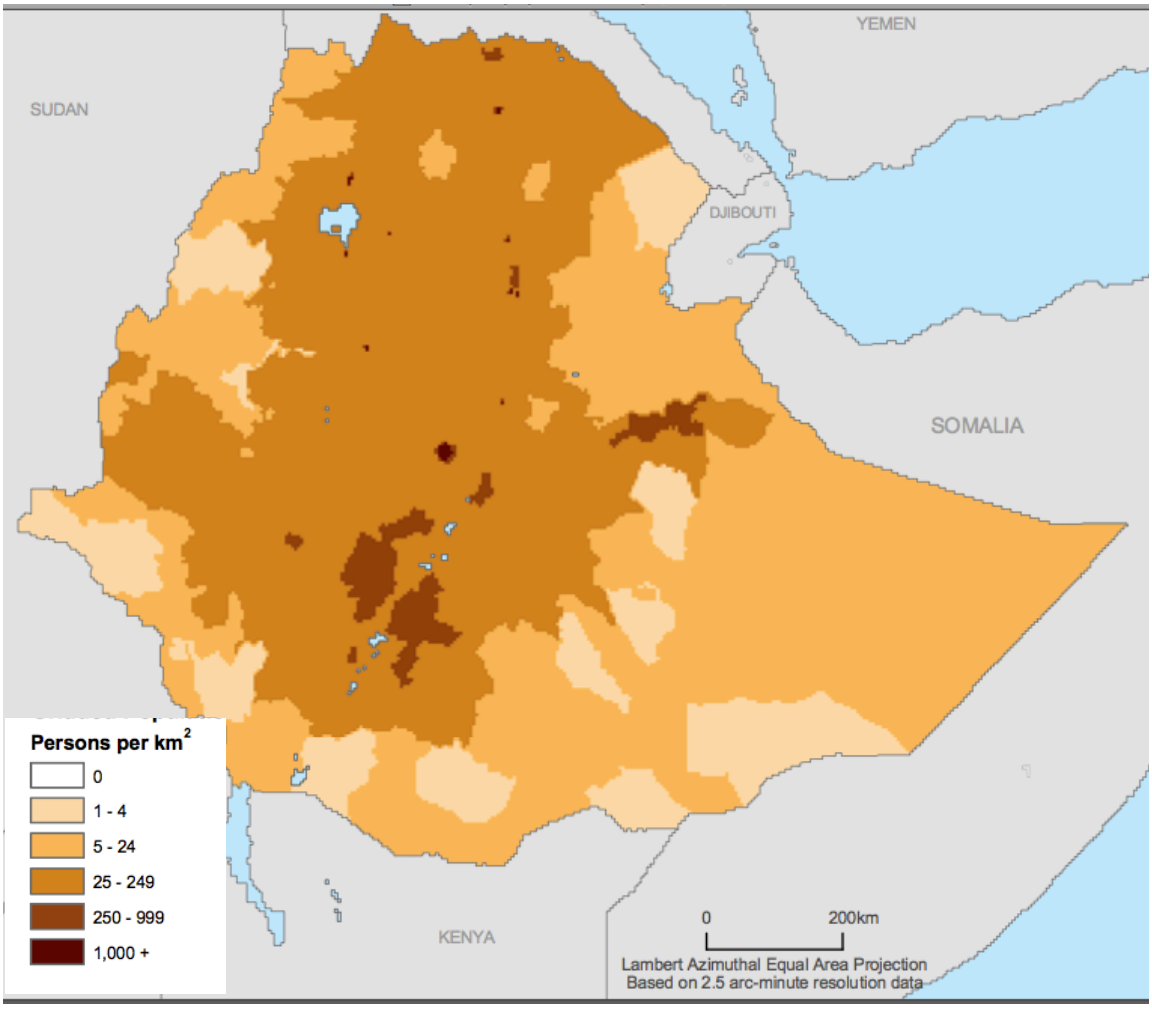


Figure 2: The population density in Ethiopia per square kilometer in 2000. The highest population density is on the Shewa Plateau, but the highlands are densely populated aswell. Map reprinted with permission from Sedac and Ciesin, 2005.

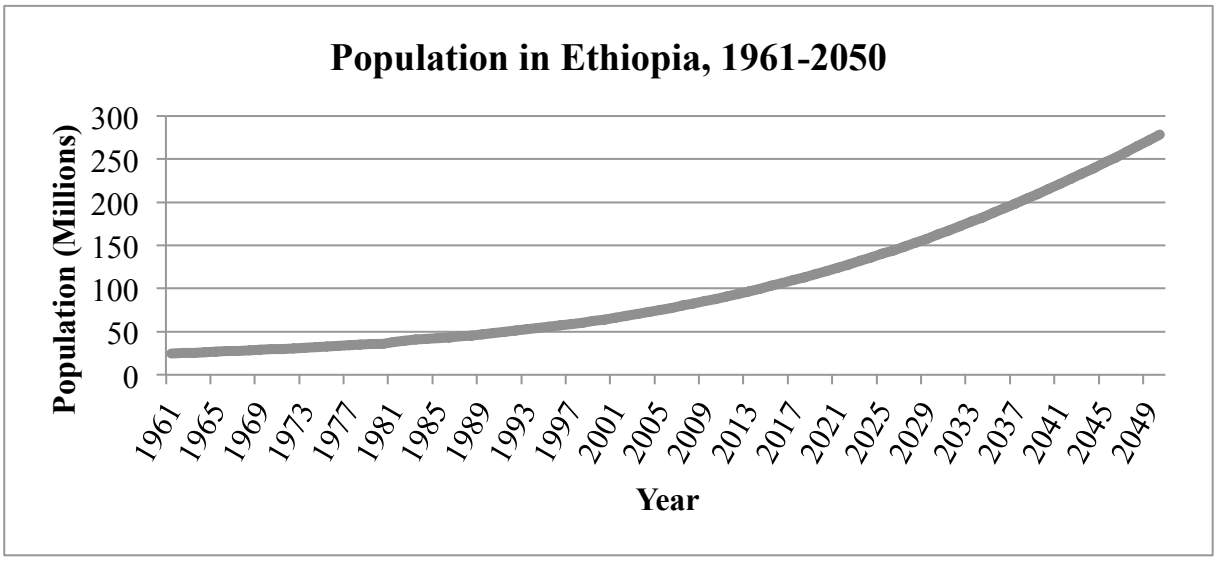


Figure 3: The projected change in population in Ethiopia between 1990 and 2050. Based on data from U.S. Census Bureau, 2011a.

2.4 Agriculture in Ethiopia

It is estimated that 80 percent of the population gain their livelihood from agriculture and pastoralism in Ethiopia (FAO/WFP, 2010). Despite attempts to introduce modern methods into the cultivation system during the time after the Second World War, it has remained out dated (Sjöberg, 2011e). A new type of land ownership was introduced in the country; the land was nationalized and divided with the right to cultivate the land between members of farmers associations. In the years 1979 and 1980 a collectivization of the land was started, and from the mid 1980´s it was often combined with merging free farms into new settlements. A complete collectivization, like the Soviet type was never finished, and in 1988 only 1/20 of the cultivated land was embraced by the producing collective. Since 1991, the Ethiopian farmers have gained more freedom making their own economic decisions. Of the total area of Ethiopia, only one eight is considered to be cultivatable (Sjöberg, 2011e).

Crops that have had great importance in Ethiopian agriculture are the domestic cereal teff (*Eragrostis tef)*, barely (*Hordeum)* and durra (sorghum, *Andropogon sorghum*), but they are today replaced by wheat and maize to a major part (Sjöberg, 2011e). Teff is nevertheless the most valuable cereal crop, but is not as productive as maize, durra, wheat and barley (FAO/WFP, 2010). Other crops grown are animal food, leguminous plants and oil plants (Sjöberg, 2011e). In the lowland parts of the country the agriculture is on a household level and slash and burn is a common cultivation method in rural areas. But occasionally the farmers practicing this method end up in conflict with the large-scale farming and new settlements with immigrating highland farmers, with large cattle and livestock keepings. There is a fine balance between the animal keeping and agriculture; the massive livestock keeping have in many cases contributed to environment degradation. This became worse after the land reform and the efforts that were made to expand the corporate sector, and a lacking understanding in the need of animal keeping and the importance of this for the farmers.

The agriculture in Ethiopia is still very labor intense, where two oxen pull the plough (FAO/WFP, 2010). The soil is ploughed until its very fine, especially were teff will be grown, since it needs a very fine seedbed. Because of this, the soil becomes very prone for erosion, especially on slopes, where many farms are located.

In 1999, only 4 percent of the arable land in Sub-Saharan Africa was irrigated compared to 31 percent in East and North Africa, 42 percent in Asia and 14 percent in Latin America (Riley et al., 2002). Irrigation may increase yields with up to 400 percent. In Pakistan, 80 percent of the food produced comes from irrigated land, in China 70 percent, and in India and Indonesia more than 30 percent. But in Ghana, Malawi and Mozambique, only 2 percent of the food comes from irrigated land. In Ethiopia the number is even less; 1 percent.

For Ethiopia, the average agricultural production trend per capita each year between 1971 and 2000 was -1.15 percent (FAO/WFP, 2001). In the 1970´s the estimated average decline was -0.84 percent, in the 1980´s -1.98 percent and during the 1990´s -0.64 percent. But between the years 1994 and 1998, Ethiopia showed an increase in food production of 2.6 percent (Myers and Kent, 2001) and according to FAO/WFP (2010) the cereal production it self is increased with 10 percent per annum between 2007 and 2009. As seen in Figure 4, the production of cereals in Ethiopia was 2009 just above 14 million tonnes and has shown a

positive trend since 1960, but so had the population. As seen in Figure 5, the annual cereal production per capita has fluctuated highly during the same time span. The production per capita has varied between below 100 kilos per person and year up to 180 kilos per person and year. Other African countries, as a group, showed during the 1990´s a small positive average annual growth in agricultural per capita production (Riley et al., 2002). The variations in rainfall explain much of the annual changes in production.

In the highlands of Ethiopia, where the landscape is relatively flat, the agriculture is to some extent mechanized, making productivity of the region higher. But farms in more food insecure areas are small and fragmented and are often located on steep hill- and mountainsides; 37 percent of the farming households cultivate less than 0.5 hectares, 87 percent cultivate less than 2 hectares (Mulat, 1997; FAO/WFP, 2010). The lack of irrigation, rainwater harvesting and watershed management prevents farmers to produce more (Mulat, 1997). The low per capita production is also a consequence of the low use of fertilizers- both organic and chemical alternatives. The usage of fertilizers reached in 1996 to 251 000 tonnes, but the average use was still only 10.8 kg per hectare usable land and year, compared to 48 kg per hectare and year in Kenya and 60 kg per hectare and year in Zimbabwe (World Bank, 1995) The recommended usage is 200 kg per hectare and year by the Ethiopian Government (Jayne et al., 2003). One of the most common and most-value-for-money fertilizer is DAP (DiAmmonium Phosphate), and 100 kg of the fertilizer contains 18 kg of nitrate (World Bank, 1995). The recommended use in Sweden is up to 185 kg nitrate per hectare and year, but this is highly dependent on the yield of the area (Albertsson, 2008) In 2000, only about one third of the cultivated land in Ethiopia (2.8 million hectares) was treated with fertilizers and only 20 percent of the farmers in Ethiopia had access to fertilizers (Riley et al., 2002). Other factors that contribute to the low productivity in Ethiopia are the diseases that are caused by the malnutrition where Malaria has a high contribution factor. The high amount of religious holidays in the country also contributes to the loss of labor, and so does the non-cropping and herding workload for women (Riley et al., 2002).

The usage of GMOs (Genetically Modified Organisms, seeds and crops with a higher resistance to drought and nutrition deficit than other seeds) is very low; less than 10 percent of the farmers use GMOs even though it is an effective way to increase the yields (FAO/WFP, 2010). This is due to difficulties for suppliers to meet the demand and lack of money of farmers.

Of all the grains that were harvested in 1996, farmers sold 79 percent directly after harvest to prices decided by various costs such as taxes and traders profit (Dessalegn et al. 1998). But there are several constrains before arriving at the market; grain checkpoints, unavailability of transport, high transport costs, lack of storage and lack of market information. Additionally, traders is faced by a numbers of uncertainties caused by the market itself and a number of external factors such as weather, civil unrest, banditry, etc. and due to this, the purchasing price from the farmers is additionally 30 percent lower than what the prices on the market suggests.

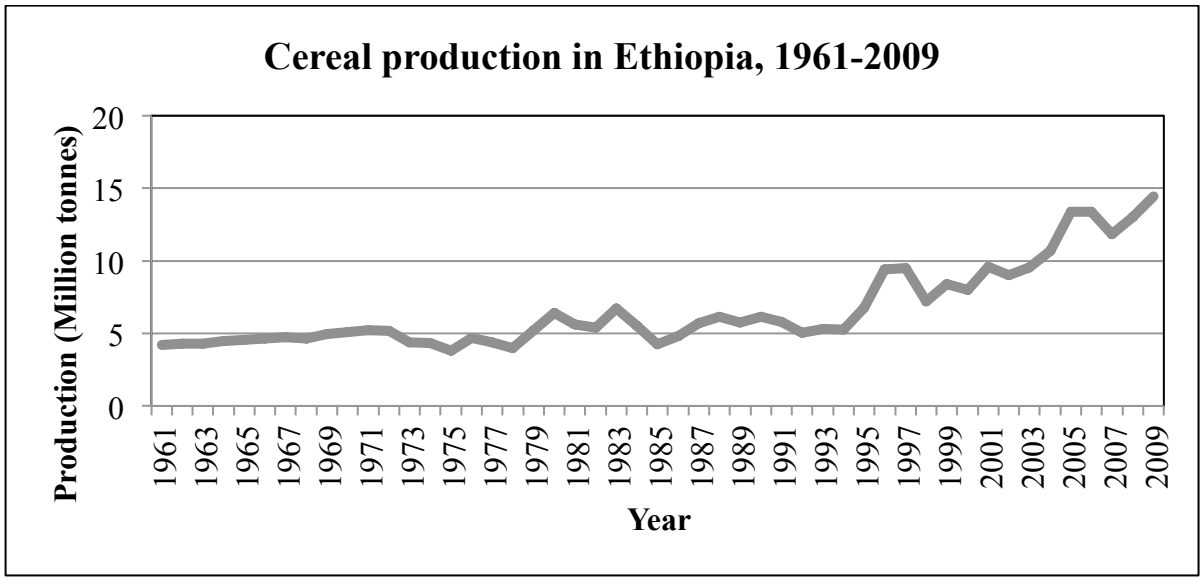


Figure 4: The trend in cereal production in Ethiopia, 1961-2009. In recent years there has been an increasing trend in the production. Data from U.S. Census Bureau (2011c).

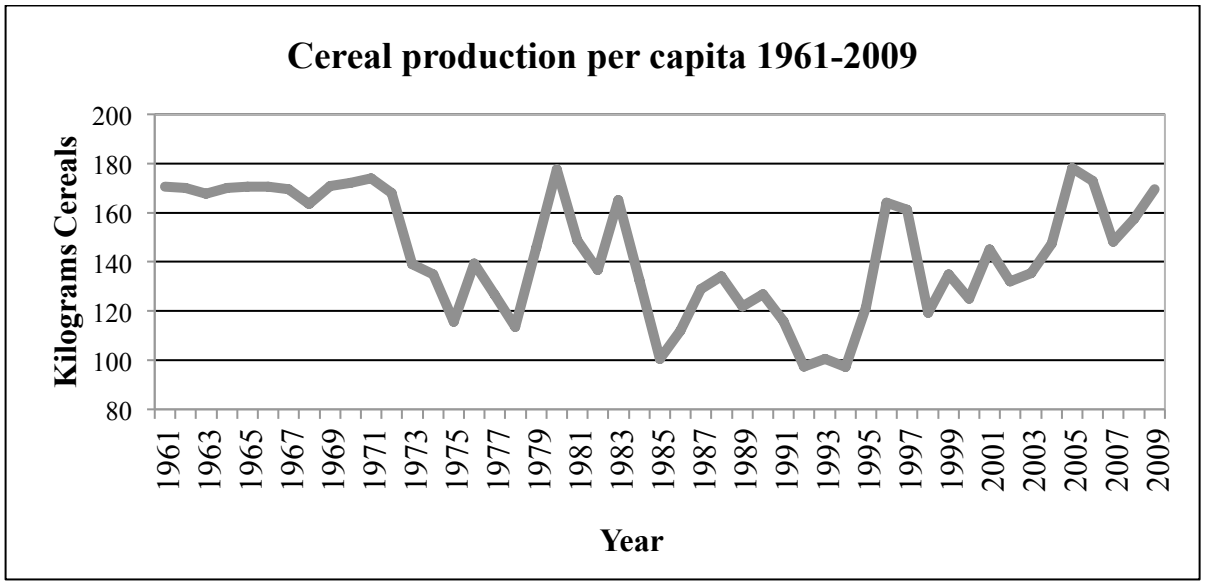


Figure 5: The cereal production per capita has fluctuated highly between 1961 and 2009, from below 100 kilos per person and year during the 1980´s and 1990´s, up to 180 kilos per person and year in 1980 and 2005. Data from U.S. Census Bureau (2011c) and FAOSTAT (2011).

2.4.1 Export

The export sector in Ethiopia is highly dependent on the agriculture. During 2009, the main exported goods were coffee, oilseeds, chat, leather and leather products, pulses and gold (FAO/WFP, 2010). The total of exported goods in 2009 was 1.2 percent less than the previous year due to declining prices of coffee, leather and pulses.

Ethiopia's location as landlocked within Africa has made export very difficult and it is far away from global markets (Riley et al. 2002). The country has not benefited at all from economic globalization. Except from coffee, Ethiopia exports very little of the goods that a typical tropical country does and that wealthy country consumers are willing to pay a high price.

2.5 A Changing Environment in Ethiopia

Ethiopia is considered to be one of the countries in the world with most serious soil degradation (Howard et al., 1995). Attempts have been made to conserve the soil and decrease the erosion, and focus have been on planting new forest and building structures like bunds, terraces and check dams in attempts to control soil erosion by water and wind. Between 1976 and 1990 large efforts were made to prevent erosion e.g. building terraces, but when the project was over only a small part of the different methods remained. The problem with soil erosion is not gone; still an estimated 12 tonnes of soil per hectare (1990) is lost each year (Howard et al., 1995). In the densely populated highlands, erosion has led to serious degradation on one fourth of the area, and moderate degradation on one third of the area. In 1990, on 4 percent of the highland area (two millions hectare), the soil depth was so reduced that it cannot longer support cultivation (GDROE/IUCN 1990). The increasing pressure on soil by population and livestock, and failure to return organic matter to the soil, have reduced the fertility of the soil. The demand of fuel wood and the shortage of it, have led to usage of manure and straws, and this has contributed to nutrient loss in the soil (FAO, 1995).

Agriculture and development of livestock keeping are according to Riley et al. (2002) the only dependable alternatives for improving food security and food sufficiency in Ethiopia. But it is dependent on the sufficiency of good quality cropland, water and a good amount of pastureland to be able to produce enough food and additional income for the Ethiopians. But there are problems with this; during recent decades the combination of environmental degradation and a rapid population growth has led to severe erosion, overgrazing and decreasing ground and surface water maintenance. These are together one of the most severe problems that are contributing to chronic and acute food insecurity and increasing the vulnerability of households.

Drought is not the same thing as famine, but the absence of precipitation may have devastating consequences on food security (Chaibva, 1996; Tadessse et al., 2008). There are both natural and human causes of draught. Natural causes may be meteorological and topographic features. Human causes may be land use methods and global warming (Chaibva, 1996). There have been drought throughout the history of Africa, and it has occurred with a variety of frequency and intensity (Tadesse et al., 2008). But politics and management affect the shortage of food much more than the weather. Drought affects different countries in

different ways, having a greater impact on poorer countries that do not have the ability to adapt and manage the situation (Tadesse et al., 2008). The economic, social and political circumstances in many developing countries can reduce the household food security. Food emergencies may have long lasting impact on incomes of households when they try to find new ways to find food and income, and it may engage unsustainable methods (Davies, 2000).

3. Sub-Saharan Africa and Eastern Africa

3.1 Food in Sub-Saharan and Eastern Africa

The supply of food has great global variations where South Asia and SSA is of great concern (Riley et al., 2002). The difference between the production of cereal and market demand is forecasted to increase from 1 million tonnes in 1990 to 24 million tonnes in 2020 in South Asia, and the same number for SSA is to triple to 27 million tonnes in 2020. The gap is expected to be even greater unless poverty is reduced significantly and SSA is particularly unlikely to be able to import foodstuff (substances that can be prepared for or used as food) commercially. According to Riley et al. (2002) the central challenges in the coming decades will be to produce enough food with an environmental sustainable method, and to increase food production in poor countries, not only to increase food supply, but also to generate income for the labor workers and employment through agricultural work.

One of the main reasons for the poor development in Africa is according to Riley et al (2002) the geography. Considering the facts that there is no major passable river in SSA making it possible to navigate in to and out from the resource rich interior. On other continents, the Amazonas, Rhine and Mississippi have opened up ways for trade, while waterfalls and other obstacles on the way to the oceans interrupt the major rivers of Africa, the Congo, Nile and Zambezi. Because of the size and shape of the continent, much of interior Africa is far away from the oceans, and it is difficult to make transportation roads in the mountainous landscape. According to Myers and Kent (2001) these are also the reasons why the region is unfavorable for sustainable agriculture.

There have been several contributing factors to the food situation in SSA today; declining food productivity per person, declining food imports in relation to needs and high population growth are some (Myers and Kent, 2001). In many countries the population has passed the carrying capacity (the maximum population load the environment can sustain given food, water, habitat and other necessities) with declining stocks of cropland, water and fuel wood access per person, soil erosion and degradation, and desertification (Myers and Kent, 2001). Research made by the UN University (2000) shows that if these trends were to continue, Africa will only be able to feed 40 percent if its population by 2025 unless large changes are made by the governments (see section *4. How to Achieve Food Security in Ethiopia, Sub-Saharan and Eastern Africa)*.

3.2 Countries of East Africa

The countries in focus for future cereal production are, except from Ethiopia, Sudan, Eritrea, Somalia, Kenya and Uganda, and to give a picture of the food situation in these countries a short introduction is given in this section. In Figure 6 the location of the countries can be seen. The population growth for the countries can be seen in Figure 7 and production of cereals in Figure 8. The cereal production has showed an increasing trend for most countries since 1961.

In Sudan, the main income comes from oil and agriculture (CIA World Factbook, 2011b). One third of the Gross Domestic Product (GDP) comes from agriculture and 80 percent of the population has their employment in the sector. The main crops grown in the

country are e.g. cotton, groundnuts, wheat and sorghum. The per capita cereal production for 1961 to 2009 can be seen in Figure 9. The per capita production varies between around 6o kg to 200 kg (FAOSTAT, 2011; U.S. Census Bureau, 2011c). The population has in some years had access to 180 kg per person; the amount of cereal a person is allocated during food aid (Kaluski et al., 2002; FAO/WFP, 2010).

Eritrea is at the moment developing their mining industry, but as many other African countries the main employment sector is agriculture where 80 percent of the population works (CIA World Factbook, 2011c). The main crops in the country are sorghum, lentils, vegetables and maize. There is also a fishing industry at the coast. The Eritrean people have been in the need of food relief during recent years due to drought. As seen in Figure 10, the production of cereals are low, and the per capita production has never been over 150 kilos per capita and year, nowhere close to the 180 kilos of cereal that a person is accounted for during food relief (FAOSTAT, 2011; U.S. Census Bureau, 2011c).

Somalia has a large livestock sector that accounts for around 40 percent of the GDP and more than 50 percent of export income (CIA World Factbook, 2011d). The main production except livestock is fish and leather, and agricultural crops grown are bananas, maize, sorghum and beans. In Figure 11 the per capita production of cereal per year in Somalia can be seen, and the trend is declining (FAOSTAT, 2011; U.S. Census Bureau, 2011c). The per capita production has not been above the critical line of 180 kg per capita and year.

Kenya has a corrupted economy and this has formed the country during the last decades and pushed the country into economical problems (CIA World Factbook, 2011e). The agriculture employs almost 80 percent of the population and stands for 22 percent of the GDP. The main crops are tea, coffee, maize, wheat and sugarcane. The trend in cereal production per capita has been downwards (see Figure 12), but until late 1970´s the annual per capita production was above 200 kg, but since this point, the per capita production has been around 150 kg or below (FAOSTAT, 2011; U.S. Census Bureau, 2011c).

Uganda has extensive natural resources with copper, gold, minerals and newly discovered oil (CIA World Factbook, 2011f). Still, the main income is from agriculture, with a fertile soil and regular rainfall, and 80 percent of the population works in the agricultural sector. Coffee is the main crop together with tea, cotton maize and millet. The population growth in Uganda is high, with a yearly increase of 3.6 percent, which results in a larger population than any of the other countries in 2050, see figure 7 (CIA World Factbook, 2011f) The per capita production was declining until the middle of the 1980´s and the annual per capita productions is about constant since then, see Figure 15 (FAOSTAT, 2011; U.S. Census Bureau, 2011c).

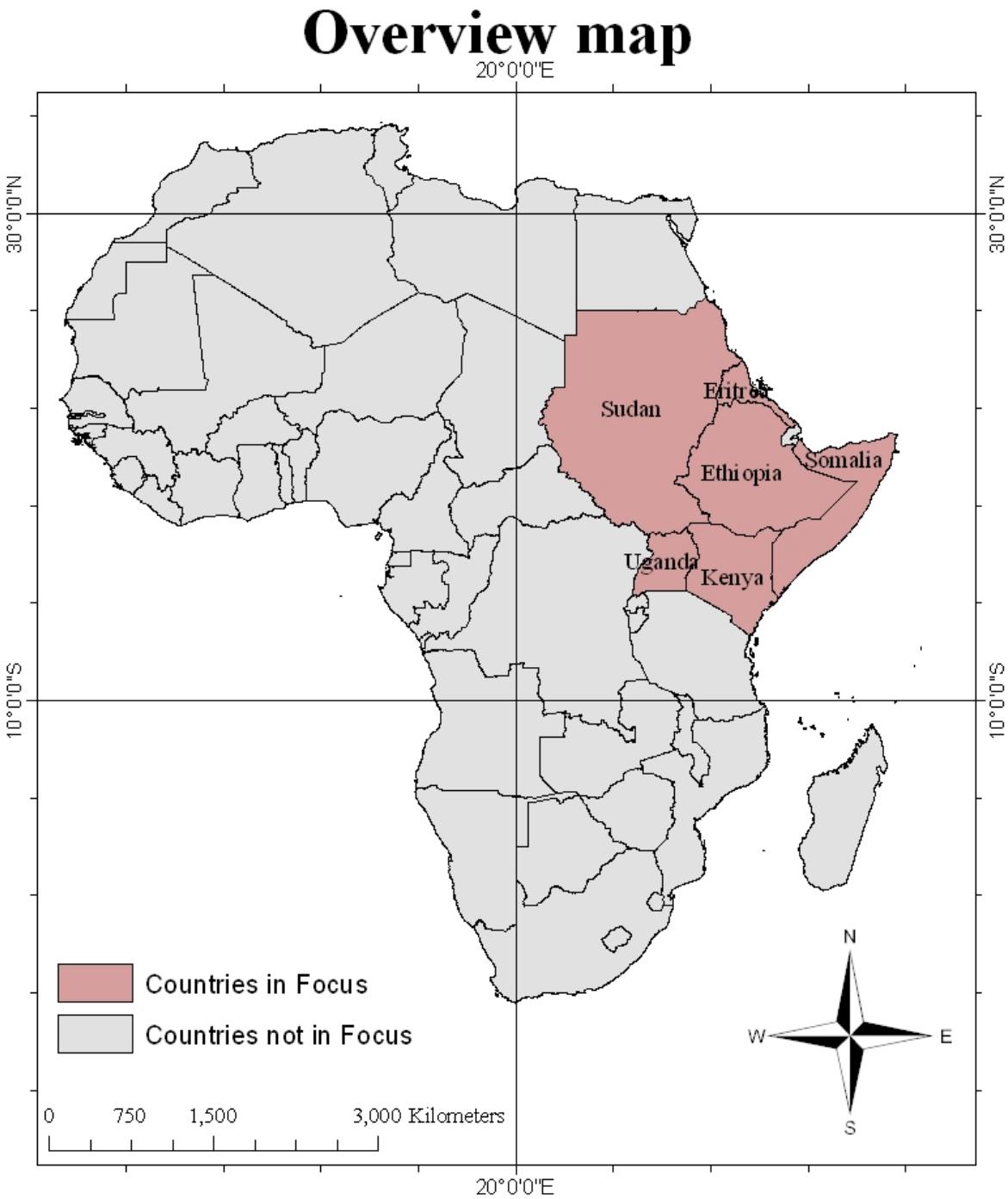


Figure 6: Location of the countries in focus.
Projection: WGS 84
Map of Africa from GIS-LAB, 2011

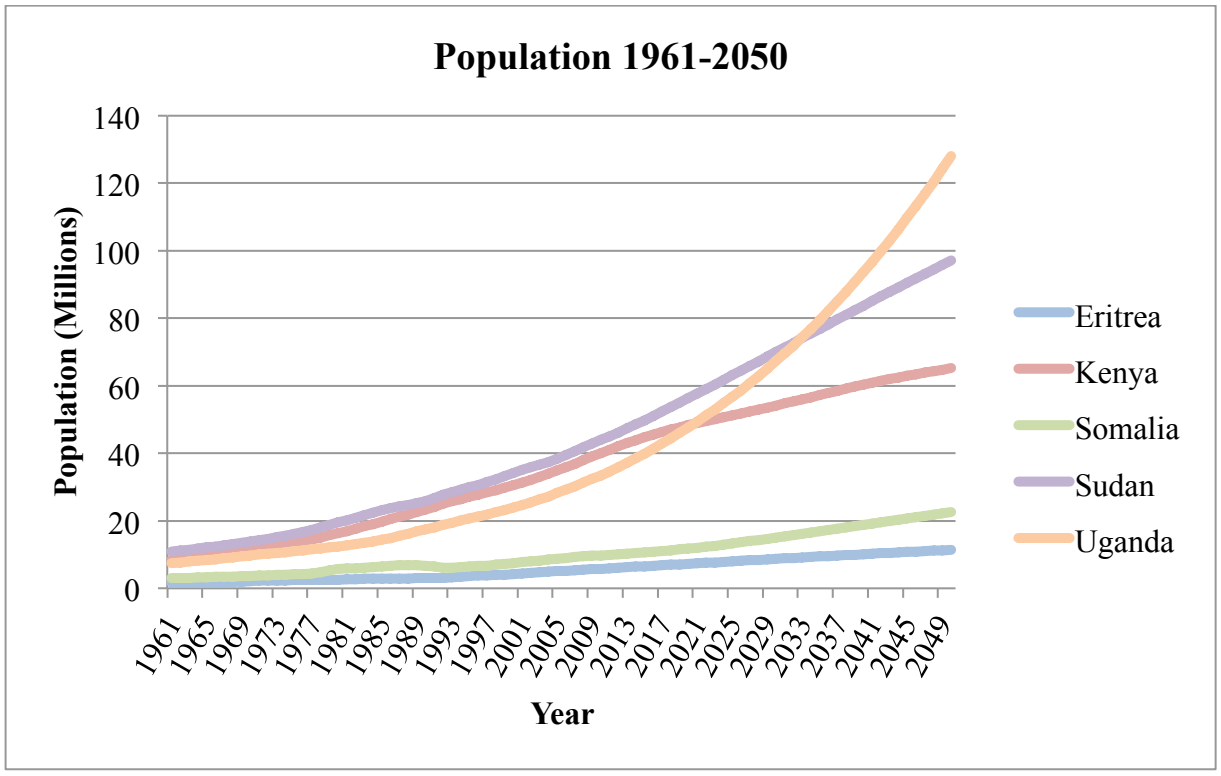


Figure 7: The population growth of the countries in focus, 2010 to 2050 is projected. Uganda show the most rapid population growth with a annual increase of 3.6 percent in 2011 (estimated) (CIA World Factbook, 2011f). Data from U.S. Census Bureau (2011c).

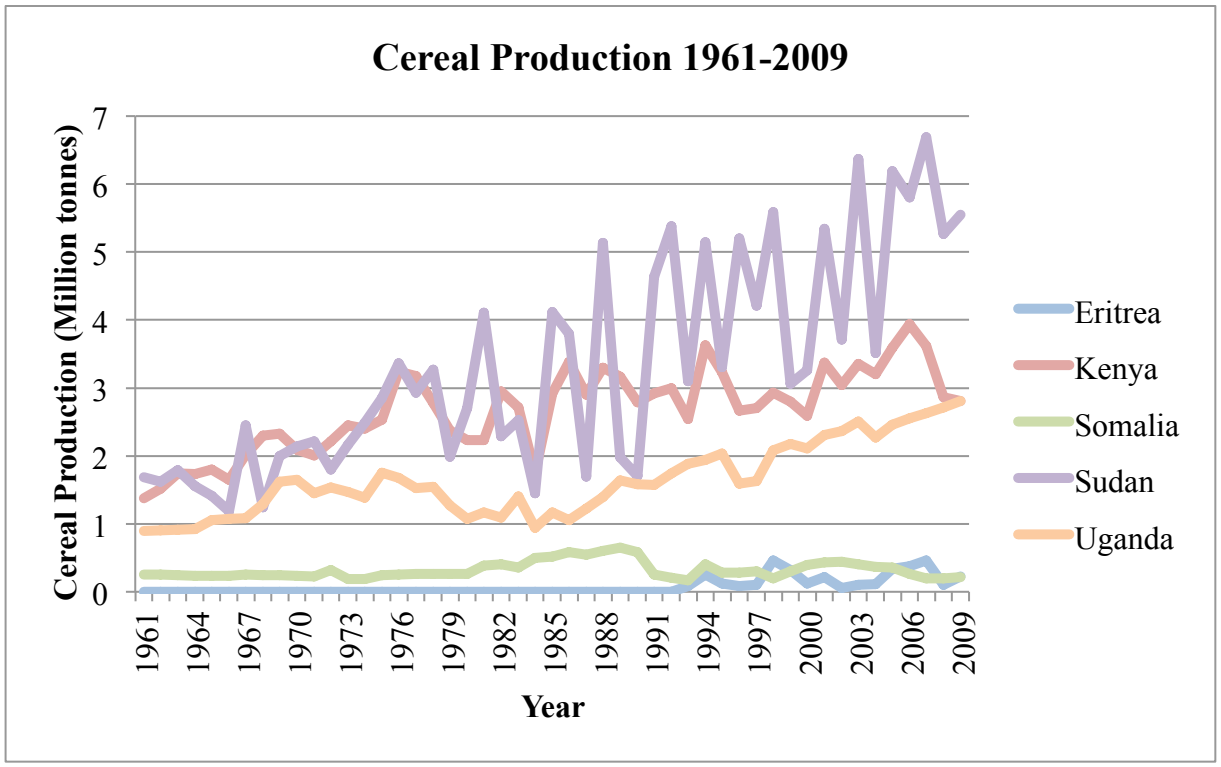


Figure 8: The production of cereals in tonnes in the countries of focus. Almost all countries have increased their production. No data was available for Eritrea before 1993. Data from FAOSTAT, 2011.

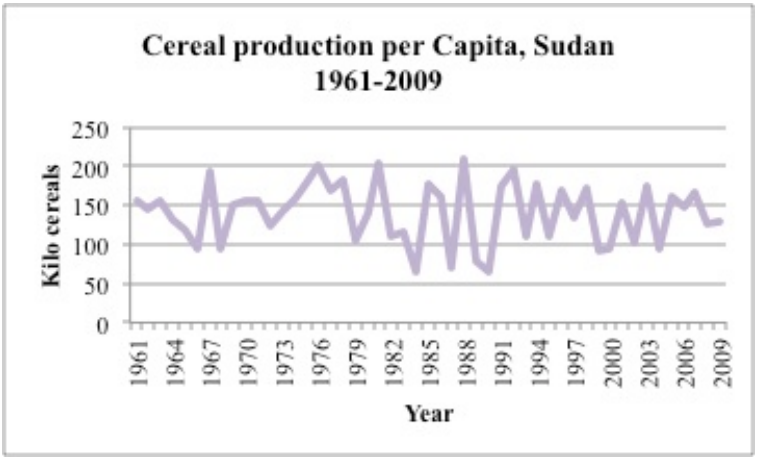


Figure 9: Cereal production per capita in Sudan. The trend in the figure is highly fluctuating, and no general trend can be seen. Data from FAOSTAT (2011) and U.S. Census Bureau (2011c).

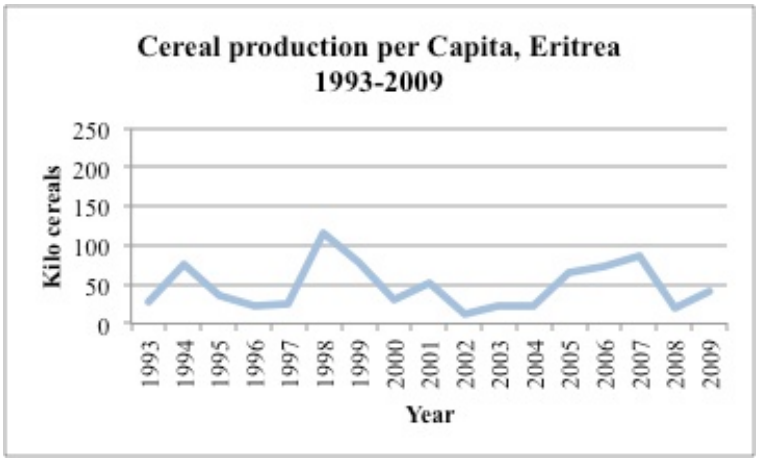


Figure 10: Cereal production per capita in Eritrea. The trend is highly fluctuating, and no real trend can be seen in the per capita production. Data from FAOSTAT (2011) and U.S. Census Bureau (2011c).

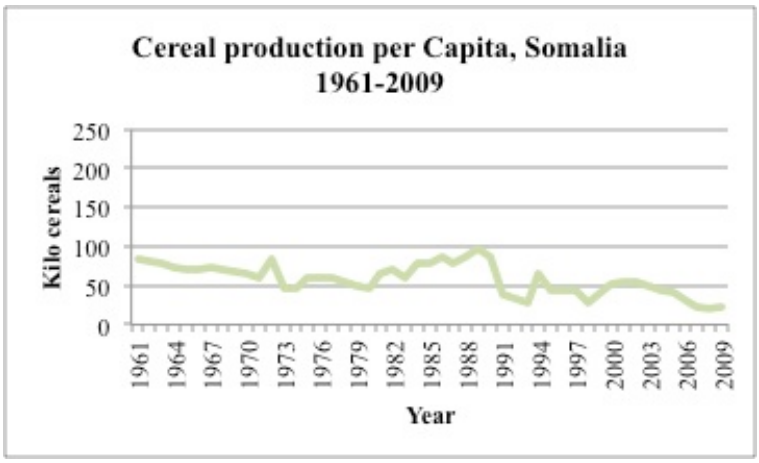


Figure 11: Cereal production per capita in Somalia. The general trend shows a declining per capita production. Data from FAOSTAT (2011) and U.S. Census Bureau (2011c).

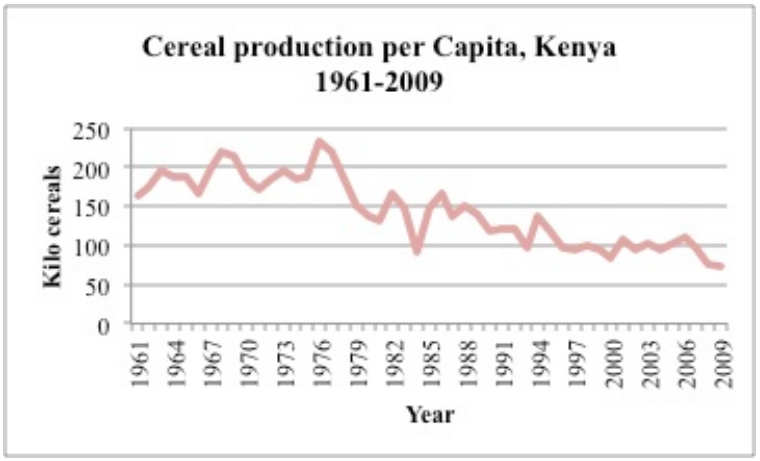


Figure 12: Cereal production per capita in Kenya. The general trend is declining, but the per capita production was until late 1970´s above 200 kg per capita, but has since then been 150 kg per capita or below. Data from FAOSTAT (2011) and U.S. Census Bureau (2011c).

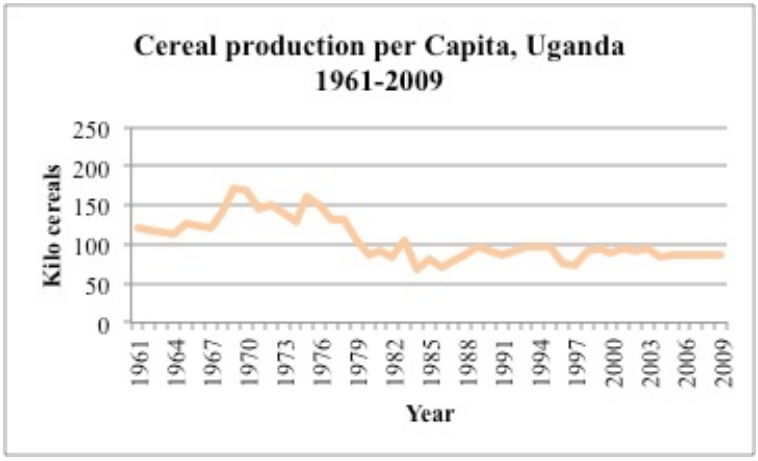


Figure 13: Cereal production per capita in Uganda. Until the middle of the 1980´s the average production trend per capita was declining, but the trend stabilized during the later part of the 1980´s and the per capita cereal production during the 2000´s was stable. Data from FAOSTAT (2011) and U.S. Census Bureau (2011c).

3.2.1 The Future of Food Sufficiency in Eastern Africa

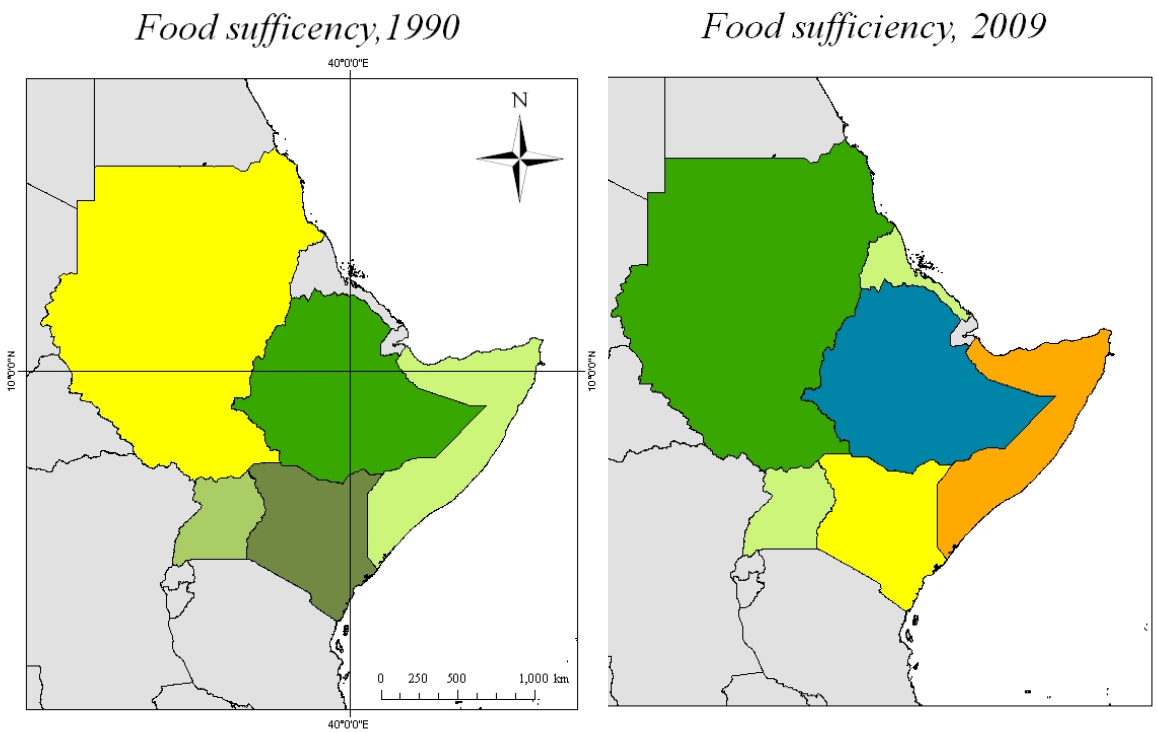
The maps in Figures 14 to 27 show how large part of the population that have been fed in 1990 and 2009 and can be fed in 2030 and 2050 by domestic cereal production i.e. the countries food sufficiency. The cereal production is based on scenarios with increases of 1 percent, 3 percent and 5 percent per annum and decreases with 1 percent, 3 percent and 5 percent per annum. The midyear population is used for the population data (U.S. Census Bureau, 2011c). Every human has access to 15 kg of cereals each month, or 180 kg per annum.

As seen in Figures 14 to 27 it is clear that the majority of countries needs to increase their cereal production with at least 5 percent per annum until 2050 to attain food sufficiency (Figure 21), but some countries, Ethiopia, Sudan and Kenya, may be self sufficient in cereals if the yearly increase is 3 percent until 2050 (Figure 20). For Sudan in 2030, with an annual increase of 1 percent, they will be able to support between 61 and 70 percent of their population (Figure 16), but the increase in population is so rapid, that in 2050, they will only be able to support 41 to 50 percent of their population (Figure 17). The same trend is also seen for all the other countries, except for Somalia, where they will be able to feed only 11-20 percent of their population, both 2030 and 2050 (Figures 16 and 17).

If the production decreases with 3 percent until 2050, none of the countries will have food sufficiency for more than 10 percent of their population (Figure 25), and if the decrease is 5 percent per year, none of the countries will have food sufficiency in 2030 for more than 10 percent of their population (Figure 26). Even if the decrease is as small as 1 percent per annum, four countries, Ethiopia, Eritrea, Uganda and Somalia will not have food sufficiency for more than 10 percent of their population in 2050 (Figure 23). Somalia will be in this situation in 2030 as well with a decrease of 1 percent per annum (Figure 22). Even in 2009, Somalia could only feed up to 20 percent of their population (Figure 15).

Ethiopia, that are in focus for this paper, had a good year in 2009 (Figure 15) according to this analysis, they were able to feed 91 to 100 percent of the population, and this was an increase compared to 1990 when they could feed 71 to 80 percent of the population (Figure 14).

Uganda decreased their food sufficiency with domestic produced cereal between the years of 1990 and 2009, and so did Somalia (Figures 14 and 15). There was no available data for Eritrea for 1990.



Figures 14 and 15: The food sufficiency for the chosen countries in 1990 and 2009. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.

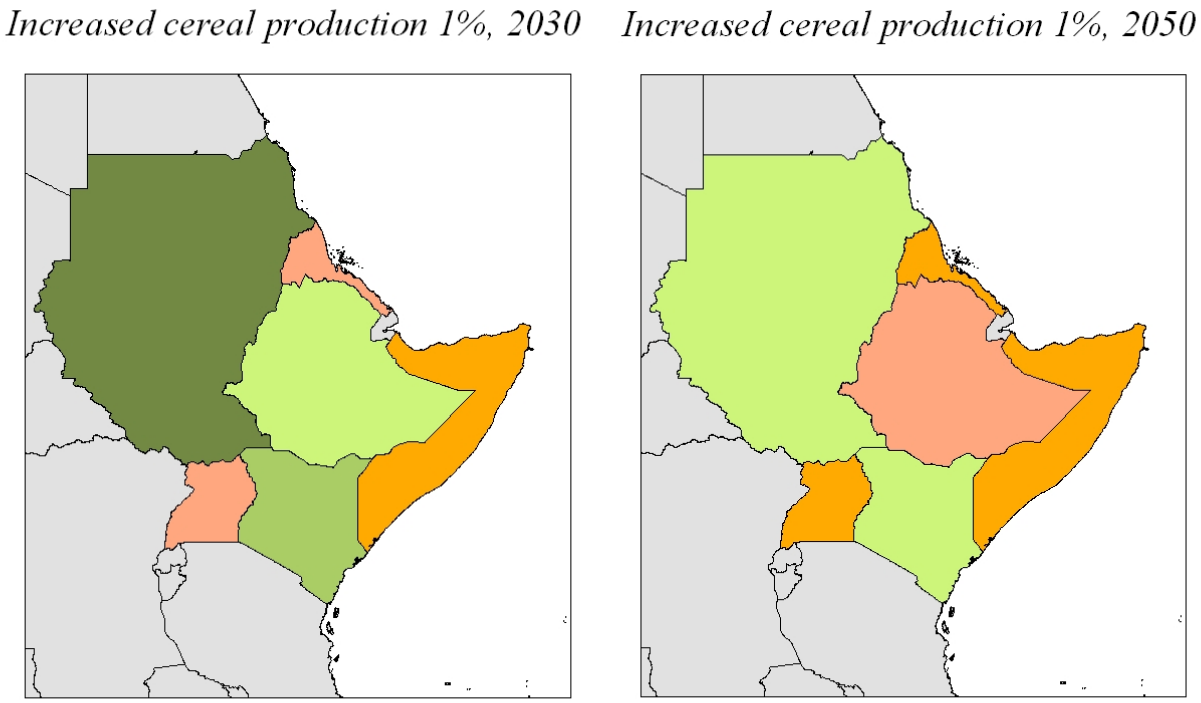
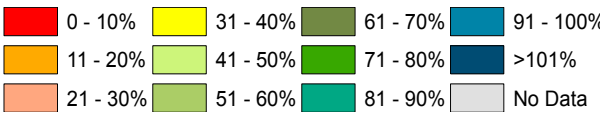


Figure 16 and 17: The percentage of population that can be fed in 2030 and 2050 if the cereal production increases with 1 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.



Increased cereal production 3%, 2030 *Increased cereal production 3%, 2050*

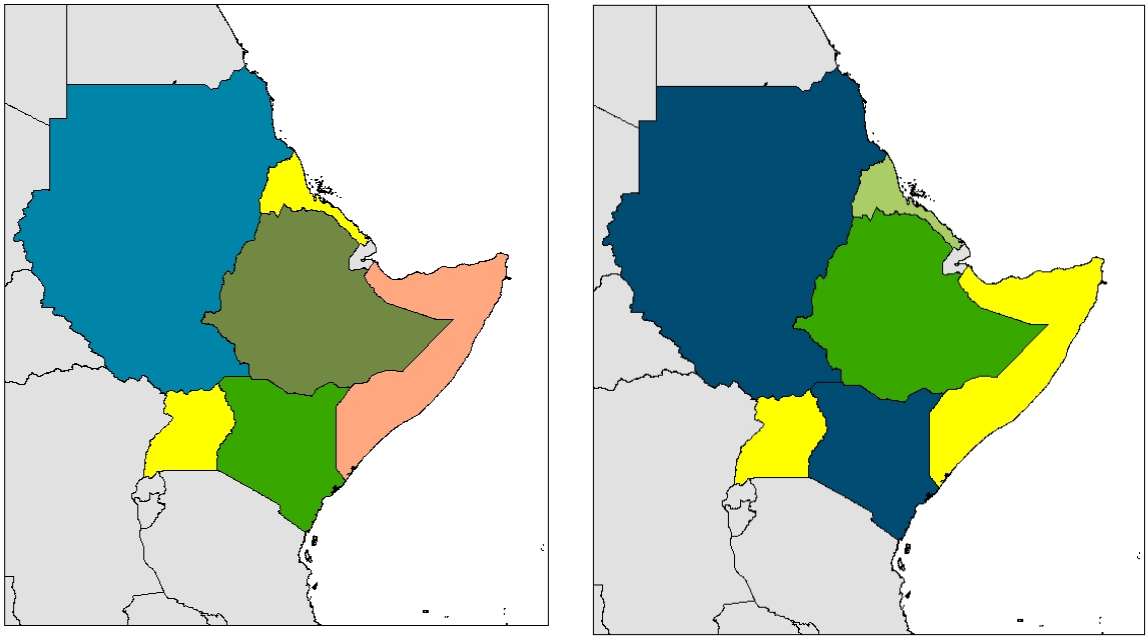


Figure 18 and 19: The percentage of population that can be fed in 2030 and 2050 if the cereal production increases with 3 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.

Increased cereal production 5%, 2030 *Increased cereal production 5%, 2050*

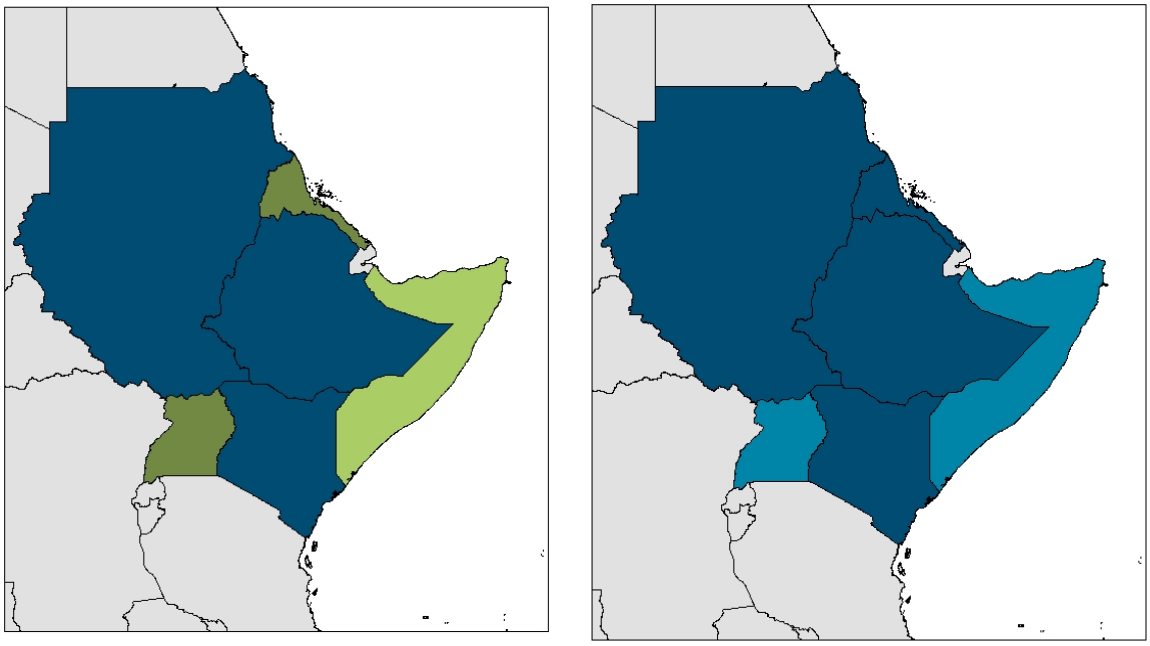
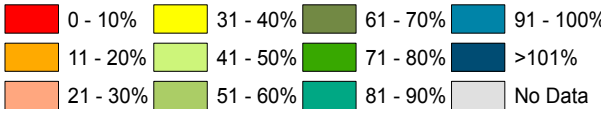


Figure 20 and 21: The percentage of population that can be fed in 2030 and 2050 if the cereal production increases with 5 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.



Decreased cereal production 1%, 2030 *Decreased cereal production 1%, 2050*

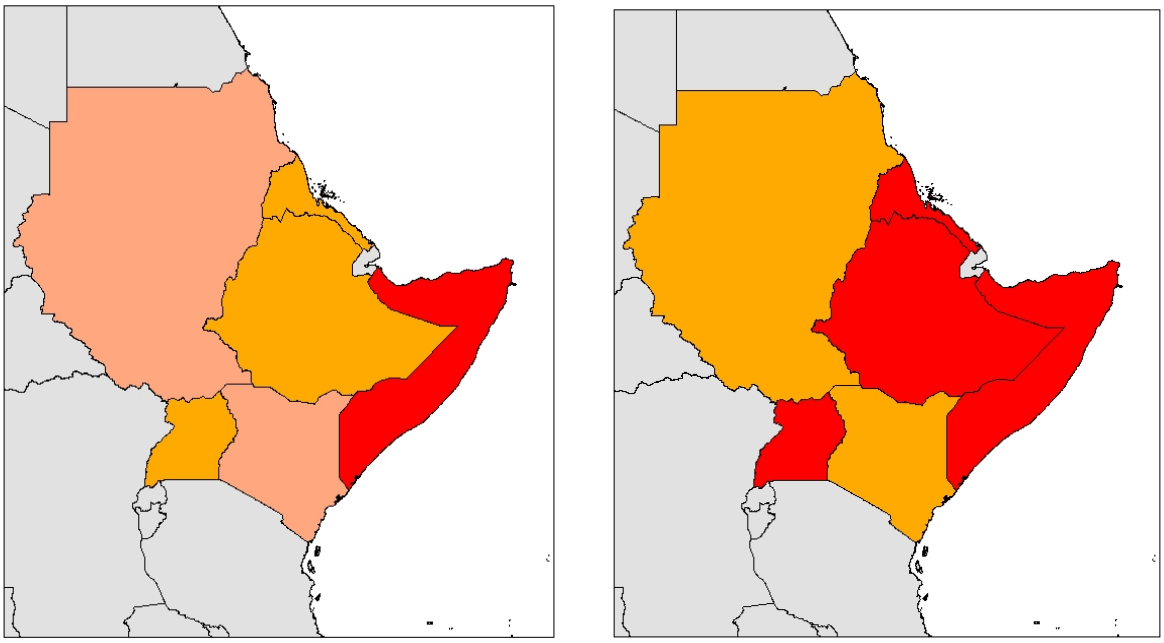


Figure 22 and 23: The percentage of population that can be fed in 2030 and 2050 if the cereal production decreases with 1 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.

Decreased cereal production 3%, 2030 *Decreased cereal production 3%, 2050*

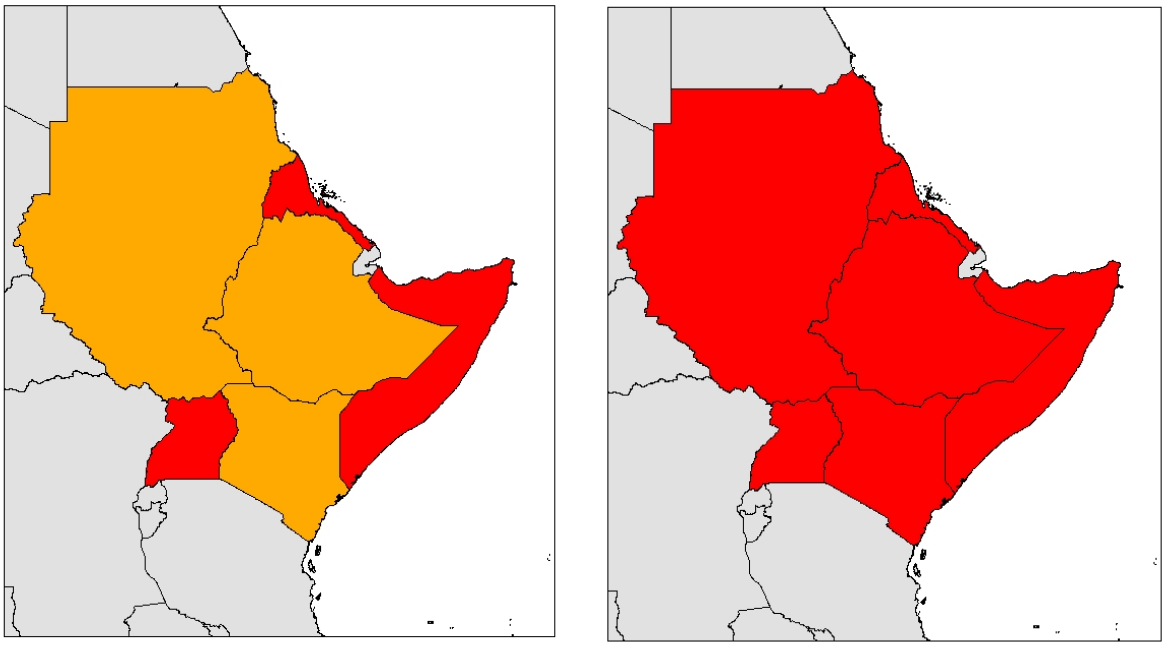
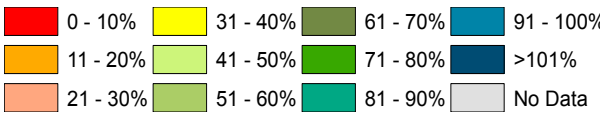


Figure 24 and 25: The percentage of population that can be fed in 2030 and 2050 if the cereal production decreases with 3 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.



Decreased cereal production 5%, 2030 *Decreased cereal production 5%, 2050*

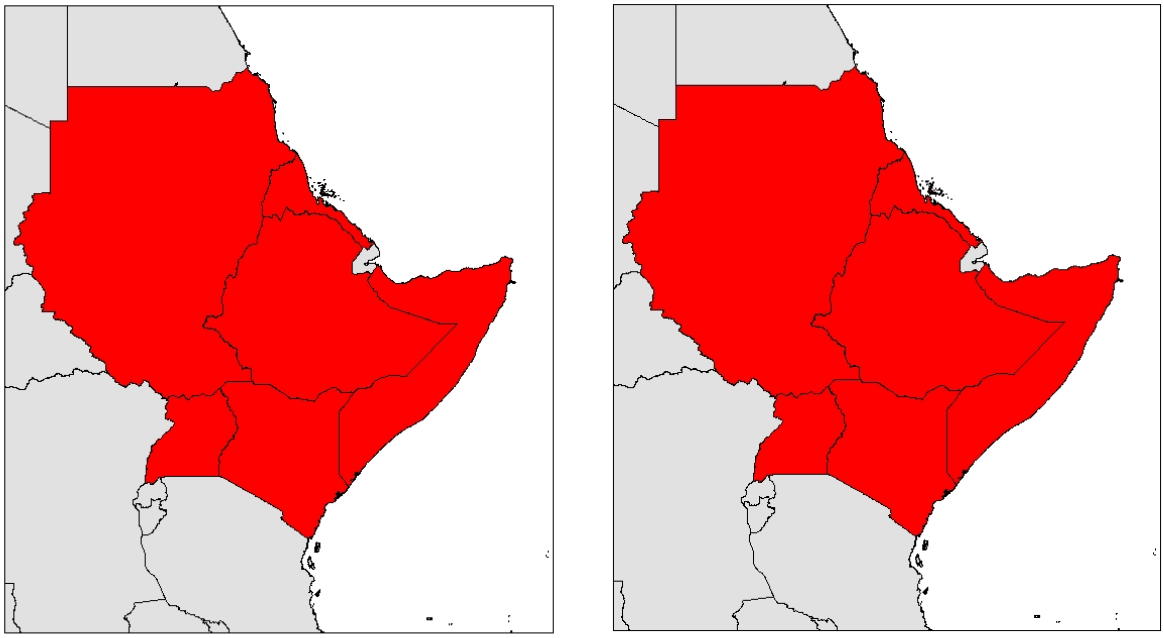
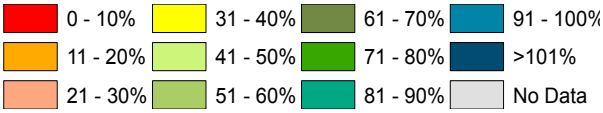


Figure 26 and 27: The percentage of population that can be fed in 2030 and 2050 if the cereal production decreases with 5 percent. Projection WGS 84. Map of Africa from GIS-LAB, 2011. Data from FAOSTAT and U.S. Census Bureau, 2011c.



3.3 The Impact of Climate Change in Sub-Saharan Africa

SSA is projected to be the area in the world that will be affected the most from climate change, due to inability to adapt and to import food to compensate for loss in production (FAO, 2005). The average annual mean surface air temperature is expected to rise with 3-4°C until 2080-2090 compared to the 1980-1999 period and an increase in precipitation is expected in East Africa and to the Horn of Africa (Parry et al., 2007; Solomon et al., 2007). Meanwhile, in the southern parts of SSA and its western margins it is expected to experience precipitation decrease, especially during the harvest months in wintertime. However, recent trends indicate a decrease in precipitation in Eastern Africa as well (Funk et al., 2008). It is expected that over SSA, that when rain falls, it will be in sporadic, intense events. The agriculture in SSA and Eastern Africa is very dependent on precipitation when only a small part of the arable land is irrigated, which means that food production also is very dependent on rain (FAO, 2005). One of the challenges that the climate change comes with is the changed pattern of intensity and frequency of drought and rainfall and these climatic variables are projected to become a part the normal climate (Salomon et al., 2007). In the region of SSA and Eastern Africa, the major part of the population is dependent on local food production (Wlokas, 2008). The food productivity is expected to decrease in the region but in the higher and middle parts of Africa, the production is expected to increase (Salomon et al. 2007; Jones and Thornton, 2009). A change in temperature is expected to have a negative effect on the production, especially in the Sub-Saharan region, due to the incapacity to adapt to new circumstances (Gregory et al., 2005). The estimated decline in yields has impacts on soils and water and the warming is expected to produce drought and the intense rains that are expected to intensify will add to soil degradation and desertification (Lal, 2009). The runoff causes nutrient loss and decreases the ability of crops to grow.

Water and irrigation is also a major concern in the process of adaptation to a different climate (UN Millennium Project, 2005). When the demand for water and irrigation increases, it will limit agricultural development and the insecurity of water and food is closely related (Thompson et al., 2010).

In SSA, there is generally a season between June to August when yields does not meet the food demand (Brown et al., 2009). There is concern that this season will become longer so the reliance on bought food from markets will increase, when the household self-sufficiency decreases (Brown et al., 2009). If the production of food decreases, the employment in the sector will decrease, and in a country such as Ethiopia where a large part of the population gain their salary from employments in the sector, this will have severe effects on poverty in the country and the ability to buy food. Persons that continue to work in the agricultural sector may still experience a insecurity when the yields gets smaller and they limit both personal food security and additional income (Ziervogel et al., 2006). Lack of money is a major constrain for farmers to adapt to climate change, and in Ethiopia the lack of information and access to land is contributing as well (Bryan et al., 2009).

4. How to Achieve Food Security in Ethiopia, Sub-Saharan and Eastern Africa

There is evidence that SSA knows how to deal with the situation; Ethiopia has doubled its production of certain staple grains between 1990 and 2001, except for 1998 and early 2000´s when a to small amount of rain fell and food relief was necessary (Myers and Kent, 2001).

According to projections made by U.S. Census Bureau (2011b), Ethiopia will be the sixth most populated country in the world in 2015, compared to todays fourteenth place. The number of people that will be supported by square kilometer of cultivable land will increase drastically. Calculations by Riley et al. (2002) show that in 2000, approximately 105 Ethiopians was supported by one square kilometer of arable land. The same number in 2050 will be 265 Ethiopians.

The absence of income and wealth not based on agriculture in Ethiopia makes it clear that the most effective way to increase the income and food security and food sufficiency for the population is to increase the productivity of the soils and the rangeland for livestock (Riley et al., 2002). But this increase must be higher than the increase of population.

Pretty (1999) presents two solutions how to meet the future demand of food in Africa;

1. Improve agriculture in the region with the help of pesticides, fertilizers, technology and modern varieties and breeds
2. Improve agriculture by adopting the methods presented in Table 1.

Pretty (1999) presents eight examples from different parts of the world where the solution presented in Table 1 are used. The example from Ethiopia is called *Cheha Intergrated Rural Development Project.* It is an example from a relatively small project that makes a great impact on regional food security. It has been working in the southwestern part of Ethiopia since the drought of 1984 and the project has introduced new crops to the agriculture, e.g. vegetables and trees, both fruit and forest, organic fertilizers, and botanicals for pest control and also veterinary services. In the project area, 12 500 households participated and adopted sustainable agriculture on about 5000 hectares of cultivated land. This resulted in a 70 percent improvement on nutrition levels within the project area and the yields improved with 60 percent. Farmers with excessive yield sold it and gained additional income. The area was once completely dependent on food relief, but are today completely food sufficient and the farmers passes their knowledge on to their neighbors, also outside the project area.

Carvalho (2006) also emphasizes the problem with fertilizers in developing countries because they can not afford the more expensive, environmental friendly ones, and instead uses ones that the developed world do not want, such as DDT (DichloroDiphenylTrichloroethane). The author also proclaims the problem with GMO´s and the risk that it might affect the natural wildlife and habitats in the region.

Table 1: The future demand of food in Sub-Saharan Africa can be met by adopting these eight improvements. Based on Pretty (1999).

Type of Improvement	**Elements (examples)**
Finance	- New sources of income - Access to credit
Better use of non-renewable inputs and technologies	- Machinery, hand tools and ploughs - Cash crops, including energy crops - Resistant crop varieties and livestock breeds - Low doses of pesticides and Fertilizers
Better use of available renewable resources	- Water harvesting - Soil and water conservation - Using manure as fertilizer - Irrigation - Rotational grazing - Bio-pesticides and bio-fungicides
Intensification of single sub-component of farm systems	- Kitchen gardens - Fish ponds
Diversify by adding new productive natural capital and regenerative components	- Agroforestry - Habitat management - Integrated livestock (poultry)
Organizations and societies for developing of new skills and better use of existing resources	- Credit groups - Farmer´s research and experimentation groups - Resource management and users groups
Reduce losses and increase returns	- Post-harvest technologies - Process before sale (e.g. dried fruit, chutney, oil)
Make it easier to sell and buy goods	- Farmers market - Rural roads and infrastructure - Producer groups for collective marketing

There are ways to predict drought in advance and make suitable decisions for the projected food situation. Drought have had great affect on the food production in SSA during recent decades because the crisis management is addressed when the crisis already have occurred rather than before (Tadesse et al., 2008). Early Warning Systems (EWS) are constructed of several indicators (see Table 2), but they are unfortunately not sensitive to local insecurity of food (Companion, 2008). EWS was established during the 1980´s and after several famine events in the Sahel and the Horn of Africa, several different EWS was constructed and located in Ethiopia. The traditional EWS is based on multiple combined sources including remote sensing, field updates, rainfall, and price analysis (see Table 2).

Households can activate a series of coping mechanisms to handle food insecurity, and according to Companion (2007) this can quickly be seen at local markets. Common mechanisms are selling less critical assets and non-productive capital, working as day labors, increasing trading activities and sale of surplus livestock (Seaman 2000; Companion, 2008). But there are institutional problems that limit the effectiveness of EWS (Tadasse et al., 2008):

- Lack of food security policies, strategies and political commitments.
- Poor integration of information into government structures. In many cases, different ministries collect the data and there is no exchange of information between the departments. The people who collect the food data has generally no authority to take decisions on their own and the decision maker do not have the full set of information to make good decisions.
- Problematic relationships between donors and governments. The donors give technical support and funding for food security but the government may have other priorities.
- Lack of communication between the local and international food security information systems. This may lead to ineffective distribution of the resources.
- Lack of memory at the institutions. The high rate of staff turnover in the different institutions does not make the systems established at the institutions.
- A focus on emergency response rather than long-term planning. The support and commitment from political institutions and donors are usually high in the aftermath of famine, but are then declining over time.

With these issues and constrains in mind, it is clear that the enhancement and improvement of food security and vulnerability monitoring systems in the region is very complex.

When it comes to drought surveillance, it is important for each country to develop a surveillance system of their own, based on their specific social, economical and political resources (Tadesse et al., 2008). There are, as with EWS, many challenges with making a surveillance system for drought functional:

- The meteorological and hydrological data is insufficient
- Sharing of data between institutions are inadequate
- The information is often to technical and detailed for decision makers to understand
- Forecasts are often unreliable due to the long seasonal timescale
- Climatic drought indices are limited to their inability to detect early onset and end of drought

Table 2: Factors used as indicators of food insecurity in traditional Early Warning Systems (EWS). Based on Companion, 2008.

Indicator	**Limitations**
Rainfall data	- Number of stations - Frequency of data collection - Inhomogeneity in collecting data - Timings of rains - Access to remote sensing - High levels of aggregation
Natural resource conditions (grazing land, watering holes)	- Inhomogeneity in collecting data - Amount of area survey - Variability of areas surveyed - Access to remote sensing - High levels of aggregation
Crop production data	- No information on non-staple crops - Focus on cash crops - Based on estimations - No consideration to soil conditions, pests, access to fertilizers or quality of seeds - High levels of aggregation
Animal production data	- Based on estimates and projections from previous reproductive cycle - Underreporting of herd sizes - Estimated losses based on other indicators High level of aggregation
Pest damage	- Frequency of assessment, small area surveyed, usually only triggered by reports of outbreaks, no consideration taken to access of insecticides, high levels of aggregation
Market and infrastructural access	- No consideration taken to road conditions or other hazards - Limited local data for distance travelled to roads
Market prices	- Interpretation of sales and price fluctuations Frequency/ consistency of collection - High level of aggregation.

These are only a few of the complications, but they indicate the kinds of challenges that there is (Tadesse et al., 2008). The importance of the governments role in this cannot be highlighted enough; a large part of the solution of the problem is to involve the government more in the drought management. The ability to monitor and disseminate drought related information has been improved by new technologies such as automated weather stations, improved satellite observations and advanced computing techniques and in this manner made it easier to forecast drought and food insecurity. The usage of climatic forecast has also been improved during recent years, and with the help of organizations and governments to make practical decisions on seasonal agriculture strategies such as planting schedules, fertilizer distribution and seed choice. Future food and marketing needs together with distribution of grazing areas for livestock can be planned for.

Since a large part of the agriculture in Ethiopia is dependent on precipitation, it is important with so called agro-meteorological monitoring which is continuous assessment of rainfall and agricultural conditions (Tadesse et al., 2008). The start of the growing season and agricultural activities are determined by when it starts to rain enough, and the monitoring of the start of the growing season is very important and gives a indication of the conditions of the agricultural season. Once the growing season with the rain has started the intensity and distribution of the rain will determine the productivity of crops, pasture and natural vegetation. These factors can help to forecast the productivity and quality and give indicators if food aid and other assistance will be needed.

To evolve a better EWS and drought monitoring in SSA, Tadesse et al. (2008) has made some recommendations:

- To support and develop drought and food security monitoring the exchange of information between national and international agencies must improve.
- Improved incorporation of local data sets and their inclusion in national and international monitoring programs to improve the accuracy of EWS and drought monitoring.
- Include both long- and short-term planning to solve food related problems

The most common adaption strategies to climate change according to Bryan et al. (2009) in Ethiopia include the usage of different crops, planting trees, soil conservation, changing planting dates and irrigation. The ones that were less common was non-agricultural employment, migrating to urban areas, changing farming types, new technologies and water conservation. But despite the large number of farmers claiming that they have experienced a change in climate and precipitation, they have not made any modifications in their farming practices. The factors that influence the decision to make modifications are wealth and access to extension of land, credit and information about climate change. The adaption to climate change will need the participation from all parts of the society, including policymakers, extension agents, NGOs (Non Governmental Organizations), researchers, communities and farmers.

Some argues that adaption to temporary climate change may simplify the adaption to permanent climate change (Burton, 1997). But some of these adaptations may not be suitable for the long-term climate change since they may be considered as coping responses to the

current climate (Smithers and Smith, 1997). So a combination between cooping with current climate and at the same time making adjustments to the long-term climate change is of utter importance.

Even though the Millennium Declaration of the United Nations where world leaders agreed on several goals with clear targets to reduce poverty, hunger, disease, illiteracy and discrimination against women until 2015, many households in SSA are still exposed to the risk of food shortages and hunger (UN Millennium Project, 2005). There have also been pointed out that sustainable agriculture and rural development are of uttermost importance for increasing food production and improve food security.

The world supply for cereals in 1999 met only around two thirds of the calculated global demand, and the supply of other crops met just more than half the demand (Döös and Shaw, 1999). The uncertainties about the future are great when there are many uncertainties about the management, use of fertilizers and climate change among others. Estimations made by Döös and Shaw (1999) indicates that the future production of cereals can support half of the global population in 2025, while other estimations by the same authors claims that the food production will support 10 percent more than the global population.

Women stand for 60 to 90 percent of food production of households in the region, including weeding, watering, processing, storage and marketing and research elsewhere shows that when women are involved in the agriculture the production increases dramatically (Quisumbing et al., 1995; Riley et al., 2002). In SSA, women and men cultivate separate plots, and women have traditionally been responsible for the food production (Quisumbing et al., 1995). But in some parts of SSA women do not have the right to own land, and must rely on e.g. male relatives. Women are allocated to low quality land and smaller plots. Irrigation has led to conflicts when it is the male that own the land and has the option to install irrigation for the cultivation. If these restrains on women and their food production was to be removed, the production of food has great opportunities to increase. Income earned by a woman is contributing more to household food security than male income (Quisumbing et al., 1995). In Kenya, one year of primary education for women is associated with an increase in maize yield with 24 percent. In general, men and women are equally effective when working in agriculture, but Ethiopian women have despite their high involvement in the farming, very limited access to relevant extension advice. Women are considered to be better borrowers since they have tendency to make the repayments in time (Sharma, 2001). One of the best ways to handle a rapid population growth is family planning and women´s empowerment (Myers and Kent, 2001). A 10 percent increase in female literacy would reduce child mortality with 20 percent; this shows the importance of education. This is closely connected with the fact that as long as parents see many of their children dying, they will continue to have many children; so reducing children mortality is a huge scope (Myers and Kent, 2001).

Women have great knowledge in how to produce food since they have the main responsibility for this in SSA, and if they were able to share their knowledge and contributing to research in agriculture and seeds this is a great base of for productive growth (Quisumbing et al., 1995).

As a final remark in this subject, it is worth mentioning that there are no sole adaption strategy to achieve food security and sufficiency for the entire SSA, due to the fact that it is a very diverse region, both in culture and in environmental dimensions (Gregory et al., 2005).

5. Discussion

The food situation in SSA today is very severe, and a large part of the population is dependent on food relief. The agriculture is dependent on natural rainfall and it is uncertain how the precipitation pattern in the future will be, but it is predicted to become more intense and overall precipitation to increase, but the frequency of rainfall will decrease. The temperature is also projected to increase, which means that the evaporation will be higher, making an already drought prone area even drier, making the land harder to cultivate and crops to grow. If this is the case, it will have great effects on the agriculture, if the agriculture still is highly dependent on rainfall, so one of the main solutions for future food security is to increase rainwater harvesting and irrigation.

The nationalized ownership type in Ethiopia has had a negative effect on agricultural production but with a larger economical freedom during the last decade, an increase in production will hopefully be seen soon. The small plots that each farm cultivate needs to increase their productivity to become food sufficient, and by introducing GMOs and fertilizers into the agriculture this can be achieved. But it must be made in a thoughtful manner, with consideration taken to natural biodiversity and environment.

Another main problem is the communication between departments that are responsible for the food security problems and the collection of data and information. As mentioned in the text, there is a lack of exchange of information between the units and has in many cases led to an insufficient food relief, and a to late food relief. The communication between the units needs to improve if a more reliable food management systems can be established together with a better surveillance over the expected yields.

The empowerment of women is one of the keys to increased production. Education of women would increase the knowledge how to cultivate the soil and increase the agricultural production and in turn decrease poverty, the main cause to food insecurity. It is also clear that women with education have fewer children, and a decreasing population growth will have great effect on availability of food.

Even though the cereal production in Ethiopia indicates a increase, the people in need of food relief is increasing, This is most likely because population growth is higher than agricultural production growth. The cereal production per capita in Ethiopia has an increasing trend (Figure 5) but this is obviously not the whole truth of the food situation in Ethiopia today. It is clear that more needs to be done than to increase the cereal production.

When it comes to the scenarios of food sufficiency in Sudan, Ethiopia, Eritrea, Somalia, Uganda and Kenya it is clear that the production of cereals needs to increase drastically if the countries will become food sufficient. But it is also important to remember that a human need more than 15 kg of cereals per month to live a healthy and productive life, 15 kg are the absolute minimum. They also need to be completed with vitamins and animal proteins, to give a human all nutrients needed. But according to the recent trend the cereal production is increasing each year in Ethiopia. Also, there is not always beneficial to be food sufficient, if other crops are produced and exported and contributing to national income and make import of food possible from countries with a production surplus. There are also some uncertainties in the maps; no consideration has been taken to the distribution of food or the production of food in different regions. Some areas may be more famine prone than other

depending on where the food is produced, and where markets are located. Additionally, no consideration has been taken to different growing and harvest season. A hungry season is in general between June and August in SSA and it is usually during this period that food aid is needed. Due to climate change in the future this period might become longer and a production that makes it possible to build up a food supply reserve is of great importance.

According to the Sukhatmes Rule, one person needs 600 grams of cereals every day to gain 2200 calories, smallest amount of calories a person needs to live a healthy and productive life (Djurfeldt, 2001). This means that a person needs 220 kg per year, 40 kg more than the 180 kg of cereals per year that been counted on in this report. This new number would most likely show that an increase in cereal production needs be more than 5 percent, if the future population was to live on only cereals and food sufficiency was to be accomplished. This makes the scenarios in this report very optimistic, and maybe shows a more positive picture than what it really is. Also, according to Djurfeldt (2001), the yield and population data that has been collected in the developing part of the world are many times very uncertain. No well-established population counting system is provided and the data is mostly estimated. The same problem exists when it comes to yield data. The data sets are based on a few collected data, especially in the past, and mainly based on interviews of the leaders of a village with no real insight of the agriculture. This makes the uncertainty of the actual data high.

The production in the future scenarios has been based on the average production between 1980 and 2009, except for Eritrea where there was no available data before 1993 for the cereal production, probably because this was the year when Eritrea became independent from Ethiopia. The production in Ethiopia increased in the years after 1993 from 50 million tonnes to 100 million tonnes, even though the land areal decreased, indicating that Eritrea was not a large contributor to the cereal production. The increase of production and the decrease of population made the cereal production per capita to increase rapidly, from 100 kg per capita and year to 160 kg per capita and year, making the country nearer self sufficiency after the liberation of Eritrea than before. For Eritrea on the other hand, the production of cereals has remained low, with producing more than 100 kg of cereals per capita per year only once since the liberation.

There is also a great uncertainty in how much the increase or decrease in food production will be in the future, even though it is clear that a increase is needed to achieve food security and food sufficiency in and SSA and Eastern Africa. There are many uncertain factors involved in making a future agricultural production scenario e.g. changed consumptions pattern, and it will probably not be certain until the future comes. The scenarios in this paper is based on scenarios developed by other authors and changes in the production in the past, and it is probably from the past that we can learn the most from, when the future is as uncertain as it is.

It was produced enough food in the world 2002 to support the entire world population, but the issue is the division of the available food between regions and people (FAO, 2002). While the population in the more developed part of the world eats so much food so a part of the population becomes overweight, people die of the consequences of malnutrition in other parts. In a global aspect, there are 925 million people that are malnourished in the world totally, and 98 percent of these live in undeveloped countries

(WFP, 2010). But as long as we can remember, human kind has always found a way to support the population of the earth, in one way or another. One of the greatest proponents of this is Danish economist Ester Boserup (Boserup, 1976). She was of the conviction that human kind always will find a way to support the population, with the help of technology, and increase the carrying capacity of the Earth. So when the limit of how many the Earth can support is reached, there will be new technology to find a way to support even more, so the population will continue to increase. But there are scientists that are of a different conviction and one of them was Thomas Robert Malthus, a British economist and demographer during the 18th and 19th century (Encyclopedia Britannica, 2011). His theory is based on the fact that population grows in a geometric trend, while the food supply in a linear trend. This means that eventually, population will outgrow the supply of food. Which of these scientist that has the correct theory, is still to be seen, but there is also the question to what cost of the environment. The environment and nature has up until today paid a high price for the comfort and survival of mankind, and will probably continue to do so, even though the awareness of its vulnerability increases each day, but a lot of the damage is already done. So the question is how much more it can take, and how much more we can increase the carrying capacity? If this can be solved with the help of technology, as Boserup beliefs, and the food is distributed more evenly around the world, the population growth would not be an issue. But the situation today is not that perfect, and we do not know if we can make the carrying capacity limit higher.

6. Conclusion

The food situation in Eastern Africa and Ethiopia is of great concern. A large part of the Ethiopian population is dependent on food relief when year with insufficient precipitation causes draught and crop failure. One of the major reasons is the lack of irrigation among the farmers.

How much cereal is produced in Ethiopia today? How large part of the population in Ethiopia is dependent on food relief today? How is the population expected to change in the future in Ethiopia?

In 2009, the production of cereals in Ethiopia was just above 14 million tonnes and if every person in Ethiopia had access to 15 kg of cereals this could achieve food security for almost the whole population. But the problems are still there. In Ethiopia, 6.5 million people are estimated to be in the need of food relief. Half of all Ethiopians live under the poverty line, and poverty is one of the major causes of food insecurity. Ethiopia is today experiencing a rapid population growth, and this has major impacts on food security. In 2050 the population is expected to be over 250 million people.

Has the agriculture in Ethiopia changed during the later part of the 20th century (crops, harvest, etc.)?

The Ethiopian agriculture system has experienced major changes during recent decades. During the last decades of the imperial era a modern, economical large scale agricultural system was introduced in Ethiopia with new crops. The sector was nationalized and the farms owned by the state, but since the beginning of the 1990´s the Ethiopian farmers have gained more economical control over their own land. The important domestic cereal teff together with barley and durra made out the major part of cereal production before the nationalization, but they have been, to a great extent, replaced by wheat and maize. The average food production has during recent decades showed a decreasing trend, with some exceptions. But cereal production has shown an increasing pattern and so has the per capita cereal production in Ethiopia. The usage of fertilizers and irrigation in the country remains low, and the reliance on precipitation is high.

How do scenarios project future food sufficiency for the countries Somalia, Ethiopia, Eritrea, Sudan, Kenya and Uganda?

Predictions for the future production in SSA and Eastern Africa are very uncertain, but projections show a negative trend in the agricultural production. The projections made in this paper shows that an annual increase of at least 5 percent until 2050 is needed to achieve food sufficiency in the majority of the countries if every person of the population have access to 15 kg of cereals per month.

How is climate change predicted to affect the production of food in Sub-Saharan and Eastern Africa?

For SSA, climate change are predicted to cause a temperature increase of 3-4°C until 2080 together with an increase in precipitation in Eastern Africa and into the Horn of Africa. But the southern parts and the western margins are expected to experience a decrease in precipitation. The rainfall are expected to be less frequent, but more intense, which will have great effects on the agriculture in the region, when only a small part of the cultivated area has irrigation today, and the inability to adapt to changes due to lack of economical resources.

What different kinds of solutions are available to increase food security in Sub-Saharan and Eastern Africa?

There are several solutions suggested for the region, where some of the suggestions are water conservation, usage of fertilizers and Early Warning Systems to predict drought and famine. But one of the major things that needs to be done is to increase the communication between the different units that manage the factors of the problem, so when food aid is needed, it is predicted before the famine starts, rather than during. It is also important to remember that there is not a single solution to achieve food security and sufficiency for the entire SSA, but every country and every region need to come up with one of their own, depending and their needs and their economical situation.

7. References

Albertsson, B., 2008. *Sänkta rekommendationer för gödsling 2009*. Greppa Näringen. http://www.greppa.nu/arkiv/nyhetsarkiv/stallgodsel2006/sanktarekommendationerforgodsling2009.5.78be32b411dd24541d28000520223.html. Retrieved 2011-05-17, 2 p.m.

Baudou, E., 2011. Nationalencyklopedin. http://www.ne.se/etiopien/f%C3%B6rhistoria. Retrieved 2011-04-06, 10 a.m.

Behrens, S., 2011a. Nationalencyklopedin. http://www.ne.se/etiopien/natur/terr%C3%A4ngformer-och-berggrund. Retrieved 2011-04-06, 10 a.m.

Behrens, S., 2011b. Nationalencyklopedin. http://www.ne.se/etiopien/natur/klimat. Retrieved 2011-04-06, 10 a.m.

Berhane, Y., Gossaye, Y., Emmelin, M. and Hogberg, U., 2001. Women´s Health in a Rural Setting in Societal Transition in Ethiopia. *Social Science and Medicine*. Vol. 53, No. 11, pp. 1525-1539.

Boserup, E. (1976). Environment, Population, and Technology in Primitive Societies. *Population and Development Review,* Vol. 2*,* No. 1, pp. 21-36.

Brown, M.E., Hintermann, B., Higgins, N., 2009. Markets, climate change, and food security in West Africa. *Environmental Science & Technology*. Vol. 43, No. 21, pp. 8016-8020.

Bryan, E, Deressa, T.T., Gbetibouo, G.A. and Ringler, A., 2009. Adaptation to Climate Change in Ethiopia and South Africa: Options and Constraints. *Environmental Science & Policy*. Vol. 12, No. 4, pp. 413-426.

Burton, I, 1997. Vulnerability and Adaptive Response in the contest of Climate and Climate Change. *Climate Change*. Vol. 36, No. 1-2, pp. 185-196.

Carvalho, F.P. 2006. Agriculture, pesticides, food security and food safety. *Environmental Science & Policy*. Vol. 9, No. 7-8, pp. 685-692.

Chaibva, S. 1996. Drought, Famine and Environmental Degradation in Africa. *Ambio.* Vol. 25, No. 3, pp. 212-213.

CIA World Factbook, 2011a. *Ethiopia*. https://www.cia.gov/library/publications/the-world-factbook/geos/et.html. Retrieved 2011-05-19, 10 p.m.

CIA World Factbook, 2011b. *Sudan*. https://www.cia.gov/library/publications/the-world-factbook/geos/su.html. Retrieved 2011-05-25, 10 p.m.

CIA World Factbook, 2011c. *Eritrea*. https://www.cia.gov/library/publications/the-world-factbook/geos/er.html. Retrieved 2011-05-25, 10 p.m.

CIA World Factbook, 2011d. *Somalia*. https://www.cia.gov/library/publications/the-world-factbook/geos/so.html. Retrieved 2011-05-25, 10 p.m.

CIA World Factbook, 2011e. *Kenya*. https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html. Retrieved 2011-05-25, 10 p.m.

CIA World Factbook, 2011f. *Uganda*. https://www.cia.gov/library/publications/the-world-factbook/geos/ug.html. Retrieved 2011-05-25, 10p.m.

Companion, M., 2007. Adaptability and survival: a case study of street vendor responses to famine conditions in Ethiopia, 1999. In J. Cross and A. Morales (eds.) *Street Entrepreneurs: People, Place and Politics in Local and Global Perspective*. Routledge, London. As cited in Companion, M., 2008. The Underutilization of Street Markets as a Source of Food Security Indicators in Famine Early Warning Systems: a Case Study of Ethiopia. *Disasters*. Vol. 32, No. 3, pp. 399-415.

Companion, M., 2008. The Underutilization of Street Markets as a Source of Food Security Indicators in Famine Early Warning Systems: a Case Study of Ethiopia. *Disasters*. Vol. 32, No. 3, pp. 399-415.

Davies, S., 2000. Effective drought Mitigation. In Whilhite, D.A., 2000. *Drought: A Global Assessment.* Routledge Press, New York, Chapter 28. As cited in Tadesse, T., Haile, M., Senay, G., Wardlow, B.D. and Knutson, C.L., 2008. The Need for Integration of Drought Monitoring Tools for Proactive Food Security Management in Sub-Saharan Africa. *Natural Resources Forum***.** Vol. 32, No. 4, pp. 265-279.

Dessalegn, G., Jayne, T.S. and Shaffer J.D., 1998. *Market structure, conduct, and performance: constraints on performance of Ethiopian grain markets*. Working Paper 8, Grain Market Research Project, Ministry of Economic Development and Cooperation.

Djurfeldt, G., 2001. *Mera mat; att brödföda en växande befolkning*. Arkiv förlag, Lund, Sweden.

Döös, B. R. and Shaw, R. 1999. Can we predict future food production? A sensitivity analysis. *Global Environmental Change*. Vol. 9, No. 4, pp. 261.283.

Encyklopedia Britannica Online, 2011. *Thomas Robert Malthus*. http://www.britannica.com/EBchecked/topic/360609/Thomas-Robert-Mathus. Retrieved 2011-05-16, 11 a.m.

FAO, 1995. *Country Information Brief*. Draft. Rome. As cited in Riley, B., Church, P., Downer, G., Faux, D. and Ulrich, P. 2002. *The impact of Title II Food Aid on Food Security in Ethiopia*. United States Agency for International Development. Food and Humanitarian Affairs Office USAID/Ethiopia.

FAO, 2002. *Reducing Poverty and Hunger: The Critical Role of Financing for Food, Agriculture and Rural Development.* Paper Prepared for the International Conference on Financing for Development Monterrey, Mexico, 18-22 March 2002.

FAO, 2005. *Impact of Climate Change, Pests and Diseases on Food Security and Poverty Reduction, Background Document*. 31st Session of the Committee on World Food Security 23-26 May 2005.

FAO Agriculture and Development Economics Division, 2006. Food Security. *Policy Brief*. No. 2, pp. 1-4.

FAOSTAT, 2011. http://faostat.fao.org/site/567/default.aspx#ancor. Retrieved 2011-04-11, 10 a.m.

FAO/ WFP, 2001. *Special report Crop and Food Supply Assessment Mission to Ethiopia*. FAO Global Information and Early Warning System on Food and Agriculture World Food Programme.

FAO/ WFP, 2010. *Special report Crop and Food Security Assessment Mission to Ethiopia*. FAO Global Information and Early Warning System on Food and Agriculture World Food Programme.

Funk, C., Dettinger, M.D., Michaelsen, J.C., Verdin, J.P., Brown, M.E., Barlow, M. and Hoell, A., 2008. Warming of the Indian Ocean threatens Eastern and Southern African Food Security but could be Mitigated by Agricultural Development. *Proceedings of the National Academy of Sciences of the United States of America*. Vol. 105, No. 32, pp. 11081-11086.

GIS-LAB, 2011. http://gis-lab.info/qa/vmap0-eng.html. Retrieved 2011-04-11.

GDROE (Government of the Democratic Republic of Ethiopia) /IUCN, 1990. *National Conservation Strategy Phase 1 Report*. Addis Ababa. As cited in Howard J.A., Said, A., Molla, D. Diskin, P. and Bogale, S., 1995. *Toward Increased Domestic Cereals Production in Ethiopia: Using a Commodity Systems Approach to Evaluate Strategic Constraints and Opportunities*. Ministry of Economic Development and Cooperation and Michigan State University Food Security Research Project.

GOE (Government of Ethiopia), 2000. *Ethiopia Interim Poverty Reduction Strategy Paper 2000/01-2002/03*. http://siteresources.worldbank.org/INTPRS1/Resources/Country-Papers-and-JSAs/ethiopia_iprsp.pdf. Retrieved from 2011-04-28, 11 a.m.

Gregory, P.J., Ingram, J.S.I. and Brklacich, M., 2005. Climate Change and food security. *Philosophical Transactions of the Royal Society B*. Vol. 360, No. 1463, pp. 2139-2148.

Gärdenfors, U., 2011. Nationalencyklopedin. http://www.ne.se/etiopien/natur/v%C3%A4xtliv. Retrieved 2011-04-06, 10 p.m.

Howard J.A., Said, A., Molla, D. Diskin, P. and Bogale, S., 1995. *Toward Increased Domestic Cereals Production in Ethiopia: Using a Commodity Systems Approach to Evaluate Strategic Constraints and Opportunities*. Ministry of Economic Development and Cooperation and Michigan State University Food Security Research Project.

Howe, P., 2010. Archetypes of Famine and Response. *Disasters*. Vol. 34, No. 1, pp. 30-54.

Jayne, T.S., Govereh, J., Wanzala, M. and Demeke, M., 2003. Fertilizer Market Development: A Comparative Analysis of Ethiopia, Kenya, and Zambia. *Food Policy*. Vol. 28, No. 4 pp. 293-316.

Jones, P.G., Thornton, P.K., 2009. Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change. *Environmental Science & Policy*. Vol. 12, No. 4, pp. 427–437.

Kaluski, D.N., Ophir, E. and Amede, T., 2002. Food Security and Nutrition- the Ethiopian Case for Action. *Public Health Nutrition.* Vol. 5, No. 3, pp. 373-381.

Kendall, H.W. and Pimentel, D., 1994. Constrains on the Esxpansion of the Global Food Supply. *Ambio*. VOl. 23, No. 3, pp. 198-205.

Kiros, G.E. and Hogan, D.P., 2001. War, Famine and excess Child Mortality in Africa: the Role of Parental Education. *International Journal of Epidemiology*. Vol. 30, No. 3, pp. 447-455.

Lal, R., 2009. Soils and food sufficiency. A review. *Agronomy for Sustainable Agriculture*. Vol. 29, No. 1, pp. 113-133.

Mulat, D., Said, A. and Jayne, T.S., 1997. *Promoting Fertilizer Use in Ethiopia: The Implications of Improving Grain Market Performance, Input Market Efficiency, and Farm Management*. Working Paper 5, Grain Market Research Project, Ministry of Economic Development and Cooperation.

Myers, N. and Kent, J. 2001. Food and hunger in Sub-Saharan Africa. *The Environmentalist*. Vol. 21, No. 1, pp. 41-69.

NE (Nationalencyklopedin), 2011. http://www.ne.se/nemaps/etiopien/mapinterface.html. Retrieved 2011-05-24, 3 p.m.

Parry, M.L., Canziani, O.F., Palutikof, J. P., van der Linden, P.J. and Hanson, C.E., 2007. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University press, 2007.

Pinstrup-Andersen, P., 2009. Food Security: Definition and Measurment. *Food Security*. Vol. 1, No. 1, pp. 5-7.

Pretty, J. 1999. Can Sustainable Agriculture Feed Africa? New Evidence on Progress, Processes and Impacts. *Environment, Development and Sustainability*. Vol. 1, No. 3-4, pp. 253-274.

Ofcansky T.P and Berry, L., 1991. *Ethiopia: A Country Study*. Washington: GPO for the Library of Congress, 1991. http://countrystudies.us/ethiopia/88.htm. Retrieved 2011-05-23, 4 p.m.

Quisumbing, A.R., Brown, L.R., Sims Feldstein, H., Haddad, L. and Peña, C., 1995. *Women: The Key to Food Security.* Food Policy Report, The International Food Policy Research Institute, Washington D.C.

Riley, B., Church, P., Downer, G., Faux, D. and Ulrich, P. 2002. *The impact of Title II Food Aid on Food Security in Ethiopia*. United States Agency for International Development. Food and Humanitarian Affairs Office USAID/Ethiopia.

Rubenson, S. and Holmertz, G., 2011. Nationalencyklopedin. http://www.ne.se/etiopien/historia/det-moderna-etiopien. Retrieved 2011-04-06, 10 a.m.

Seaman, J., 2000. Making Exchange Entitlements Operational: The Food Economy Approach to Famine Prediction and the RiskMap Computer Program. *Disasters*. Vol. 24, No. 3, pp. 133-152.

Sedac and Ciesin, 2005. Center for International Earth Science Information Network (CIESIN), Columbia University; and Centro Internacional de Agricultura Tropical (CIAT). http://sedac.ciesin.columbia.edu/gpw. Retrieved 2011-05.25, 2 p.m.

Sharma, M., 2001. Empowering Women to Achieve Food Security. *Focus* 6. Brief.

Sjöberg, Ö., 2011a. Nationalencyklopedin. http://www.ne.se/lang/etiopien. Retrieved 2011-04-06, 10 a.m.

Sjöberg, Ö., 2011b. Nationalencyklopedin. http://www.ne.se/etiopien/kommunikationer. Retrieved 2011-04-06, 10 a.m.

Sjöberg, Ö., 2011c. Nationalencyklopedin. http://www.ne.se/etiopien/befolkning. Retrieved 2011-04-06, 10 a.m.

Sjöberg, Ö., 2011d. Nationalencyklopedin. http://www.ne.se/etiopien/sociala-f%C3%B6rh%C3%A5llanden. Retrieved 2011-04-06, 10 a.m.

Sjöberg, Ö., 2011e. Nationalencyklopedin. http://www.ne.se/etiopien/n%C3%A4ringsliv/jordbruk. Retrieved 2011-04-06, 10 a.m.

Smithers, J. and Smit, B, 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change*. Vol. 7, No. 2, pp. 129-146.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L, 2007. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007*. Cambridge University Press.

Thompson, H.E., Berrang-Ford, L. and Ford, J.D. 2010. Climate Change and Food Security in Sub-Saharan Africa: A Systematic Literature Review. *Sustainability*. Vol. 2, No. 8, pp. 2719-2733.

Tadesse, T., Haile, M., Senay, G., Wardlow, B.D. and Knutson, C.L., 2008. The Need for Integration of Drought Monitoring Tools for Proactive Food Security Management in Sub-Saharan Africa. *Natural Resources Forum*. Vol. 32, No. 4, pp. 265-279.

UN Millennium Project, 2005. *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals*. Millennium Project. New York.

UN University, 2000. Africa can Feed just 40% of its Population in 2025; Soil Infertility, Malnutrition cause Half of Child Deaths. http://update.unu.edu/archive/issue2_2.htm. Retrieved 2011-05-02, 1.30 p.m.

U.S. Census Bureau, 2011a. http://www.census.gov/ipc/www/idb/worldpopgraph.php. Retrieved 2011-05-14, 1 p.m.
U.S. Census Bureau, 2011b. http://www.census.gov/ipc/www/idb/region.php. Retrieved 2011-05-02, 1 p.m.

U.S. Census Bureau, 2011c. http://www.census.gov/ipc/www/idb/informationGateway.php. Retrieved 2011-04-11, 11 a.m.

Wlokas, R.L, 2008. *The Impacts of Climate Change on Food Security and Health in Southern Africa.* Energy Research Centre, University of Cape Town, and the Free University, Berlin.

World Bank, 1986. *Poverty and Hunger: Issues and Options for Food Security in the Developing Countries*. Washington D.C., USA.

World Bank, 1995. *Ethiopia National Fertilizer Sector Report*. Staff Appraisal Report. Agriculture and Environment Division, Eastern Africa Department, Africa Region

WFP (World Food Programme), 2010. *Hunger*. http://www.wfp.org/hunger. Retrieved 2011-05-16, 11 a.m.

Ziervogel, G., Bharwani, S. and Downing, T.E., 2006. Adapting to climate variability: Pumpkins, people and policy. *Natural Resources Forum*. Vol. 30, No. 4, pp. 294–305.

Lunds Universitets Naturgeografiska institution. Seminarieuppsatser. Uppsatserna finns tillgängliga på Naturgeografiska institutionens bibliotek, Sölvegatan 12, 223 62 LUND. Serien startade 1985. Hela listan och själva uppsatserna är även tillgängliga på http://www.geobib.lu.se/

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