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Food Security, Land Degradation, Water Depletion, and Sustainable Farming in Sub-Saharan Africa: Linkages and Opportunities

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Abstract: The challenge of achieving simultaneously food security, rural welfare, land protection and soil fertility regeneration, as well as climate change adaptation in the face of demographic growth, are overwhelming for Sub-Saharan Africa. However, sustainable farming offers opportunities to maintain food security, mitigate effects of climate change, protect land and raise cash at the same time.

Keywords: Sub-Saharan Africa, food security, climate change, land and water degradation, and sustainable farming.

JEL Classification: Q01, Q15, Q54, Q54

1. Introduction

In Sub-Saharan Africa (henceforth, 'SSA'), food security will meet considerable problems in view of continuing population growth during the next four decades (Falkenmark et al., 2009). The Food and Agricultural Organization (FAO) of the United Nations has determined that Africa will have to triple its food production by 2050 to provide food for an African population which is projected then to reach two billions (Soudan, 2009; Ejeta, 2009) . Still today, the number of malnourished in SSA stays stubbornly high (Shah et al., 2008), despite the latest commitment of the world community through UN Millennium Development Goals (MDG) to half hunger by 2015, only four years from now. At the beginning of the twenty-first century, three SSA's countries - Ethiopia, Malawi and Niger- have suffered mass mortality food crises since 2000 (Devereux, 2009). These famines have claimed at least a hundred thousand and possibly a quarter of a million lives (Salama et al., 2001; Devereux and Tiba, 2007; Rubin, 2009). It is widely recognized that food security will remain a big challenge in SSA throughout the twenty-first century (Rosegrant et al., 2000; Rosegrant and Cline, 2003; FAO, 2005), and the Millennium Development Goal of cutting hunger by half by 2015 will not be met, particularly in SSA (Bruinsma, 2003; Falkenmark et al., 2009; de Graaff et al., 2011).

Food security implies physical, social and economic access to sufficient, safe and nutritious food by all people at all times to meet their dietary and food preferences for an active and healthy life (FAO, 1996). One of the components of food security is the food production through agronomic management of natural resources (Schmidhuber and Tubiello, 2007; Moyo, 2007). In large parts of SSA, the increasing population pressure on arable land and water leads to the degradation of these resources, this often results in the loss of the productive capacity and food insecurity. Consequently, the strong degradation of land and reduction of soil fertility are compromising the agricultural production of land for future generations (Bidogeza et al., 2011a). Furthermore, the declining agricultural productivity is aggravated by stochastic rainfall as a consequence of climate change. As a result, the vicious cycle of declining productivity-degradation of land and water resources-lower yields perpetuates the poverty, malnutrition, hunger, and substandard living in SSA.

This paper is discussing the linkages between the critical biophysical resources scarcity (e.g. land degradation, water depletion and changing rainfall patterns) and welfare of the population (e.g. food security), and the opportunities offered by sustainable farming to improve food security in SSA.

The paper is structured as follows: section 2 gives an overview of the linkages between the depletion of natural resources and food insecurity in SSA, section 3 presents the opportunities offered by sustainable farming to combat food insecurity. Conclusions are given in section 4.

2. Depletion of natural resources and food security

2.1 Soil degradation and food security

In Sub-Saharan Africa (henceforth, 'SSA'), food security will meet considerable problems in view of continuing population growth during the next four decades (Falkenmark et al., 2009). The Food and Agricultural Organization (FAO) of the United Nations has determined that Africa will have to triple its food production by 2050 to provide food for an African population which is projected then to reach two billions (Soudan, 2009; Ejeta, 2009) . Still today, the number of malnourished in SSA stays stubbornly high (Shah et al., 2008), despite the latest commitment of the world community through UN Millennium Development Goals (MDG) to half hunger by 2015, only four years from now. At the beginning of the twenty-first century, three SSA's countries - Ethiopia, Malawi and Niger-have suffered mass mortality food crises since 2000 (Devereux, 2009). These famines have claimed at least a hundred thousand and possibly a quarter of a million lives (Salama et al., 2001; Devereux and Tiba, 2007; Rubin, 2009). It is widely recognized that food security will remain a big challenge in SSA throughout the twenty-first century (Rosegrant et al., 2000; Rosegrant and Cline, 2003; FAO, 2005), and the Millennium Development Goal of cutting hunger by half by 2015 will not be met, particularly in SSA (Bruinsma, 2003; Falkenmark et al., 2009; de Graaff et al., 2011).

Soil is one of the ultimate resources, like water and air. This slowly renewable resource is a place of several ecosystems functions (Singer and Munns, 1999). Soil quality is "the capacity of a soil to function within land use and ecosystem boundaries, to sustain biological productivity, maintain environmental quality and promote plant, animal and human health" (Doran and Jones, 1996). Stocking (2003) indicated that in most agro-ecosystems, declining trends in crop yields is exponentially related to loss of soil quality. Conversely, soil degradation is considered in terms of loss of actual or potential productivity or utility as a result of natural or entropic factors (Anecksamphant et al., 1999). In other words, soil degradation refers to diminution of soil's current or potential capacity to perform ecosystem functions, notably the production of food, feed and fiber as a result of one more degradation processes (Lal, 1997).

Low agricultural production is attributable to a large extent to low soil fertility status, low organic matter and high soil acidity characterizing soils of large part of SSA (Sanchez, 2002; Breman et al., 2011). Soil degradation worsens a situation already fragile. Soil degradation affects food insecurity directly and indirectly. A major direct effect of soil degradation is attributed to the reduction in crop yields and decline in their nutritional values (Lal, 2009). Crop yields in SSA have stagnated at about 1 t ha^{-1} for cereals (e.g., sorghum, millet, maize), 3 to 5 t ha^{-1} for roots and tubers (e.g., cassava, sweet potato and yam) and 100 to 200 kg ha^{-1} for legumes (e.g.cowpeas), because of soil degradation caused by erosion, nutrient mining, and depletion of soil organic matter (SOC) (Lal, 2009). The adverse impacts are more severe in soil managed by resource-poor farmers (the majority of rural population in SSA) who do not use chemical fertilizers, soil amendments and supplemental irrigation. In their bio-economic farm model of resource-poor farmers, Bidogeza et al. (2011a) highlighted the fact that with more people having less land food security cannot be achieved and soil loss has a high economic impact at least for the marginal land. Resource-poor farmers of SSA with an average arable land of less than 0.5 ha and use of extractive farming practices cultivate marginal soils with marginal inputs and produce marginal yields (Lal, 2009). Extractives farming and low-input farming practices have depleted the SOC pool by as much 75% (Lal, 2004) and have impoverished the soils already eroded at 65% (Naude, 2009; Ejeta, 2009). Moreover, Drechsel et al. (2001) indicated a strong relationship between increase in rural population density in SSA and decline in soil nitrogen (N) and phosphorus (P).

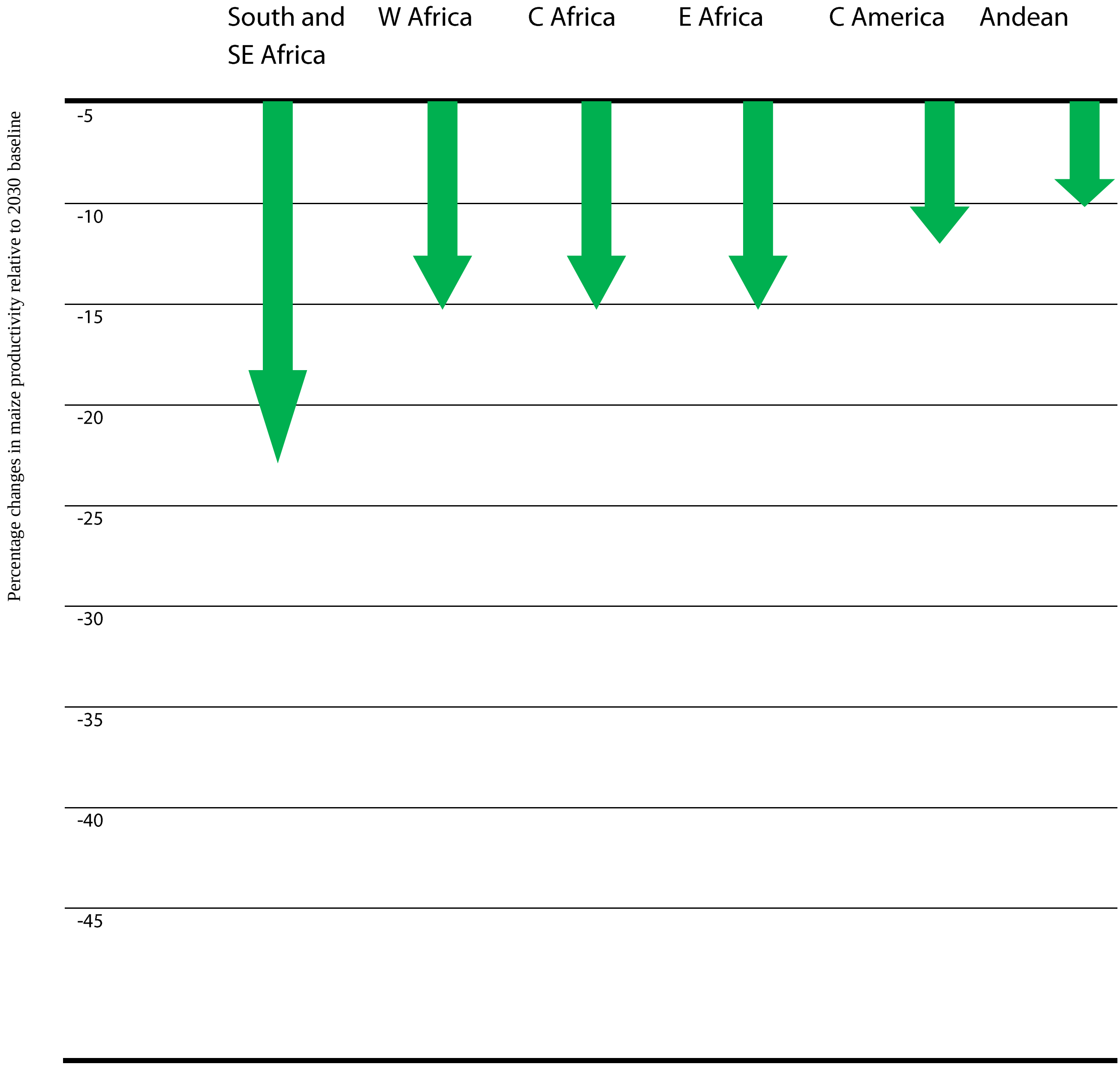
Soil degradation increases susceptibility to elemental imbalance. Crops cultivated on eroded soils have low concentration of protein content and micronutrients (e.g., Zn, Fe, Se, B, I), which aggravate malnutrition that affect mostly children (Humphrey et al., 1992; Sazawal et al., 2001; Lal, 2009). The nutrient imbalance in crops' yields cultivated on eroded soils is caused by deficiency of some and toxicity owing to excess of others. The nutrients prone to deficiency include both macro nutrients (e.g. N, P, K, Ca, Mg, S) and micro elements (e.g. Zn, Cu, Mo, B, Se) and those prone to toxicity have excess Al, Mn, As, and Fe (Lal, 2009). The overall result of soil degradation is the perpetuation of marginal living and poverty in rural areas of SSA.

Soil degradation is a serious problem which contributes to the low and declining agricultural productivity and consequently to food insecurity. Soil erosion and soil mining is believed to be the most important causes of soil degradation in SSA with a soil loss of 50 to 400 tons per hectare per year depending on location (Mugabo, 2005). Some slopes are totally degraded by erosion and no production is possible without restoring fertility. Soil erosion is moderate to severe on 50% of land area in some regions of SSA (Clay et al, 1998), thus 14 million tons of soil are lost per year in Countries such as Rwanda and Burundi, which is equivalent to the loss of capacity to feed 40,000 people annually (GoR, 2007*).* In addition, it is estimated that 95 M ha of arable land in Africa have reached such a state of degradation due to accelerated erosion that only huge investments could make them productive again (Lal, 1995). Ferralsols and Acrisols are the most dominated soils in SSA (van Ranst, 2003). These type of soils have high susceptibility to erosion (stocking, 2003). Once the vegetation is removed, they degrade quickly through intensive acidification, increasing free aluminium and phosphorus fixation. Therefore, without combinations of mechanical structures (e.g. terraces) and biological measures (e.g., intercropping), these soils cannot withstand degradation and produce indefinitely. Deplorably, these measures required financial resources which are beyond the means of smallholders' farmers, the majority of rural population in SSA. Nutrient depletion is exacerbated by accelerated erosion (Stocking, 2003), which has adverse impacts on crop yields and agronomic production such as in SSA. A research conducted by Stoorvogel and Smaling (1990) revealed that some countries in SSA have the most severe nutrient depletion rates, with on average -54 kg N ha^{-1} $year^{-1}$, -20 kg P ha^{-1} $year^{-1}$, and -56 kg K ha^{-1} $year^{-1}$. The annual loss of nutrients in Africa is equivalent to US $4 billion in fertilisers (Sanchez and Swaminathan, 2005).

2.2 Climate change and food security

The intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report confirms and reinforces the evidence that climate change is real and poses serious environmental, social and economic treats to the globe (IPCC, 2007). Many studies have concluded that the impacts of climate change will not be equally shared among the population of the world (Kurukulasuriya and Rosenthal, 2007; Thorthon et al., 2008). There is high confidence that developing countries will be more vulnerable than developed countries (Smith et al, 2001). A review conducted by Kotir (2011) confirms the general consensus that SSA is the most vulnerable region to climate change because of its reliance on agriculture which is highly sensitive to weather and climate variables, and the limited ability to adapt (Molua, 2002; FAO, 2010). For example, maize is a major staple food across much of SSA, Central America and Andeans. However, climate change will have adverse effect on maize productivity in SSA by 2030 (See Figure 1) (Oxfam, 2011). Furthermore, the Oxfam's commissioned research points to a marked climate change effect in reducing yields of sweet potatoes and yams, cassava, and wheat by 2050 (respectively 13, 8, and 22% lower than under a scenario without climate change).

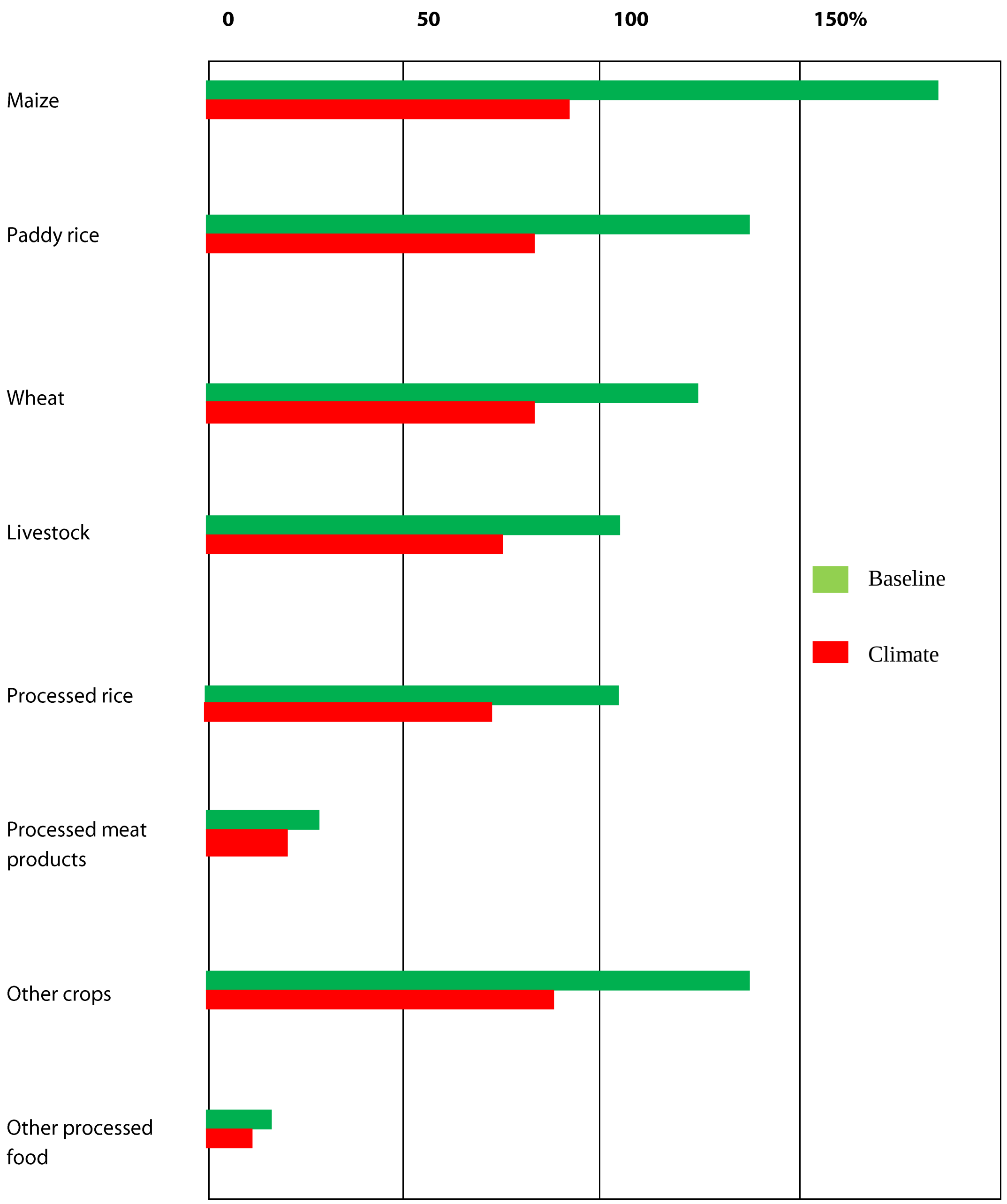
Figure 1- The predicted impact of climate change on maize productivity to 2030



Source: Adapted from Oxfam (2011).

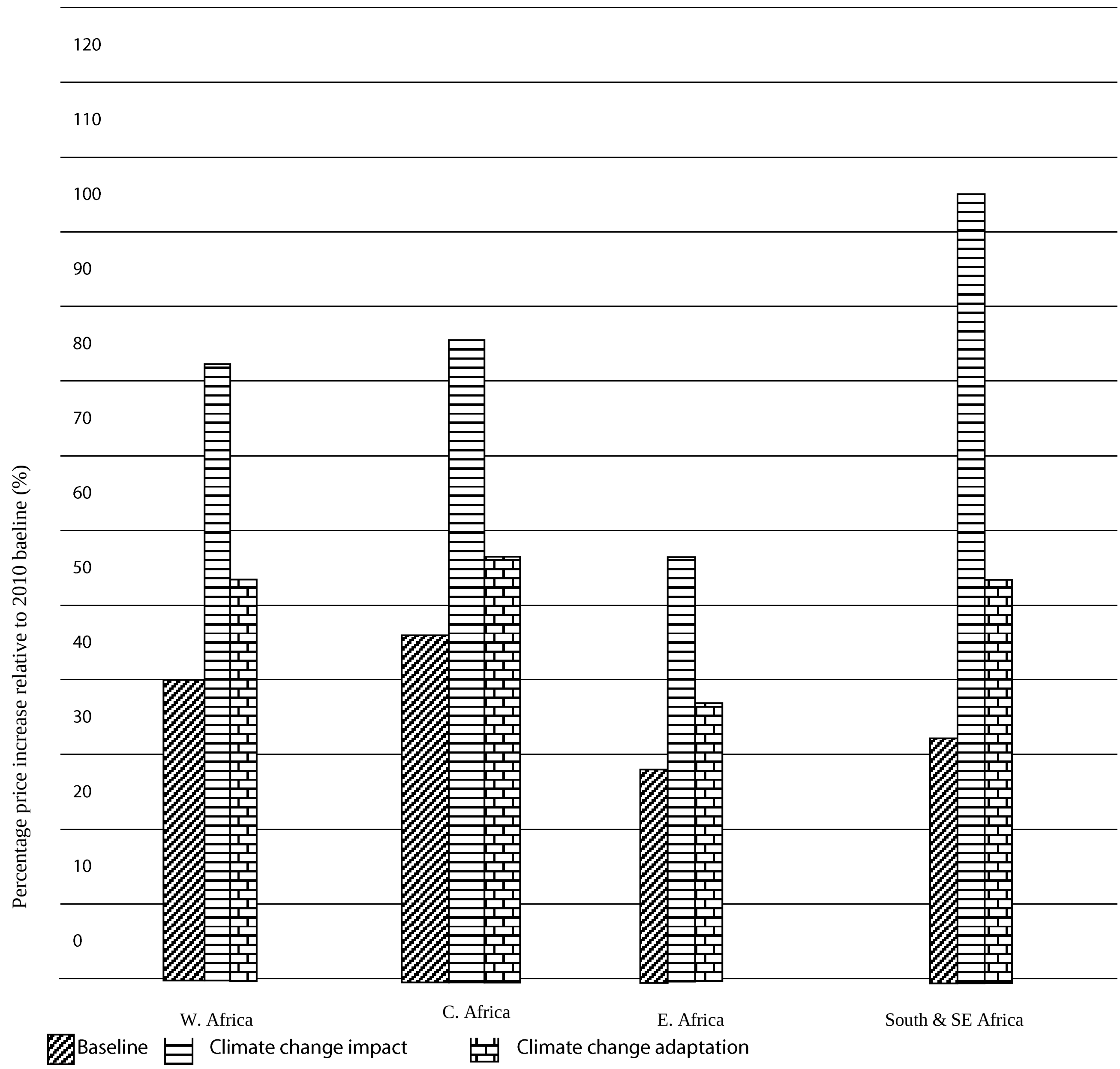
According to Willenbockel (2011), climate change will result in high world prices in 2050 with major increase for maize (Figure 2). This scenario is consistent with long-term trend analysis carried out by IFPRI for wider set of crops. However, although SSA faces some of the gravest threats from high prices in 2050, adaptation to climate change would damp the price of maize as it is shown in Figure 3.

Figure 2- Increase in world market export prices in 2030 relative 2010



Source: D. Willenbockel (2010) 'Exploring Food Price Scenarios towards 2030'.

Figure 3- Predicted dampening impacts of climate change adaptation on the price of maize



Source: Oxfam, 2011.

Climate change is expected to affect rains, increase the frequency of droughts, and raise average temperatures, threatening the availability of fresh water for agricultural production availability (IFAD, 2009). The weather and climate exert a direct and considerable effect on agriculture, especially farming (Menzhulin, 1992; CTA, 2009). In SSA, the livelihoods of about 90% depend on rain-fed agriculture (Mutiro et al., 2006), while the subcontinent accounts only 2% of the world's irrigated land area (Lal, 2004). Rain-fed agriculture exposes agricultural production to vulnerability because of the high rainfall variability and elevated temperature.

The changing rainfall patterns resulting from climate change has been observed in SSA for the last 40 years (Bohle et al, 1994; Dixit et al., 2011). The current records indicate that rainfall pattern across Africa varies extremely and exhibits different scales of temporal and spatial variability (Boko et al., 2007). The torrential rains that fell in West Africa, particularly in the months of September 2007 and 2009, the highest in thirty years, are there to testify. Paeth and Stuck have emphasized that the projected climate change will lead to drier conditions in the West African Sahel. In East Africa, 1997 was very wet year and, like 1961 and 1963, led to a surge in the level of Lake Victoria (Birket et al., 1999). Southern Africa has seen an increase in inter-annual variability over the past 40 years, but with intermittent droughts (Boko et al, 2007; Brown and Crawford, 2009). Table 1 illustrates the increase in the number of natural disasters observed in Mozambique over the three decades (Queface, 2009).

Table 1-Summary of the impacts of natural disasters due to climate change in Mozambique (Period 1956-2008).

Disaster type	Number of events	Total killed	Total affected
Drought	10	100,200	16,444,000
Flood	20	1,921	9,039,251
Tropical Cyclone	13	697	2,997,300

Observed temperatures have shown a greater warming trend since the 1960s (IPCC, 2007). For example, countries lying around the Nile Basin witnessed an elevated temperature of between 0.2 and 0.3°C per decade in the second half of the century, while in Rwanda, temperature increased by 0.7 to 0.9°C (Eriksen et al., 2008). According to New et al. (2006), between 1961 and 2000, there was an increase in the number of warm spells over Southern and Western Africa, and a decrease in the number of exceedingly cold days. With respect to future changes, the whole SSA is expected to warm across all seasons throughout this century (Boko et al., 2007).

Climate models converge on one certainty: rainstorms and increase in temperatures will be more severe depleting arable land that are already eroded at 65% in SSA (Naude, 2009). There is a strong link between food security and climate change (Sanchez, 2000; Brown and Funk, 2008). A model of the International Food Policy and research Institute (IFPRI) has projected that in low-income countries, climate change will increase the number of malnourished children by 9.3% on average in 2050 (IFPRI, 2009). The impact of climatic change and weather variations on food production is greatest in SSA countries where agriculture, even in favorable years cannot meet people's food needs (Pulwarty and Cohen, 1984). Lotsch (2007) indicates that cropland area in SSA is likely to decrease significantly in response to transient change in climate. The losses of crop land area in eastern Africa is likely to occur at a much faster rate, losing up 15% of their current cropland area within the next 30 years (Lotsch, 2007). Using the agro-ecological zone (AEZ) model, Shah et al. (2008) projected that by 2080 1.1 billion hectares of arid and dry semi-arid in Africa will develop under current climate conditions, i.e., the temperature growing period will be less than 120 days forcing large regions of marginal agricultural lands out of production (Fischer et al., 2005; Boko et al., 2007; Shah et al., 2008).The stochastic rainfall as a consequence of climate change is perpetually threatening household food security (Parry et al., 1999). A model results by International Food Policy and research Institute (IFPRI) indicates that in 2050, average rice, wheat, and maize yields will decline by up to 14, 22, and 5%, respectively, as a result of climate change (IFPRI, 2009). Molua (2009) projected that in Cameroon, a 7% decrease in precipitation would cause net revenues from crops to fall by US $ 2.86 billion and a 14% decrease in precipitation would cause net revenue from crops to fall by US $ 3.48 billion. His earlier study showed that a 2.5^{o}C warming, net revenues would fall by US $ 0.79 billion, and a 5^{o}C warming would cause net revenues to fall US $ 1.94 billion (Molua, 2008). In semi-arid regions of Zimbabwe, erratic rainfall deteriorated household food security with a 10-20% decrease in food availability in vulnerable households (Bohle et al*., 1994*). Jones and Thorthon (2003) estimated an annual reduction in maize yield of 10% in Africa by 2055. In all the studies, warming is expected to be harmful to rainfed farming (Kotir, 2011). A 10% increase in temperature would lead to 13% decline in net revenue (Kurukulasuriya and Mendelson, 2007). Recently a link has been established between the Sahel famines of 1975-1980 and the global warming (Naude, 2009). Devereux (2009) indicated that the famine in Ethiopia of 1999-2000 was preceded by a protracted drought that started in 1997-1998, while the trigger for famine in Malawi was erratic weather during the 2000-2001 farming season, which resulted in a maize harvest of 32% lower than in 2000. Overall, approximately 40% of SSA countries will be at risk of significant declines in crop and pastures production due to climate change (Kotir, 2011).

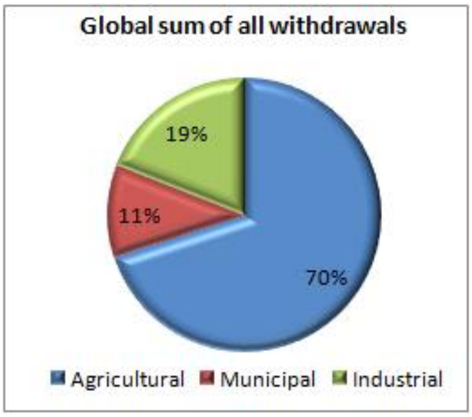
2.3 Water scarcity and food security

Food security depends on a wide set of different factors and resources, however, the physically limited and most basic of these resources, the freshwater that makes the photosynthesis-based biomass production possible, will introduce a fundamental constraints in some parts of the world (Falkenmark et al., 2009).

The amount of precipitation falling on land is almost 110 000 km^3 per year (FAO-AQUASTAT, 2011). Almost 60, 000 km^3 of this amount evaporates from the ground or transpires from vegetation (forest rangeland, cropland), while the remaining 40, 000 km^3 per year is converted to surface runoff (feeding rivers and lakes) and groundwater (feeding aquifers) (FAO-AQUASTAT, 2011). The latter amount of water are called renewable freshwater resources. Part of this water is being removed from these rivers or aquifers for different uses. This removal of water is called water withdrawal.

Water use can be divided into three major categories: agriculture, industry, and domestic (Rosegrant and Perez, 1997). At global level, the withdrawal ratios are 70 percent agricultural, 11 percent domestic (municipal) and 19 percent industrial (Figure 4). Agriculture is by far the biggest water user, accounting for over 85% of water withdrawals in SSA (Rosegrant and Perez, 1997). Yet, by 2050, its share will have declined to about 60% as a result of competing water demands from urban expansion and industrial development (Ejeta, 2009).

Figure 4- Water withdrawal ratio at global level



Source: FAO-AQUASTAT, 2011.

The aggregate water availability in Africa suggests ample water supplies of 5,100 cubic meters per capita per year in 2000 (Ayibotele, 1992). However, that figure hides the huge variability in water availability within the region. Table 2 shows water resources and water use in some selected SSA's countries. Rosegrant and Perez (1997) stated that countries are considered water scarce when annual internal renewable water resources are less than 1,000 cubic meters per capita per year. Table 1 shows that expect for Cameroon the amount of renewable water resources per capita is rather limited in some countries. Burkina Faso and

Kenya are the most deprived, with only about 800 m^3 per capita per year (Table 1). Countries such as Namibia and Botswana are both extremely experiencing water shortage, however, water availability mainly as green water is beyond what will be needed to be food-self-sufficient (Falkenmark et al., 2009).

Table 2- Water resources and water use in selected countries of SSA

Indicator	Unit	Burkina Faso	Senegal	Ethiopia	Kenya	Mali	Rwanda	Cameroon	South Africa
Average annual Rainfall	mm	748	686	848	630	1181	1212	1604	495
Renewable water Resources	m^3/cap./yr	821	3177	1512	792	1164	977	14957	1007
Withdrawal as% of renewable water	%	7.8	6.7	5.3	9.1	6.9	1.8	0.4	26.9
Area irrigated as% of cultivated area	%	0.5	3.8	2.7	1.8	1.9	0.6	0.4	9.5
Withdrawal for irrigated agriculture	m^3/cap./yr	55	198	75	57	64	12	44	171
Water available outside agriculture	m^3/cap./yr	9	15	5	15	16	6	16	100

Source: FAO-Aquastat (2011) and de Graaff et al. (2011).

More pressure on the water resource base is expected to occur in the group of developing countries, where water withdrawals are projected to increase by 43% in 2020 because of the rapid urbanization (Rosegrant and Ringler, 1999). In developing countries, roughly 150, 000 people are added to the urban population every day (WRI, 1996). Furthermore, with the expansion of urban areas and income rise, people are consuming more meat and eggs, and feed grain use is growing. For example, to produce one kilogram of pork it takes four kilograms of grain, and one kilogram of chicken takes two kilograms of grain (Brown and Halweil, 1998; Rosegrant and Ringler, 1999). More grains mean more water. The water demand, particularly in the domestic and industrial sectors will be met with massive transfers of water out of agriculture that could derail the projected growth in crop yield (Brown and Halweil, 1998). The effect of transferring water from agriculture had been simulated using the IMPACT model (Rosegrant and Perez, 1999). The model results showed that in developing countries, yield growth for all cereals will slow from 1.20% annually to 1.07% per year during 1993-2020, while rice yield growth will decline from 1.08% to 0.89%. As water is being removed from production, cereal prices begin to increase rapidly, thereby depressing consumption. In SSA, imports of food by 2020 would decrease, because high cereal prices would severely depress demand (Rosegrant and Perez, 1999). Consequently, malnutrition and hunger will continue to be challenging in SSA.

In sub- Saharan Africa, over 60% of the population depends on rain-based rural economies, generating in the range of 30–40% of the countries' gross domestic product (GDP) (World Bank, 1997). Rain-fed agriculture in SSA is practised on more than 95% of the agricultural land, while the remaining percent is under irrigated agriculture (FAO-STAT, 1999, cited in Kotir, 2011). Water-related problems in rain-fed agriculture in the water-scarce tropics are often related to high-intensity rainfall with large spatial and temporal variability, rather than to low cumulative volumes of rainfall (Rockström *et al.*, 1998; Rockström *et al.*, 2003). With unpredictable spatial and temporal rainfall patterns in SSA, the rain-fed agriculture remains fragile. Moreover, in rain-fed agriculture only 10% to 30% of rainfall received is used by crops (Falkenmark and Rockström, 2004), while 70% to 90% is lost. Therefore, water use by crops can be improved by decreasing losses caused by surface runoff and evaporation. There is a close link between an efficient use of limited water resources and food security (Lal, 2009).

3. Opportunities for advancing food security through sustainable farming in SSA

The simultaneous occurrence of rapid population growth and stagnation of agricultural yields in large parts of Sub-Saharan Africa have caused a steady threaten to household food security, a strong reduction in soil fertility, and a continuous expansion of the cultivated area (Pinstrup-Andersen, 1994). As a result of land degradation and increasing population pressure in Sub-Saharan Africa, there is an urgent need to simultaneously enhance food security, rural welfare and agro-ecological sustainability (Kruseman, 2000). This is commonly referred to as sustainable farming, i.e agricultural technologies and practices that maximize productivity of land while minimizing damage to valued natural assets (soils, water, air and biodiversity) and to human health (Pretty and Hine, 2001). Sustainable farming is the domain of bio-physical scientists who develop new technologies, the domain of policy makers who influence the economic circumstances faced by households, and the domain of farm households who make decisions on actual land use. Sustainable farming is increasingly concerned with how decisions are made optimally between environmental sustainability and economic and social sustainability, of which food security is an elemental part (Devereux and Maxwell, 2001).

The challenge of achieving simultaneously food security, rural welfare, land protection and soil fertility regeneration, and to adapt to climate change in the face of the growing population is overwhelming to SSA. SSA's farmers need to pursue a sustainable intensification to maintain food security, mitigate effects of climate change, protect land and raise cash at the same time. This means using inputs and capital which provide net gains in productivity, but which also protect land and enhance soil fertility over time (Reardon et al., 1996).

Technical options for sustainable land use, which could ensure food security, regenerate soil fertility and adapt to climate change, are available in SSA (Breman and Sissoko, 1997;

Palm et al., 2001; Place et al, 2003; Lal, 2009). As shown from agricultural trials, yields levels of maize can be more double in Botswana, by adopting green water management practices, such as conservation tillage, mulch farming, water harvesting and soil and water conservation practices (SIWI, 2001). The Integrated Soil Fertility Management (ISFM) is a sustainable farming approach that acknowledges the need for both organic and mineral inputs to sustain soil health and crop production due to positive interactions and complementarities between them (Buresh et al., 1997; Vanlauwe et al., 2002). ISFM is key to increasing agricultural productivity, while decreasing the risk of negative side effects of fertilizer use to the environment. Table 2 summarizes some agronomic successes of ISFM on trials conducted in West Africa. After 4 years of using ISFM, annual yield increases between 800 and 2500 kg/ha are observed, beside of increases of fertilizer profitability (Table 3). Bidogeza et al. (2011b) investigated the effects of ISFM on food security and land protection using a bio-economic farm model for smallholders. Thus, they found that ISFM strategy ensures a more intensive crop production, a better food security, and a higher farm income. Moreover, it prevents soil loss and improves soil quality for the farm households who adopt them.

Table 3- ISFM improvement of crop yields and fertilizer profitability in West Africa

[a] value incremental yield / fertilizer cost, [b] no fertilizer use by farmers

	farmer's practice		after 4 years of ISFM	
	cereal yield (kg/ha)	VCR fertilizer [a]	cereal yield (kg/ha)	VCR fertilizer [a]
maize: bush field	750	- [b]	2750	4
maize: compound field	3000	- [b]	4600	12
sorghum	1000	- [b]	1800	8
cotton	1150	5	2000	8
irrigated rice	3000	8	5500	12

Source: Breman et al.(2011).

Africa's population is expected to reach 2 billion by 2050 (Soudan, 2009). Pison (2009) stated that the future threat in SSA will not be to feed its population. The fast growing population could be seen as an opportunity to intensify african agriculture. In their study conducted in Machakos region in Kenya entitled: 'More people, less erosion: environmental recovery in Kenya' that examined interactions of people and environment over a period of sixty years, Tiffen et al. (1994) asserted that population growth has a positive impact on the economic development since farmers adopt more sustainable farming technologies to intensify agriculture on depleted land.

For an increase use efficiency of scarce water on crops, technologies such as rainfall harvesting, conservation agriculture (CA) and growing crops in clumps alleviate biophysical constraints to attaining high yields (Rockström, 2003). Growing sorghum and millet in clumps can improve early season growth in dry areas of SSA, enhance grain yields and use effectively scarce rainwater (Lal, 2009).

Considering the relative scarcity of water resources in most SSA countries, expansion of irrigated land is an option to use all available water efficiently and to cope with the increasing food's needs for the growing population in SSA. Irrigation plays a vital role in achieving food security and sustainable livelihoods in developing countries. In India, for example irrigated areas (one third of total cropped area) account for more than 60% of total food production (Rosegrant and Ringler, 1999), while SSA accounts 2% of world irrigated land (Lal, 2009), with 5% of the food production of SSA (FAO-STAT, 1999, cited in Kotir, 2011). Because of low-cost and less environmental impacts, the emphasis in SSA should be on promotion of small scale irrigation schemes (de Graaff et al. 2011). Furthermore, Uppugunduri (2006) outlined a strategy for sustainable management of water resources in developing regions (e.g. SSA) as to increase areas under supplemental irrigation, and using drip sub-irrigation and other modern innovations, including the use of waste water.

To mitigate the effects of climate change in SSA, farmers will need a great access to sustainable technologies for a better adaptation to climate change. Lal (2009) has identified several soil and crop management strategies to adapt to climate change which include adjustments in: Soil and crop management strategies to adapt to climate change include adjustments in: (a) time of sowing, (b) methods of seed bed preparations, (c) use of crop residues, mulch and cover crops, (d) adoption of complex crop rotations including agro-forestry and mixed farming, (e) water management systems such as drainage or irrigation as necessary, (f) time, rate formulations and mode of application of fertilizers and amendments, and (g) choice of species and varieties suitable for the changing climate.

With proven sustainable farming technologies, natural resources are adequate to meet food and nutritional needs of the present and future generations. However, the major concern is how to induce farmers to adopt these technologies. Thus, appropriate policy incentives targeting to improve access to credit, inputs and outputs price policies, market stabilization, infrastructure, education, etc., can be used to enable farmers to invest in sustainable farming technologies (Bidogeza et al., 2011b).

4. Conclusions

This paper reviewed the existence literature on the linkages between the depletion of natural resources and food security. From the review, the challenge of achieving simultaneously food security, rural welfare, land protection and soil fertility regeneration, and to adapt to climate change in the face of the growing population is overwhelming to SSA.

The strong degradation of land and reduction of soil fertility observe in large parts of SSA are compromising the agricultural production of land. This is aggravated by stochastic rainfall and elevated temperature as a consequence of climate change. The growing water demand, particularly in the domestic and industrial sectors will be met with massive transfers of water out of agriculture that could derail the projected growth in crop yield.

Our review identified the sustainable farming as great opportunity to improve agricultural food production. SSA's farmers need to pursue a sustainable intensification to maintain food security, mitigate effects of climate change, protect land and raise cash at the same time. Technical options for sustainable land use, which could ensure food security, regenerate soil fertility and adapt to climate change, are available in SSA. However, the major concern is how to induce farmers to adopt these technologies. Appropriate policy incentives should be put in place to enable farmers to adopt these technologies.

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