CHAPTER 2:
AGRICULTURE AND FOOD SECURITY
BASELINE FOR EAST AFRICA

OCTOBER 2017

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VULNERABILITY, IMPACTS AND ADAPTATION ASSESSMENT IN THE EAST AFRICA REGION

CHAPTER 2
AGRICULTURE AND FOOD SECURITY BASELINE FOR EAST AFRICA

October 2017

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<tbody>
<tr>
<td>ARDP</td>
<td>Agricultural Rural Development Policy</td>
</tr>
<tr>
<td>ARDS</td>
<td>Agricultural Rural Development Strategy</td>
</tr>
<tr>
<td>ASARECA</td>
<td>Association for Strengthening Agricultural Research in Eastern and Central Africa</td>
</tr>
<tr>
<td>ASDS</td>
<td>Agricultural Sector Development Strategy</td>
</tr>
<tr>
<td>CAADP</td>
<td>Comprehensive Africa Agriculture Development Programme</td>
</tr>
<tr>
<td>CCU</td>
<td>Climate Change Unit</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control</td>
</tr>
<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
</tr>
<tr>
<td>CV</td>
<td>Coefficient of variation</td>
</tr>
<tr>
<td>DOM</td>
<td>Department of Meteorology</td>
</tr>
<tr>
<td>EAC</td>
<td>East African Community</td>
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<tr>
<td>EEZ</td>
<td>Exclusive economic zone</td>
</tr>
<tr>
<td>ENSO</td>
<td>El Niño/La Niña-Southern Oscillation</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
</tr>
<tr>
<td>FSAP</td>
<td>Food Security Action Plan</td>
</tr>
<tr>
<td>FSNWG</td>
<td>Food Security and Nutritional Working Group</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>IFAD</td>
<td>International Fund for Agricultural Development</td>
</tr>
<tr>
<td>IFMP</td>
<td>Implementation of a Fisheries Management Plan</td>
</tr>
<tr>
<td>IFPRI</td>
<td>International Food Policy Research Institute</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
<tr>
<td>IPC</td>
<td>Integrated Phase Classifications</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>KNCCAP</td>
<td>Kenya National Climate Change Action Plan</td>
</tr>
<tr>
<td>LVB</td>
<td>Lake Victoria Basin</td>
</tr>
<tr>
<td>LVFO</td>
<td>Lake Victoria Fisheries Organization</td>
</tr>
<tr>
<td>MAAIF</td>
<td>Ministry of Agriculture, Animal Industry and Fisheries</td>
</tr>
<tr>
<td>NAPA</td>
<td>National Adaptation Programs of Action</td>
</tr>
<tr>
<td>NCCRS</td>
<td>National Climate Change Response Strategy</td>
</tr>
<tr>
<td>NDMA</td>
<td>National Disaster Management Authority</td>
</tr>
<tr>
<td>NGO</td>
<td>Nongovernmental organization</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>RCMRDP</td>
<td>Regional Centre for Mapping of Resources for Development</td>
</tr>
<tr>
<td>RVF</td>
<td>Rift Valley Fever</td>
</tr>
<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>VIA</td>
<td>Vulnerability, Impacts and Adaptation Assessment</td>
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</tbody>
</table>
EXECUTIVE SUMMARY

Agriculture is an important economic driver for sustainable development in East Africa and employs about 80 percent of its rural population. The sector contributes to food security and foreign exchange earnings, and it provides raw materials for agro-based industries. It accounts for about 34 percent of GDP in Burundi, 29 percent in Kenya, 32 percent in Rwanda, 25 percent in Tanzania, and 23 percent in Uganda.

Agriculture in this region is largely rain-fed, so its productivity is highly sensitive to climate variability and change. The region has inadequate development of irrigation infrastructure despite the presence of a good network of water resources.

Climate data show that the East Africa is getting warmer and drier, by between 0.9°C and 1.2°C, with rainfall declining at an average rate of 20–100 millimeters every 10 years. This is accompanied by high inter-seasonal rainfall variability, especially in marginal agricultural areas. These trends are resulting in the reduction of arable land suitable for staple food production, shifts in agro-ecological zones, and declines in agricultural productivity, as well as increases in natural resource conflicts. It is, in many ways, negatively affecting local livelihoods.

The frequency and intensity of extreme weather events is also increasing. Droughts, floods, strong winds, and hailstorms are becoming more frequent (3–5 year cycles), limiting the ability of vulnerable households to recover from the prolonged drought cycles.

Crop productivity in the region is below global averages. This is because production is dominated by smallholder farmers (about 60 percent of farmers) who are constrained by limited access to quality inputs and markets, limited access to credit, low use of appropriate production technologies, and high food and energy costs.

Low crop productivity is evident in the average growth rate in maize production, which is about 1.1 percent. While at the global level, maize yields are 4.9 tons per hectare, yields in the East African Community (EAC) are highly variable and average about 1.6 tons per hectare per year. Rice productivity has been growing, with a regional average yield of 2.0 tons per hectare over the 45 years (1965–2010). Productivity of dry beans is generally low and stagnating, currently averaging 2 tons per hectare. Cassava production in the region rose from about 5.4 tons per hectare in the 1960s to a high of 10.3 tons per hectare in the mid-1980s and is now at an average of 8.3 tons per hectare. Meanwhile, sorghum is at an average of 1 ton per hectare, up from 0.9 tons per hectare in 1965–70.

Though East Africa contributes 28 percent of the world’s tea supply, its overall production is still low due to high production costs and other underlying economic factors.

The regional livestock resource base is estimated at 50.2 million head of cattle, 59.6 million goats, 25.3 million sheep, 6.3 million pigs, 109.8 million poultry, and 0.9 million camels. The productivity of livestock and livestock products is below global averages, and is constrained by climate variability due to seasonal water changes and pasture scarcity. Average milk productivity in the region was 340 kilograms per animal during the period 1965–2010 and increased to 410 kilograms per animal during the period 2005–2010.

Fisheries and aquaculture has potential for expansion. Capture fisheries in East Africa are dominated by the Nile perch and the pelagics, while aquaculture production in the Lake Victoria Basin is based on two main species: catfish (Clariasgariepinus) and the Nile tilapia (Oreochromis
niloticus). Total aquaculture production from the LVB is estimated to be around 100,000 tons, 50 percent of which comes from Uganda.

An estimated 25–60 percent of the EAC population is undernourished, with almost 10 percent of its population living under chronic food insecurity conditions in the past decade, due to both worsening climatic shocks and non-climatic stressors; such as escalating food prices, conflicts over natural resources, high poverty rates, rapidly increasing population rates, and high post-harvest losses.

The estimated post-harvest-loss of maize in the region is 10–20 percent, translating to about 0.6–0.7 million metric tons, which could feed most of the food insecure population in the EAC region. The losses are attributed to poor storage, disease and pests, and recurrent extreme climatic conditions, such as above-normal off-season rains.

An assessment of the vulnerable population within the LVB, based on key climatic and socioeconomic indicators, identified several vulnerable hotspots within the basin. These hotspots require a pragmatic action plan to mitigate their exposure to recurrent shocks, enhance their adaptive capacity, and reduce their vulnerability.

Agricultural development of the LVB is constrained largely by non-climatic drivers, which include high poverty levels, disease, and high and increasing pressure on resources due to rapidly growing population, all of which are exacerbated by soil degradation.

Gender is an important determinant of adaptive capacity. In most of the EAC region, women, youth, and children are the most vulnerable to climate change, as they are highly dependent on natural resources. However, they lack both access to information about climate change and the authority to make decisions about natural resource management, which keeps them highly vulnerable.

Policies and institutional and legal frameworks in the East African region guide agriculture production and food security systems and address adaptation to climate change. However, these policy initiatives have not been well integrated into national and regional policy frameworks and have not been consistently and adequately implemented. This has resulted in inefficiencies in the sector, leading to enhanced vulnerabilities of the systems as the frequency and intensity of extreme weather events increases.

The agriculture sector is underfunded in the EAC. Budgets for the EAC countries for 2015/16 show that Rwanda allocated 5.9 percent of budget to the agricultural sector, Uganda 3.35 percent, and Kenya 3.15 percent. This is far below the 10 percent level that the African heads of state agreed under the Maputo Declaration.

Lessons learned from countries such as Brazil and Korea, which transformed their agriculture over 30–50 years, indicate that consistent implementation of relevant policies, coupled with appropriate finance stimulus packages, have caused notable increase in agricultural productivity, food security, and economic growth.

The 2014 Malabo Declaration to End Hunger and Halving Poverty by 2025, and boosting intra-African trade in agricultural commodities and services, have yet to be realized. In fact, in the EAC region the rate of under-nourishment has increased by almost 20 percent, comparing 1990/92 to 2014/16.
I. THE IMPORTANCE OF THE AGRICULTURE AND FOOD SECURITY SECTOR

GLOBAL AGRICULTURE AND FOOD SECURITY

Agriculture is considered the engine for overall economic growth in much of the developing world; it contributes directly to food security and supports poverty reduction as well. In some of the world’s poorest countries, agriculture can account for 30–70 percent of gross domestic product (GDP), but its contribution declines with economic development. The ability of agriculture to generate GDP growth and its comparative advantage in reducing poverty varies from country to country. In this regard, a typology introduced by the World Bank (Figure 1) stresses that in agriculture-based economies (most of them in Sub-Saharan Africa), agriculture contributes significantly to economic growth, and because the poor are concentrated in rural areas, it will also contribute significantly to poverty reduction. Among EAC Partner States, the agriculture sector contributes 23–34 percent to GDP, the highest proportion in Burundi and the lowest in Tanzania.

![Figure 1: Agricultural contribution to global GDP [%] (source: World Bank 2010)](image)

Much of the agricultural productivity in these countries is by small-scale farmers (60–70 percent), however, due to lack of policies that favor those farmers, the contribution of the sector to regional GDP is gradually declining in Kenya and has remained stable in Tanzania (Figure 2). This reflects low agricultural input and low productivity by small-scale farmers.
Low agricultural productivity has a negative impact on the region's food availability, access, and use, rendering some regions of the EAC highly food insecure with increasing levels of undernourishment, compared to other region of Sub-Saharan Africa. According to FAOSTATs, the number of undernourished in East Africa increased by almost 20 percent from 1990–92 to 2014–16.
In the following sections of the report, EAC agriculture and food security status is analyzed relative to global trends. Critical factors affecting production systems are described and linked to food security vulnerabilities at regional to subnational levels, emphasizing the direct and indirect impacts of climatic trends on these sectors. These impacts are largely due to over-reliance on rain-fed agriculture, despite the huge potential for increasing arable land through irrigation. National and regional policy issues are also highlighted, with a view toward understanding where policies are effective or require strengthening.

2. AGRICULTURE PRODUCTION TRENDS IN EAST AFRICA

Agriculture is one of the most important sectors in East Africa. It employs about 80 percent of the rural population, the majority of whom are poor, thus, the development of the sector presents a great opportunity for sustainable poverty reduction. The sector also contributes to foreign exchange earnings and provides raw materials for agro-based industries. The sector accounts for about 34 percent of GDP in Burundi, 29 percent in Kenya, 32 percent in Rwanda, 25 percent in Tanzania, and 23 percent in Uganda (EAC 2014).

The major food crops in the region are maize, rice, potatoes, bananas, cassava, beans, vegetables, wheat, sorghum, millet, and pulses. Some of these are also sold to earn incomes for households. Cash crops include tea, cotton, coffee, pyrethrum, sugarcane, sisal, horticultural crops, oil crops, cloves, tobacco, coconut, and cashew. Recent trends indicate that maize has become both a food and cash crop in Tanzania and Uganda. Despite its contribution to food security, crop productivity in the region is low. The average yield for major crops is currently below elsewhere in Africa and even further below global levels. Low productivity has translated into poor overall agricultural growth rates in individual countries and for the East Africa region. Under current agricultural practices and projected population increases the sector is more vulnerable to the projected effects of climate change.

The relatively low yield levels for key food crops in the EAC region underscores the need for in-depth analysis of critical factors affecting agricultural productivity. Figure 4 shows that the region’s average yield for maize (a key source for starch) is about 1.39 tons per hectare, which is far below the global levels of 4.5 tons per hectare. Productivity of beans, a major and relatively cheap source of protein, averages 0.60 tons per hectare, which compares favorably to other parts of Africa and global levels of between 0.62 and 0.7 tons per hectare. Rice yield is 60 percent lower than the global average, 1.12 tons per hectare compared to 3.84 tons per hectare. Similarly, millet, sorghum, and wheat are almost 50 percent below global yields, as provided in FAOSTAT (2015).

Livestock is also a major factor in the growth of world agriculture. According to Wirtz et al. (2015) the livestock sector contributes an average of 9 percent (Burundi), 8 percent (Uganda), 9 percent (Kenya), 10 percent (Rwanda), and 8 percent (Tanzania) to GDP of the region. Unfortunately, the EAC livestock sector is also under-performing at 127 kilograms per animal compared to 200 kilograms per animal globally. Milk production is also well below global averages, 427 kilograms per animal in the EAC compared to 2,197 kilograms per animal per year globally. The low productivity in beef and milk is attributed to poor animal quality, husbandry, cultural beliefs, and prevailing environmental conditions such as climate, carrying capacity, animal diseases, and access to credit and loan facilities for small-scale and poor livestock keepers.
The EAC has some major world producers of tea and coffee and has achieved global levels of productivity for both commodities—1.85 tons per hectare for tea and 0.6 tons per hectare for coffee. However, the region is lagging well behind in wheat productivity—about 1.38 tons per hectare compared to 2.66 tons per hectare globally. This is attributed to recurrent extreme climatic conditions, such as drought and frost at critical phenological stages in wheat-producing areas. This is accompanied by high cost for commercial wheat farming, storage, and processing or value addition.

Productivity for other EAC commodities is summarized in Table 1, which indicates significant progress in cassava productivity, with Uganda the main producer in the region. As for banana, the average yield is 4.69 tons per hectare compared to 15.25 tons per hectare globally. Similarly, the EAC is only producing 4.11 tons of sugarcane per hectare, compared to 65.29 tons per hectare globally. This makes the region a net importer of sugar for its household and commercial consumer needs.

Table 1: Agricultural commodity yields (tons/ hectare) in East Africa, Africa and Global

<table>
<thead>
<tr>
<th>Commodity</th>
<th>East Africa</th>
<th>Africa</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1.39</td>
<td>1.16</td>
<td>4.47</td>
</tr>
<tr>
<td>Rice</td>
<td>1.12</td>
<td>1.87</td>
<td>3.84</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.38</td>
<td>2.03</td>
<td>2.66</td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.67</td>
<td>0.88</td>
<td>1.30</td>
</tr>
<tr>
<td>Millet</td>
<td>0.47</td>
<td>0.70</td>
<td>0.82</td>
</tr>
<tr>
<td>Potatoes</td>
<td>7.46</td>
<td>11.17</td>
<td>16.45</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>4.49</td>
<td>4.32</td>
<td>13.49</td>
</tr>
<tr>
<td>Cassava</td>
<td>8.18</td>
<td>8.83</td>
<td>10.76</td>
</tr>
<tr>
<td>Beans</td>
<td>0.60</td>
<td>0.62</td>
<td>0.70</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>0.62</td>
<td>0.86</td>
<td>1.35</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>4.11</td>
<td>56.74</td>
<td>65.29</td>
</tr>
<tr>
<td>Banana</td>
<td>4.69</td>
<td>6.59</td>
<td>15.25</td>
</tr>
<tr>
<td>Coffee</td>
<td>0.59</td>
<td>0.45</td>
<td>0.75</td>
</tr>
<tr>
<td>Tea</td>
<td>1.85</td>
<td>1.95</td>
<td>1.33</td>
</tr>
<tr>
<td>Barley</td>
<td>1.18</td>
<td>1.24</td>
<td>2.48</td>
</tr>
<tr>
<td>Oil seeds</td>
<td>0.51</td>
<td>0.69</td>
<td>1.75</td>
</tr>
<tr>
<td>Beef (kg/animal)</td>
<td>127</td>
<td>148</td>
<td>200</td>
</tr>
<tr>
<td>Chicken (kg/animal)</td>
<td>0.92</td>
<td>1.17</td>
<td>1.72</td>
</tr>
<tr>
<td>Cow milk (kg/animal/year)</td>
<td>427</td>
<td>496</td>
<td>2197</td>
</tr>
</tbody>
</table>

Source: FAOSTAT 2014.
Although cultivated land has steadily increased over the past 45 years, comparing changes in area planted in 1965–1970 and 2005–2010, the yield or productivity remains low, indicative of many underlying constraints. Figure 5 shows that cereal cropped areas in the region doubled during this period, with maize increasing from 2.69 percent to 5.99 percent, followed by dry beans, rice, and cassava. However, expansion in cropped land did not correspond to increased yield. The mismatch between increased cropped area and stable or declining yield may be attributed to various factors, including changing climatic patterns, coupled with under-funding of the agricultural sector.

According to EAC Fact Sheet (2015), Rwanda has increased its total cultivated area by 200 percent (from 816,000 hectares to 1,735,000 hectares) since 2008 and has 25 percent left to achieve full utilization of its total agricultural land of 2,294,000 hectares. In Tanzania and Uganda, meanwhile, cultivated area has remained generally stable since 2005 but only 50 percent of the total arable land has been utilized.

The regional livestock resource base is estimated to consist of 50.2 million head of cattle, 59.6 million goats, 25.3 million sheep, 6.3 million pigs, 109.8 million poultry, and 0.9 million camels. The productivity of livestock and livestock products also remains lower than global averages and is constrained by, among other things, climate variability and change, which are often associated with poor rangeland conditions or seasonal water and pasture scarcity. The average milk productivity in the EAC was 340 kilograms per animal during the 1965–2010 and increased slightly to 410 kilograms per animal during the 2005–2010.

Over the decade 2004–2014, Kenya, Tanzania, and Uganda showed steady growth in cattle herds from 20–30 to 30–42 million head (Figure 6). Kenya is the largest producer of beef and between 2009 and 2011 its cattle herd declined due to the severe drought during this period. This underscores the sensitivity of the sector to climatic conditions, especially prolonged drought, which is becoming more recurrent in the eastern and northern pastoral regions of East Africa. Meanwhile, Rwanda has also increased its cattle population, while Burundi experienced a slight decline in cattle. The overall increasing trend in cattle in the region is mostly driven by increased demand for beef and beef products in the Middle East.
Chicken breeding increased by almost 200 percent in Tanzania, Kenya, and Uganda between 2004 and 2014. This increase is also attributed to increased demand for white meat. Rwanda and Burundi had little or no growth in this sector.

Figure 6: Number of Cattle and Chicken in EAC Partner States, 2004–2014 (EAC 2015)

The fisheries industry is strongly influenced by global ecosystem processes. The social, economic, and nutritional requirements of the growing human population are already driving heavy exploitation of capture fisheries and rapid development of aquaculture. This trend is expected to continue over the next 20 to 30 years. The impacts of climate change will add to and compound threats to the sustainability of capture fisheries and aquaculture development (FAO 2009a).

Worldwide, more than 90 percent of the people engaged in the sector are employed in small-scale fisheries, many of whom are in the poorer countries of the world (Cochrane et al. 2011). The fisheries sector, which for EAC Partner States includes aquaculture development, is an important contributor to food security in the region. The sector significantly contributes to employment in the EAC, with an estimated 600,000 jobs in direct employment, mainly fishermen, and nearly 2.5 million jobs for people engaged in fish handling and cleaning, fish transport, net gear manufacture, trade, and processing, as well as boat builders and repairers, and others.

Overall, the EAC region had a 17–20 percent increase in fish catch between 2007 and 2013. Uganda had the highest catch, followed by Tanzania and Kenya. Rwanda and Burundi had the least fish catch during the period. Figure 7 shows current trends in fish catch in the region (though data for 2014 are lacking).

Figure 7: Percentage changes of fish catch in EAC for the 10 years, 2003–2014 (source: EAC FactSheet)
To understand agriculture, livestock, and fishery trends, key agricultural production systems are described in the subsequent sections, highlighting key constraints and opportunities in EAC agricultural sector.

3. MAIN FARMING SYSTEMS IN EAST AFRICA

The EAC region has 16 farming systems, but the three dominant ones are mixed farming, mixed irrigation, and pastoral systems. The three systems are all rain-fed and support cereal, root, and tree crop farming as well as livestock rearing. The systems have varying potential and face a range of constraints (the aridity ranges from hyper-arid to arid to humid). All three are highly vulnerable to climate variability and change (Figure 8).

Figure 8: EAC Farming Systems
The maize-mixed farming system is the main driver of agricultural growth and food security in the region, followed by the root crop (irrigated) and agro-pastoral systems. The system faces challenges such as limited access to agricultural resources, smallholder competitiveness, and household risk management.

The irrigated root crop farming system is considered to have among the highest agricultural growth potential in East Africa, both through expansion of cropping area and through mechanization and diversification into high-value crops and livestock.

The agro-pastoral farming system is characterized by low population density and high land pressure and vulnerability to drought. Crops and livestock are equally important in this system. Rain-fed sorghum and pearl millet are the main food crops. The pastoral farming system, mainly involving cattle, sheep, and goats (and camels in the hyper-arid areas), is found across large areas of the arid and semi-arid zones of East Africa. The system is characterized by seasonal migration in search for pastures and water.

### 3.1 EAC Staple Food Crop Production Trends

Many of the world’s least-developed countries, particularly in Sub-Saharan Africa and other marginal production environments, continue to experience low or stagnant agricultural productivity, rising food deficits, and high levels of hunger and poverty. In a 2014 report, FAO and IFAD estimated that global agricultural production may need to increase by 60–110 percent to meet increasing demand and provide food security. However, crop production is likely to increase by only 38–67 percent by 2050.

According to Karugia et al. (2013), during the period 1965–2010, the annual average growth rate in maize production was 1.1 percent. However, the annual average growth rate in maize yields fluctuated highly at both regional and country levels. Declines in maize productivity were registered in 1975–1980, 1995–2000, and 2000–2005. The period 2000–2005 had the highest rate of decline in maize productivity per year since the 1960s. Most countries in the region were affected by drought during this period. Regionally, cereal trends followed almost the same pattern as maize. While global maize yields increased 1.6 tons per hectare per year, the annual average maize productivity (1965–2010) for the EAC was 1.3 tons per hectare, far below the global average. The highest productivity level from the five EAC countries was 1.8 tons per hectare (Kenya, for 1985–1990), the lowest 0.7 tons per hectare (Tanzania, for 1965–1970), both of which were lower than the global average of 4.9 tons per hectare.

Analysis of EAC maize yields shows declining trends in Kenya and Burundi, while Rwanda and Uganda have significant increases. Tanzania’s yield trend is mixed with a steady increase from 1970 to 2000, before a gradual decline over the past 10 years. The significant increase in maize yield in Rwanda is attributed to the government policy on land consolidation and agriculture input subsidy programs for smallholder farms. It resulted in significant maize yield from 1.0 to 2.5 tons per hectare. In Uganda, the steady increase in maize yields is because maize has become both a food and cash crop, with increasing demand and export to Kenya and South Sudan. Uganda also benefits from its relatively fertile soils and ample rainfall throughout the year in its key agricultural areas in central and western parts of the country.

Maize production in Burundi, on the other hand, has declined steadily since the 1990s and has worsened recently due to ongoing domestic conflict. While Tanzania’s recent declining yield trends are attributed mostly to the northern bimodal rainfall areas, which experienced successive poor rainfall seasons. Those declines outweighed high yields in the southern unimodal rainfall
areas, which constitute the breadbasket region of Tanzania. Input subsidies and stable weather patterns have since improved yields in the southern but not the northern regions.

Meanwhile, Kenya had steady increase in maize yield in the 1970–1980s, but the trend took a downward turn in 2000–2010 and has remained stable with yields of about 2.0 tons per hectare. Interestingly, Kenya’s large-scale commercial farmers are still having high yields due to use of optimum inputs, but small-scale farmers in medium-potential to marginal cropping areas have generally continued to have low yields due to their limited agricultural resources and increasing rainfall variability in the central and eastern region of the country. Closer analysis of Kenya’s maize productivity reveals worrying trends and interventions by various stakeholders (Figure 9).

![Maize Yield Trends in East Africa, 1960–2010](source: FAOSTAT/ICPAC/FEWS NET/CamCO)

Despite the high rainfall variability and severe drought, the Nyanza region around Lake Victoria Basin (LVB) has increasingly adopted better agronomic practices (Figure 10). As land parcels become smaller, access to various donor-aided projects has led to increasing maize yields, after many years of poor production due to neglect. Severe droughts had adverse impacts on yield in this region. While the Rift Valley, the key agricultural area of Kenya, has had a downward trend, occasioned by erratic rainfall patterns, high costs of farm inputs due to degraded soils, increased maize crop pests and diseases have reduced yields, as have reductions in subsidy programs. Competition from cheap regional imports has also exerted downward pressure on prices resulting in some farmers using near average inputs leading to low yields.

Western Kenya has had continued challenges from decreasing land sizes due to high population pressure (over 1,000 people per square kilometer), with many farms becoming small with no optimum agricultural inputs. Medium to large farms have average-to-good input use and relatively higher yields but they are weighed down by the many low-yield small-scale farmers in the area who have a high proportion of area under maize.
The high yield variability and declining trends are largely attributed to these factors and particularly to the recurrent severe and prolonged droughts over 2000–2010. The national average has generally declined, making Kenya a net importer of maize, which is its main staple food.

**Rice production:** Rice production has been growing. The regional average annual production for the period 2005–2010 was 1.9 million tons, an increase of 0.14 million tons over the 1965–1970 period. Regional rice yields have nearly doubled, from 1.1 tons per hectare in 1965–1970 to 2.0 tons per hectare in 2005–2010. Average rice yields over 1965–2010 were 2.7 tons per hectare for Burundi, 4 tons per hectare for Kenya, 2.9 tons per hectare for Rwanda, 1.5 tons per hectare for Tanzania, and 1.3 tons per hectare for Uganda. During 2005–2010 rice productivity was 3.3 tons per hectare for Burundi, 2.9 tons per hectare for Kenya, 4.7 tons per hectare for Rwanda, 1.9 tons per hectare for Tanzania, and 1.8 tons per hectare for Uganda (Figure 11) (Karugia et al. 2013).

**Common Bean Production:** Dry beans historically have been an important food staple in East Africa. Productivity of this crop is generally low in the EAC, and a stagnating trend has been observed over time (Figure 11). Between 1965 and 2010, bean yield in the region rose marginally from 0.7 tons per hectare in 1970, to 0.8 tons per hectare by 1995, dropping to 0.6 tons per hectare in 2010. Such levels are far less than what is achieved in other African countries, including Egypt, Libya, and Sudan whose yields of dry beans are more than 2 tons per hectare.

**Cassava production:** Cassava production in the EAC rose from about 5.4 tons per hectare in the 1960s to a high of 10.3 tons per hectare in the mid-1980s (Figure 11). However, such productivity is far below the global average of 40 tons per hectare. It has since declined and stagnated at around 8.3 tons per hectare since the early 2000s. From 1965 through 1995 Burundi had a constant level of productivity of around 9 tons per hectare while it marginally declined to 8.4 tons per hectare during 2000–2005. Before 1985, Rwanda was leading in productivity with a high of 12.3 tons per hectare during the early 1980s; however, this decreased to 2.2 tons per hectare in the 1990–1995 period. In Uganda, the yield increased from 4.3 tons per hectare in the 1960s to a high and leading yield of 13.5 tons per hectare by early 2000s (Karugia et al. 2013).
3.2 PRODUCTION TRENDS FOR SELECTED CASH CROPS

3.2.1 Coffee

**Burundi**: Total coffee production in Burundi has declined, with more extreme fluctuations of production since 2000. In the 1980s coffee production fluctuated around 30,000 tons. After 2005, production fluctuated between 5,000 and 30,000 tons. According to the government regulatory authority, coffee production in Burundi decreased from 23 million tons in 2012–2013 to 10 million in 2013–2014, a decline of more than 50 percent. Possible explanations for these extreme fluctuations are climate and climate change, aging coffee trees, and low fertilizer use.

**Kenya**: Coffee production increased at an average annual rate of 6.6 percent between 1963 and peak production in 1988. However, production declined 62 percent between 1989 and 2008–10. Yields increased at an average annual rate of 0.9 percent per year between 1963/64 and 1987/88 but declined at 5.5 percent per year between 1988/89 and 2009/10. Possible explanations for this include declining and fluctuating prices between 1986 and 1992, climate variability, and diseases (Niragira et al. 2015).

**Tanzania**: Despite fluctuations in production, Mild Arabica leads other types of coffee produced followed by Robusta. Robusta production peaked in 2008/2009 after several reforms in the subsector, including the improvement in Robusta varieties. Hard Arabica and Mild Arabica have been fluctuating significantly, with modest increases, but not enough to surpass 1992/1993 and...
1988/1989 levels (Craparo et al. 2015). Coffee production in Tanzania is extremely price elastic, so market prices are a major factor in production fluctuations. In 2008/09, the volume of coffee produced increased to nearly 70,000 tons as international prices spiked during the food price crisis. Production then decreased to just 36,000 tons in the following year, possibly because coffee trees are biennial bearing, yielding a heavy crop in one year and a light crop the next. The industry suffered from other factors as well, including lack of adequate moisture, aging coffee trees, and highly volatile coffee prices, as well as limited access to credit, lack of adequate farming inputs, and low use of inputs.

**Uganda:** Two types of coffee, Arabica and Robusta are grown in a ratio of 1:4. Coffee is mostly grown in mixed stands and among shade trees that contribute to sustainable coffee production, with minimal use of agro-chemicals (fertilizers, pesticides, and fungicides). Coffee farmers in Uganda use a low-input system and producer households strongly rely on family labor (Wang et al. 2015). Total acreage under coffee in 2010 was estimated at 182,875 hectares, an increase from 178,125 hectares in 2009 (Figure 12). The increase in acreage notwithstanding, coffee production in the past three years exhibited a negative trend largely due to effects of climate change with prolonged droughts at the critical time of bean development. In addition, traditional coffee growing areas are experiencing labor shortages.

**Rwanda:** The volume of coffee production has varied dramatically from year to year, but the overall production trend is downward. In 2009, production stood at 14,000 tons, a drastic drop to half of the 2004 peak level of 28,000 tons (Figure 12). The observed fluctuation is coupled with changes of environmental drivers of production. The Republic of Rwanda National Adaptation Programs of Action (NAPA) document (2006) indicates frequent climatic fluctuation over time and space. The analysis of rainfall variability registered from 1961 to 2002 shows that the period between 1991 and 2000 has been the driest since 1961, with the Kigali station indicating a rainfall deficit during five years (1992, 1993, 1996, 1999, and 2000) out of which two were very remarkable (1992 and 2000). Further there are two pronounced rainfall excesses (1998, 2001). Similar excess was observed in 1979. Pests (Antestia bugs and coffee berry borers) and diseases (coffee leaf rust) have also affected production levels (Niragira et al. 2015).

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3.2.2 **Tea**

Tea is the second most popular beverage in the world, with an estimated 18 to 20 billion cups of tea consumed daily. Tea production in East Africa contributes 28 percent of the world market supply and is carried out in highland areas characterized by high annual rainfall and all-season river flows. Despite these favorable conditions, optimal tea production has been hampered by unreliable, insufficient, and expensive energy from the national grid system as well as by a lack of supply in remote areas. The processing of tea, which requires both electrical and thermal energy, has made it necessary for all tea factories to install backup diesel generators that are highly polluting and emit greenhouse gases.
Burundi: Over the past two decades, tea production fluctuated from about 5,000 to 8,000 ton per year. The lowest production was recorded in 1996 while output boomed in 2001, when about 10,000 tons was produced (Ndayitwayeko and Ndimanya 2015). This could be attributed to unfavorable weather conditions in some years as well as price volatility in the world market.

Kenya: Tea production consistently increased over past decades mainly because of the increase in plantation area. During 2001–2010, production generally increased, supported by an increase in the harvested area. However, two drops in production occurred, in 2006 and 2009, both due to a decrease in land productivity (Figure 12). The 2009 decrease is explained by a drought that affected many countries in the region and almost exclusively affected the production of smallholders (decreasing more than 40,000 tons) compounded by lack of irrigation infrastructure (Cheserek et al. 2015).

Rwanda: Tea production has been increasing since 2003, and in 2007 it increased by more than 40 percent due to the government’s intensification of fertilizer distribution and application. Tea cultivation is predominantly rain-fed and one hectare of plantation produces 1,800 kilograms of processed tea. Reliance on rain-fed production makes the sector sensitive to rainfall variability, which is common in many places in the region (Ndayitwayeko and Ndimanya 2015).

Tanzania: By the mid-1990s the share of smallholder contribution to the tea subsector dropped below 10 percent and by 1998 it fell to 5 percent, the lowest level since tea was introduced as a smallholder crop (Table 2). Contributing to the decline were low prices and late payments by the Tea Authority, old and inefficient processing factories, inadequate use of inputs, rundown transport equipment, poorly maintained roads connecting farms to tea factories, and low yields due to failure to adopt new clonal varieties (Larsen and Birch-Thomsen 2015).

Table 2: Tanzania Tea Production and Yield by Sector (1975/76–1999/2000)

<table>
<thead>
<tr>
<th>Production</th>
<th>Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td>Estates</td>
</tr>
<tr>
<td>Tons</td>
<td>Share</td>
</tr>
<tr>
<td>1975/76</td>
<td>10,890</td>
</tr>
<tr>
<td>1980/81</td>
<td>12,864</td>
</tr>
<tr>
<td>1985/86</td>
<td>12,050</td>
</tr>
<tr>
<td>1990/91</td>
<td>13,695</td>
</tr>
<tr>
<td>1995/96</td>
<td>18,037</td>
</tr>
<tr>
<td>1998/99</td>
<td>22,473</td>
</tr>
<tr>
<td>1999/2000</td>
<td>20,074</td>
</tr>
</tbody>
</table>

Source: Tanzania Smallholders Tea Development Agency

Uganda: Tea production has fluctuated considerably over time. In the early 1970s, Uganda produced about 23,400 tons of tea from 19,000 hectares of plantation with productivity exceeding 1.2 tons per hectare. Since then, production declined to as low as 1,533 tons in 1980, but it recovered to 3,500 tons in 1988 when the government began implementation of the Smallholder Tea Rehabilitation Project. Since then, the tea sector has slowly recovered, primarily due to rising productivity (Figure 12). Production reached a record high of 25,900 metric tons in 1998, surpassing for the first time the 1972 level of 23,400 metric tons. Production increased from 37,700 tons in 2005 to 48,663 tons in 2009 before declining to about 40,800 tons in 2010 (Ndayitwayeko and Ndimanya 2015). Despite the successful recovery of the tea industry, the
challenges it faces include lack of active research, increasing cost of energy, labor shortage, high cost of transportation to Mombasa, and auction price fluctuations (Independent 2010).

3.3 **TRENDS IN LIVESTOCK SUBSECTOR**

The world’s livestock sector is growing at an unprecedented rate, driven by a combination of population growth, rising incomes, and urbanization. Annual meat production is projected to increase from 218 million tons in 1997–1999 to 376 million tons by 2030 (Gardner 2013). In East Africa, livestock production is mainly done on marginal rangelands that are not usable for crop production, although there is a small but well developed and increasingly intensive livestock production system for dairy, poultry, wool sheep, and pig and goat production (EAC 2011). Where the potential for crop growth is limited by moisture availability, cattle, camels, sheep, and goats are raised in low-productivity pastoral systems in which mobile stock can take advantage of seasonal, patchy vegetation growth. In these areas, raising livestock is the only viable form of agriculture (CGIAR 2011).

More than 90 percent of livestock belong to traditional small owners. The animals are normally used for meat, milk, transport, trade, and draft power. Their herds are often large and in poor condition, but hardy enough to survive periodic drought and sparse vegetation (Fratkin 2001). In general, pastoralists occupy savanna, semi-arid, or arid deserts where climatic and soil conditions do not favor crop production. However, agro-pastoralist are found in low rainfall areas. The purpose of animal production at regional level is to produce enough quality animals and animal produce to match the requirements for the rapidly increasing population and create surpluses for export. The cattle population increased by 4.5 percent in 2011 while that of sheep increased by 11.6 percent. During the same period, the population of goats and pigs increased by 3.8 and 3.0 percent, respectively. Investment in intensive poultry production, both layers and broilers, has over the past 15 years become increasingly common in peri-urban areas of Uganda. Seventy percent of Ugandan households are engaged in some form of livestock rearing (MAAIF and UBOS 2009).

The livestock sector grew during the period 2007–2010 (Figure 13). All livestock types increased in number, except pigs. Poultry grew more than all other livestock types, followed by goats and cattle. However, this growth is a result of increase in number of stock and land under production rather than productivity.

The region recorded an increase in all livestock production. The increment is a result of increased number of farmers joining the sector and dedicating more land to livestock husbandry. This further demonstrates the growing importance of the sector in the EAC. Cows contribute significantly to the total livestock sector (MAAIF 2011).
From the period 1965–1970 to 2005–2010, average beef productivity in the region stagnated at around 130 kilograms per animal and an overall growth rate of 0.1 percent per year (Karugia et al. 2013). Average productivity was 160 kilograms per animal in Burundi, 140 kilograms per animal in Kenya, 100 kilograms per animal in Rwanda, 100 kilograms per animal in Tanzania, and 150 kilograms per animal in Uganda. Growth rates were 1.35 percent, 0.06 percent in Burundi, 0 percent in Kenya, 0.2 percent in Rwanda, and 0 percent in Tanzania (Figure 14). This stagnation in productivity resulted from domination by low-quality breeds and low-quality pastures, among other factors.

The average milk productivity in the EAC was 340 kilograms per animal during 1965–2010 (Figure 14). In the period 2005–2010, average productivity rose to a high of 410 kilograms per animal. At country level, variations were observed. Before 1990, milk productivity in Tanzania stagnated at 160 kilograms per animal. Even though milk yield in Tanzania has improved to 240 kilograms per animal over the period 2005–2010, about a 50 percent increase, the country is still trailing others in the region. Milk production grew steadily in East Africa in the 1980s and 1990s as the number of milk-producing animals increased (Figure 14). Some gains in beef and milk productivity have been recorded as well; however, rates of growth have been rather slow. Milk productivity growth has been especially slow, suggesting that most of the observed increase in milk production is driven by growth in number of animals rather than growth in productivity per animal. These show the challenge of failure to keep pace with population growth. As population grows there is pressure on land and therefore sustainable policies must address productivity levels (Karugia et al. 2013).

Rwanda and Kenya led in annual productivity with 580 and 620 kilograms per animal respectively, which is more than double the yield in Tanzania. Rwanda milk yields have almost doubled from 300 kilograms per animal in the late 1960s to the recent 580 kilograms per animal and so have the numbers, while Kenya had increased by 38 percent from 450 kilograms per animal. The increment in milk production reinforces the importance of the sector and its potential to increase farm and country incomes.
3.4 TRENDS IN THE FISHERIES AND AQUACULTURE SUBSECTOR

Global fish production has grown steadily over the past five decades, with the supply of food fish increasing at an average annual rate of 3.2 percent, outpacing world population growth at 1.6 percent. The average global per capita apparent fish consumption increased from an average of 9.9 kilograms in the 1960s to 19.2 kilograms in 2012 (FAO 2014). World food fish aquaculture production expanded at an average annual rate of 6.2 percent in the period 2000–2012 (9.5 percent in 1990–2000) from 32.4 million to 66.6 million tons. In the same period, growth was relatively faster in Africa (11.7 percent). Global production of marine capture fisheries increased from 17 million tons in 1950 to about 80 million tons in the mid-1980s, oscillating since then between 78 and 88 million tons (excluding discards) representing 60 percent of the overall fisheries production including aquaculture in 2001. The annual rate of increase of marine catches decreased to almost zero in the 1990s, indicating that the world oceans had reached their maximal production under the prevailing fishing regime.

Fisheries are an important economic activity as well as a direct source of food in the EAC region. Lake Victoria is the most important inland fishery on the continent (Njiru et al. 2008). The lake supports freshwater fishing with estimated annual yields of about 800,000–1,000,000 tons (LVFO 2011). The value of the fisheries industry on the lake is valued at more than US$650 million, of which US$250 million is revenue from fish exports.

Lake Victoria provides a habitat for over 500 species of endemic species, the most important of which is the cichlid family (LVFO 2011). The Nile perch is now the dominant commercial species of economic importance in the region accounting for more than US$200 million. Currently, the Lake Victoria fishery is estimated to produce 1 million tons per year, 66.6 percent of which is from the Tanzanian part of lake, followed by 18.6 percent from Uganda, and 14.8 percent from Kenya (Regional Catch Assessment Survey Synthesis Report 2005–2011) based on three key commercial species of Nile perch (Lates niloticus), Nile tilapia (Oreochromis niloticus), and dagaa (Rastrineobola argentea) (LVFO 2013). This is a change from the diverse multispecies fishery of the 1980s to one dominated by only three species. Since 2006, the large fishes, including Nile perch and Nile tilapia, started to decline and debate is ongoing as to whether this is due to overfishing or to environmental changes in the aquatic system. With the drastic reduction in the large fishes, there has been reported resurgence of the haplochromines and increased volume of the small silver fishes. The introduction of alien species like the Nile perch is estimated to have reduced the number of fish species by 200 (Kaufman 1992). Rapidly increasing fishing effort in recent years may have reduced biodiversity further. Reduced biodiversity is largely attributed to the increasing
vulnerability of the ecosystem. There are also indications that overfishing of Nile perch has been beneficial for biodiversity in the lake by reducing predation pressure on other fishes.

The Tanganyika sardine is the main fishery product for commercial and artisanal fishing. It accounts for 50–90 percent of the commercial fishery and artisanal fishermen are almost entirely dependent on this species.

Figure 15: Fish Catch Trends in the EAC, 1959–2014

Marine fisheries production is a major activity along the Indian Ocean coastline. Kenya and Tanzania are the only EAC Partner States with coastal fisheries. Marine fisheries in Tanzania contribute about 15 percent of the total fish production in the country (Republic of Tanzania 2007) and 6.5 percent of fisheries revenue in Kenya. The main marine species consumed are snapper, scombrids, and mackerel, among others.

Figure 16: Lake Victoria Water Level Trends, based on satellite observations (source: USDA/TOPEX – POSEIDON)

Rising ocean temperatures and ocean acidification (also linked to increasing global emissions of carbon dioxide) are radically altering aquatic ecosystems. Climate change is modifying fish distribution and the productivity of marine and freshwater species. This has impacts on the sustainability of fisheries, including aquaculture, on the livelihoods of the communities that depend on fisheries, and on the ability of the oceans to capture and store carbon (biological pump). The effect of sea level rise means that coastal fishing communities are on the front line of climate change, while changing rainfall patterns and water use affect inland (freshwater) fisheries and aquaculture.
Declining water levels in Lake Victoria (45 percent attributable to recurrent droughts) and rising temperatures will likely lead to decline in fish stocks. For example, studies show that Lake Tanganyika has warmed significantly over the past 90 years, leading to an increase in stratification and, consequently, a decrease in primary productivity.

Although aquaculture was introduced six to seven decades ago in all EAC Partner States, it only recently began to make a significant contribution in the region. The share of aquaculture—11.4 percent of the regional fish production—remains small compared to capture fisheries, but it is growing and has vast potential in all five countries (Table 3). The trend for aquaculture has been significantly positive with the entry of profit-minded farmers and increased public support to rural smallholder farmers across the region. The increased value of fish, ready access to technology, and growing number of success stories in aquaculture have created a rush to invest as farmers seek to take advantage of the situation presented by increasing demand for fish against a backdrop of stagnated or dwindling supplies from natural stocks.

Table 3: Fisheries in East African Partner States

<table>
<thead>
<tr>
<th></th>
<th>Burundi</th>
<th>Kenya</th>
<th>Rwanda</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland waters (km²):</td>
<td>2,180</td>
<td>13,400</td>
<td>1,390</td>
<td>&gt;61,500</td>
<td>36,330</td>
<td>114,800</td>
</tr>
<tr>
<td>Marine waters (km²):</td>
<td>N/A</td>
<td>230,000</td>
<td>N/A</td>
<td>287,300</td>
<td>N/A</td>
<td>517,300</td>
</tr>
<tr>
<td>Major inland waters and percent share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Tanganyika</td>
<td></td>
<td>L. Victoria 6%</td>
<td>L. Kivu – &gt;50%</td>
<td>Lake Victoria &gt; 90%</td>
<td>L. Victoria 73%</td>
<td>L. Albert, L. Kyoga, L. Edward and R. Nile (27%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lake Turkana</td>
<td>R. Kagera –</td>
<td>Lake Tanganyika</td>
<td>Lake Nyasa</td>
<td></td>
</tr>
<tr>
<td>Marine Coastline km</td>
<td>N/A</td>
<td>536</td>
<td>N/A</td>
<td>424</td>
<td>N/A</td>
<td>960</td>
</tr>
<tr>
<td>Exclusive economic zone (km²)</td>
<td>N/A</td>
<td>142,400</td>
<td>N/A</td>
<td>230,000</td>
<td>N/A</td>
<td>372,400</td>
</tr>
<tr>
<td>Inland fish production</td>
<td>12,309</td>
<td>156,860</td>
<td>19,475</td>
<td>372,257</td>
<td>407,638</td>
<td>968,269</td>
</tr>
<tr>
<td>Inland aquaculture</td>
<td>160</td>
<td>21,488</td>
<td>516</td>
<td>9,917</td>
<td>95,906</td>
<td>127,987</td>
</tr>
<tr>
<td>Marine production (t)</td>
<td>N/A</td>
<td>10,000</td>
<td>N/A</td>
<td>15,000</td>
<td>N/A</td>
<td>25,000</td>
</tr>
<tr>
<td>Total fish production (t)</td>
<td>12,469</td>
<td>188,348</td>
<td>19,991</td>
<td>397,174</td>
<td>503,544</td>
<td>1,121,526</td>
</tr>
<tr>
<td>Population</td>
<td>9,850,000</td>
<td>43,178,000</td>
<td>11,458,000</td>
<td>47,783,000</td>
<td>36,346,000</td>
<td>148,615,000</td>
</tr>
<tr>
<td>Per capita supply kg/yr</td>
<td>1.3</td>
<td>4.4</td>
<td>1.8</td>
<td>8.3</td>
<td>13.9</td>
<td>7.6</td>
</tr>
<tr>
<td>Per capita consumption kg/yr</td>
<td>1.0</td>
<td>3.1</td>
<td>1.6</td>
<td>6.5</td>
<td>8.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Production value (USD)/yr</td>
<td>783,000</td>
<td>250,000,000</td>
<td>25,000,000</td>
<td>500,000,000</td>
<td>800,000,000</td>
<td>1,575,783,000</td>
</tr>
<tr>
<td>Imported fish value (USD/yr)</td>
<td>104,000</td>
<td>8,300,000</td>
<td>10,000,000</td>
<td>250,000</td>
<td>1,600,000</td>
<td>48,538,000</td>
</tr>
<tr>
<td>Direct employment (jobs)</td>
<td>4,000</td>
<td>65,500</td>
<td>40,000</td>
<td>202,654</td>
<td>400,000</td>
<td>557,552</td>
</tr>
<tr>
<td>Indirect employment (jobs)</td>
<td>120,000</td>
<td>300,000</td>
<td>200,000</td>
<td>600,000</td>
<td>1,100,000</td>
<td>2,441,748</td>
</tr>
<tr>
<td>Estimated livelihoods</td>
<td>300,000</td>
<td>1,600,000</td>
<td>1,000,000</td>
<td>2,000,000</td>
<td>2,800,000</td>
<td>8,652,000</td>
</tr>
<tr>
<td>Leading source of fish</td>
<td>Inland Fisheries</td>
<td>Inland Fisheries</td>
<td>Imported fish</td>
<td>Inland Fisheries</td>
<td>Inland Fisheries</td>
<td>Inland Fisheries</td>
</tr>
</tbody>
</table>

Source: FAO Yearbook of Fishery and Aquaculture Statistics - Commodities Summary Tables (PDF) 2014, and National Fisheries Reports for Respective Member countries.

The upsurge in aquaculture production in East Africa has been remarkable, with Uganda aquaculture moving from a paltry 285 tons in 1999 to the current level of nearly 100,000 tons per year; while Kenya is currently reporting over 40,000 tons in annual aquaculture production from
under 2,000 tons in 2007. This is followed by Tanzania with nearly 10,000 tons (7,000 from seaweed and 3,000 from farmed fish), from under 3,000 tons in 2005. Rwanda has moved from under 500 tons to over 1,500 tons annually, while Burundi has moved from under 200 tons in 2010 to nearly 500 tons of farmed fish annually.

**Burundi:** Fisheries production in Burundi is predominantly based on Lake Tanganyika, which is shared with the Democratic Republic of the Congo, Tanzania, and Zambia. The waters under the jurisdiction of Burundi make up about 8 percent of the lake and are restricted to the northern coastline. Lake fisheries are generally divided into near-shore fisheries and offshore fisheries. Near-shore fisheries are characterized by fishers targeting sardines with light lift nets and, in some parts of the lake, hooks, lines, long lines, gill nets, and ring nets. Offshore fisheries are made up of artisanal lift nets and, in some areas of the lake, the industrial purse seine fishery (based in Zambia) operates more sophisticated gear. Although to date, aquaculture has seen little development in Burundi, smallholder pond culture does exist in many areas and is expanding in response to government policy. Other water bodies that contribute, though minimally, to fisheries production in Burundi are Cyohoha and Rweru, which are shared with Rwanda. Nearly 70 percent of the fisheries production is contributed by two pelagic small clupeids (locally known as "ndagala") *Limnothrissa miodon* and *Stolothrissa tanganicae*; the other 30 percent is contributed by the clupeids predator, a much larger species of the group of Lake Tanganyika centropomids (perches) known as *Lates stappersii*. Other *Lates* species in the fisheries are mostly incidental catch and include *L. angustifrons*, *L. mariae*, and *L. microlepis* (FAO 1999).

The Frame Survey (a technical survey and assessment of fishing effort) of Lake Tanganyika estimated 642 planked canoes and 46 dugout canoes distributed among the 54 landing sites along the Burundi shoreline of Lake Tanganyika. The artisanal fishery has grown immensely since the late 1950s, when the lift-netting was first introduced in the northern portion of the lake primarily targeting clupeids, with *S. tanganicae* accounting for most of the catch by weight. Industrial fishing units each consist of a large (16–20 meter) steel main vessel, a smaller net-setting vessel, and three or more light boats, requiring in all a crew of 20–40 persons. The industrial fishery traces back to the mid-1950s, when Greek nationals introduced the technique into Burundian waters. Purse seine units operated from larger ports throughout the lake until the early 1990s, when they started to concentrate in the southern portion. The drastic decline in industrial fishing in northern waters is reflected in the migration or retirement of many purse seine units.

**Kenya:** Kenya has a surface area of 582,650 square kilometers of which 13,400 square kilometers is inland water surface. Kenya has a coastline of 640 kilometers and exclusive economic zone (EEZ) of 142,400 square kilometers. Despite the vast marine resources (over 10 times the inland waters), 96.3 percent of Kenya’s fish production comes from inland waters with foreign fishing vessels exploiting the marine resources, which are not declared or recorded in national production statistics. The smaller component of marine fish production is mostly by artisan coastal communities.

Lake Victoria, for which Kenya shares 6 percent, contributes 81.5 percent of the inland fish production while Lake Turkana and rivers and Rift Valley lakes produce the other 18.5 percent. The artisanal fishery accounts for almost all the inland and marine water catches and consequently is the most important fishery in the country. The Government of Kenya began to intensified efforts to develop aquaculture in 2007, resulting in an increase in production from under 4,000 tons to over 21,000 tons in 2012.

Thirty percent of the total production, mainly Nile perch, is processed and exported to international markets. Kenya imports nearly the same amount of fish as it exports, but the imports are of lower value and quality. There is a growing ornamental fish trade in Kenya, with most fish
collected from the wild while a few pioneers are beginning to farm ornamental fish. Nile perch (*Lates niloticus*) account for about 43 percent of the total national fresh fish production (by weight), followed by Nile tilapia (*Oreochromis niloticus*) at 10 percent and then the silver fish (*Rastrineobola argentea*) local known as “omena” contributing another 43 percent of the total production. Marine fisheries consist of lobsters, prawns, crabs, octopus, and squid with only 4 percent contribution to total fisheries production. Aquaculture is based mainly on Nile tilapia and African catfish.

**Rwanda:** Of the surface area of 26,338 square kilometers, 1,390 square kilometers is water. There are 24 large lakes and several minor ones, including three shared lakes: Kivu with Democratic Republic of Congo, and Cyohoha and Rweru with Burundi. National fish production is currently 24,500 tons of which capture fisheries contribute 23,000 tons and aquaculture 1,500 tons (RAB 2014). Rwanda imports from Uganda and Tanzania more fish than it produces, although most of it is re-exported to the Democratic Republic of Congo. It is estimated that the fisheries and aquaculture sectors provide about 200,000 jobs (both direct and indirect employment). Fishing is basically artisanal and is mainly done in Lake Kivu using about 250 trimaran boats. These boats are used for capture of small pelagic “sardine” clupeid, *Limnothrissa miodon*, locally known as “isambaza.” Haplochromis (cichlid fishes) are also caught in the bays; while the large fish that contribute the minor component of the catch, include *Tilapia* sp., *Clarias* sp., and *Protopterus* sp.

**Tanzania:** This country is well endowed with water resources, sharing three of the largest inland lakes in Africa: Lake Victoria, Lake Tanganyika, and Lake Nyasa, a diverse river system, numerous wetlands, and the Indian Ocean. The country is rich in marine and inland fishery resources and therefore has a large fisheries sector. The Tanzania fishery is categorized into artisanal and commercial fisheries. The artisanal fishery comprises fishing in all the freshwater bodies and fishing for finfish, crustaceans, and cephalopods in the territorial waters in the Indian Ocean. The commercial fishery is mainly for prawn, octopus, and lobsters in the territorial waters, while the EEZ is exclusively exploited by Distant Water Fishing Nations vessels. The common fish species in the EEZ include tuna and tuna-like species such as marlin and swordfish; sharks are also caught mainly as by-catch. Fishing gear used include gill nets, hook and line, trawling for prawns, purse seining for sardines, and long lining and purse seining in the EEZ.

The fisheries sector has a significant role in social and economic development by contributing to the economic and social well-being of the country, particularly in supply of animal protein, income generation, employment and recreation, tourism, and food security, all of which are crucial for the attainment of the Millennium Development Goals. The sector currently supports 202,654 people directly as fishers/farmers deriving their livelihood from various fishery resources. Of this number, 19,223 are fish farmers while 183,223 are fishers. It also supports more than 4 million people who are engaged in related fisheries activities such as processing, trading, fish transporting, net making, and boat building.

Fish production and value in the country have been increasing in recent years, with the highest quantity of 375,534.6 metric tons of fish landed in 2005 and the fishing effort has been increasing. The peak of the fisheries production in 2005 was followed by sharp drop until 2008, then another peak in 2013. This trend closely resembles that of the fishing effort, indicating that once the fisheries resources decline there will be a corresponding decrease in effort until fish stocks rise again. However, despite the decline in resources and fisheries production, overall earnings steadily grew owing to the increasing value of the fish. The fall in fisheries volume seemed to have been made up by the rise in prices. The contribution of the sector has been estimated at 1.4 percent of national GDP while the fishery industry accounts for 10 percent by value of national exports (Annual Fisheries Statistics Report 2014).
**Uganda:** This is a leading freshwater fisheries producer in Africa and a global leader. Uganda is third in aquaculture production in Africa after Egypt and Nigeria (FAO 2014). Fisheries and aquaculture contribute more than 12 percent to agricultural GDP and nearly 3 percent of the national GDP. The sector is the leading provider of animal protein for household dietary needs, estimated at 61 percent. The sector provides more than 400,000 jobs in direct employment and another 700,000 jobs in related downstream activities with nearly three million people dependent on these sectors for livelihood. The capture fisheries sector contributes about 88 percent of the national fish production while aquaculture contributes about 12 percent.

The mainstay of Uganda’s fisheries is the Nile perch, Nile tilapia, and the minnow-like silver fish locally known as “mukene.” Nile perch is by far the most valuable species economically. About 120,000 tons of fish, mainly Nile perch, is processed annually by established modern factories for export to international markets. Another 80 million of mainly immature Nile perch and Nile tilapia is processed by artisans and traded regionally. Another 210,000 tons of mukene (*Rastrineobola argentea*) and other two mukene-like species from Lake Albert, 40 percent of which is used locally for human food and in processing of animal feeds. The major destinations for Uganda fish internationally include: the European Union, United States, Japan, Israel, and the Middle East. In Africa, Uganda fish is exported mainly to the Democratic Republic of Congo, Sudan, Kenya, Rwanda, Burundi, Central African Republic, South Africa, and Egypt.

Lake Victoria is the major contributor to Uganda’s fish productivity, followed by lakes Kyoga and Albert. The other fish-producing waters include lakes George and Edward. A sizable amount also comes from the various rivers, with the leading contributor being the Victoria and Albert Nile system. Wetlands and floodplains are also one of the sources of the fish, but these fisheries tend to be seasonal with the receding waters following the end of rains. Aquaculture is practiced nearly throughout the country, though the north has the highest potential. Nile tilapia and African catfish contribute over 90 percent of the aquaculture production with minor contribution from *Tilapia zilli*, common carp, and Nile perch (with seed sourced from the wild).

### 4. CRITICAL FACTORS AFFECTING AGRICULTURAL PRODUCTION IN THE REGION

#### 4.1 IMPACTS OF CLIMATE VARIABILITY AND CHANGE TRENDS ON AGRICULTURAL PRODUCTION

Climate trend analysis based on 1981–2014 gridded rainfall and temperature data sets indicate highly variable inter-seasonal rainfall trends, coupled with significant declining rainfall during the long and short rainy seasons. The areas affected the worst are in marginal agricultural (mixed farming) and predominantly pastoral farming systems, mostly the eastern part of the EAC region. The maps below (Figure 17) show that eastern lowlands, the coastal strip, and parts of the southern Rift Valley region of Kenya, the neighboring regions of northeastern Tanzania, together with northwestern Uganda, and parts of southwestern Rwanda and northwestern Burundi are experience declining rainfall patterns. However, because the eastern lowlands of Kenya receive relatively less rainfall they are more adversely affected by current climatic patterns. The rest of the identified areas will eventually be similarly affected if these climatic trends continue unabated. Eastern regions of Kenya fall within the arid and semi-arid (ASAL) regions of the EAC, which have been disposed to low rainfall amounts and high land surface temperature. A continuing decline in
rainfall amounts means that some of these maize cropping zones are becoming less suitable and are likely to become predominantly pastoral zones, though with limited rangeland resources (pasture and water).

Figure 17: EAC maize zones average seasonal rainfall amounts, variability and trends, 1981–2014 (source: FEWS NET/ICPAC/CamCO)

Analysis of maize production in Burundi, Kenya, and Rwanda, using FAOSTAT crop data and long-term climatic (EAC-CHIRPS) data sets, show a positive relationship with the rainfall patterns within the region (Figure 18). This underscores the importance of rainfall as a climate variable and the dependence of maize production on rain-fed production. Of the three countries, Kenya exhibits a relatively stronger correlation between rainfall and maize yield. Rwanda, meanwhile, due to its high rainfall amounts and government intervention in support of agricultural productivity since 2008, exhibits less response to prevailing rainfall patterns. Similarly, ongoing civil insecurity and underlying issues constraining maize productivity in Burundi result in relatively lower correlation with rainfall variability, indicating that other factors in these countries drive maize production.

Figure 18: Relationship between annual precipitation and maize yield for Burundi, Kenya, and Rwanda (source: FAOSTAT and EAC-CHIRPS data sets)

Within the LVB, analysis shows a strong correlation between maize and rainfall variability. This analysis was undertaken for Kenya, due to the ready availability of agricultural production statistics. Analysis of maize yield data (1970–2013) and rainfall for three major maize growing regions in the LVB in Kenya (Nyanza region, western Kenya region, and Rift Valley) shows positive correlation over the years (Figure 19). Declines in maize productivity were registered in 1983/84, 1975–1980, 1991/92, 1995–96, and 2004/2005 due to drought. Apart from effect of climatic variables,
however, push and pull factors determine maize production in this region. Drought is the main cause of poor yields as the region experiences droughts every five to seven years.

Figure 19: Relationship between annual precipitation and maize yield for the Lake Victoria Basin regions of Kenya (source: Kenya Ministry of Agriculture and EAC-CHIRPS data sets)

As climate is a driver of crop productivity, its variability and subsequent change will have implications for crop production in different parts of the region. Recent trends and the current performance of agriculture indicate that the region is progressively less able to meet the needs of its rapidly increasing population.

As discussed in chapter 2, on climate variability and change, the northern and eastern regions of the EAC face the same predicament of declining rainfall, coupled with unpredictable weather and climate conditions. This makes it very challenging for both the crop and livestock farmer to predict and plan on the decreasing rainfall and its evident impact on vegetation conditions. Its net effect is declining rangelands, often worsened by prolonged severe droughts in a 3–5 year cycle.

Years of successive severe drought, especially over 2000–2010, have resulted in significant losses of livestock and increased small animal poaching in neighboring national parks and conservancies. Recurrent droughts also have led to environmental degradation and increasing competition for meager rangeland resources among pastoralists and wildlife in these localities. These trends have led to escalating civil insecurity and human-wildlife conflict over dry season grazing and designated water points. Northern Kenya and northeast Uganda pastoralists are particularly vulnerable to these extreme conditions due to their high poverty levels and lack of basic services and infrastructure and their livelihoods are often pushed to brink of collapse.

4.2 THE COST OF AGRICULTURAL PRODUCTION IN EAST AFRICA

Agriculture in the EAC is dominated by smallholder farmers characterized by low productivity. This stems from the lack of access to land, markets, and credit, and to the low application of technology. Where available, credit facilities and bank lending rates are too high to guarantee profitability for small-scale agricultural production. Low profitability is exacerbated by high costs for energy and transportation across all the EAC Partner States. Government subsidies and appropriate agricultural extension services for farmers are very limited and inconsistent. The net result is high costs for agricultural production in the region with a negative impact on the accessibility of basic food commodities, the prices for which have remained highly volatile and generally unaffordable for most poor households (earning less than US$1.25 per day). The costs of global and regional agricultural inputs have a strong effects on local costs of food production systems in the region.

Figure 20 shows the cost of maize production in the region, as influenced by the main producers in Kenya, Tanzania, and Uganda. The highest costs (US$0.5 per kilogram) occurred during the severe drought of 2010/11, the impacts of which lasted into early 2014. The current costs have stabilized between US$0.1 and US$0.3 per kilogram. The cost of production in Burundi has
remained anomalously high due to ongoing civil insecurity and reduced basic services in some of its maize cropping areas. The high maize prices distort the average cost of maize production, so it is omitted from the average costs in the region. The high cost of production is attributed to high costs of agricultural inputs, level of soil degradation, and costs of transportation and tariffs for importation of seeds and fertilizers in the region. In countries where the national governments have intervened by providing subsidies the costs of agricultural production are relatively lower and supportive of small-scale farmers.

![Figure 20: Cost of maize production in East Africa (US$/kg), 2007–2015](source: FEWS NET/Markets and Trade)

### 4.3 PESTS, DISEASES, AND POST-HARVEST LOSSES

According to the Food Security and Nutritional Working Group (FSNWG) report of 2012, Maize Necrosis Disease (MLND) was first reported in Kenya (southern Rift Valley, Bomet, and Naivasha districts) in September 2011. Its extent at that time suggested that the disease had been present for some time. The Ministry of Agriculture estimated that it resulted in a 2 percent reduction in the 2012 national maize harvest. MLND also spread rapidly into Tanzania, Uganda, and South Sudan (Figure 21). However, insufficient data on the disease may mean that the extent of its spread could have been more extensive than indicated.

![Figure 21: MLND prevalence in East Africa and impact in Kenya, 2011–2014](source: FSNWG and Kenya Ministry of Agriculture)
MLND, also referred to as Corn Lethal Necrosis, results from a combination of two viruses, the Maize Chlorotic Mottle Virus and any of the cereal viruses in the Potyviridae group, like the Sugarcane Mosaic Virus, Wheat Streak Mosaic Virus, or Maize Dwarf Mosaic Virus. MLND is mainly spread by a vector that transmits the disease from plant to plant and field to field. The most common vectors are maize thrips, rootworms, and leaf beetles. Hotspots appear to be places where maize is being grown continuously.

The impact was significant for smallholder farmers as some completely lost their maize crop. Losing a harvest has significant impact on the food and nutrition security of farming families as maize makes up a large part of the diet in East Africa. For countries like Tanzania that export maize, the further spread of MLND may have a significant impact on the economy. Figure 21 shows the impact of MLND in Kenya, which lost 9 percent of its 2014 maize production.

The rapid spread of MLND in the region and the potential threat to food security and trade has aroused the interest of governments, national and global research organizations, and the private sector, culminating in several initiatives. While several short-term interventions have been suggested, the more sustainable long-term solution appears to be the development of MLND-resistant maize varieties. The success of this endeavor calls for a facilitative legal and policy environment including explicit governmental support for deployment of modern breeding techniques, including the use of biotechnology.

### 4.4 Rift Valley Fever and its Impacts in East Africa

Rift Valley Fever was identified in Africa in 1931, when the virus was isolated during an investigation into an epidemic among sheep on a farm north of Lake Naivasha in the Rift Valley of Kenya. Over subsequent decades its range has expanded from East Africa across the Sub-Saharan region to North Africa and the Arabian Peninsula. RVF is a deadly mosquito-borne disease that affects both humans and livestock. Disease outbreaks in East Africa occur during specific environmental conditions: heavy rains and vegetation overgrowth in areas with low grassland depressions (Greenhalgh 2015).

As with all animal diseases, RVF adversely affects human populations by reducing the quantity and quality of food, other livestock products (hides, skins, fibers), and animal power (traction, transport) that can be obtained from a given quantity of resources and by reducing people’s assets. RVF is a highly contagious, transboundary disease and in 2006–2007 outbreaks in Kenya, Madagascar, Somalia, Sudan, and Tanzania caused more than 200,000 human infections and led to roughly 500 deaths. In Kenya alone, the outbreak cost US$32 million in livestock losses and international export bans. An outbreak in 1997 caused 170 hemorrhagic fever deaths and approximately 27,500 infections. The most serious outbreak occurred in Kenya in 1950–1951 and resulted in the death of roughly 100,000 sheep.

Although, it has proved challenging and expensive to stop an outbreak of RVF once it begins, it is relatively easy to predict outbreaks, as scientists from the U.S. National Oceanic and Atmospheric Administration (NOAA) and U.S. Centers for Disease Control (CDC) have identified climate patterns that cause these conditions. With enough warning, health officials can work to prevent RVF illnesses in animals and humans. While no RVF vaccine is currently approved for human use, there are vaccines for livestock. When heavy rains are known to be on the way, health officials can be alerted and they can vaccinate animals or facilitate the spreading of pesticides to kill mosquitoes before they hatch.
4.5 **IMPORTANCE OF WATER, ENERGY, AND HEALTH TO THE AGRICULTURAL SECTOR**

Although the EAC has large irrigation potential, due to its river systems and available land, only a small percent of its agricultural production benefits from large-scale irrigation systems. Figure 22 shows the potential water recharge, based on simple water balance approximation of available water through average cumulative rainfall amounts versus amount lost through corresponding evapotranspiration. Expansive tracts of land in central and eastern Kenya, together with northern and parts of central Tanzania, show significant rainfall deficits and therefore less potential for underground (aquifer) water recharge. However, by similar measure, Burundi, Rwanda, Uganda, and the western and Rift Valley regions of Kenya show large potential for large-scale irrigation schemes.

For areas already under irrigation in Kenya and Tanzania, vegetation trends have shown positive improvements in the past 20–30 years, underscoring the importance of implementing reliable and well-conceived irrigation schemes in the region. Kenya is currently planning to put one million hectares under irrigation in the Tana River region, which has been adversely affected by rainfall variability.

Several EAC countries have extended their irrigated areas, for instance Kenya has planned to establish the Galana/Kulalu irrigation scheme to cover one million acres with an estimated yield of 40 bags per hectare, in comparison to a national average of 17 bags per hectare. If realized, this scheme is likely to address Kenya’s food insecurity, reduce the cost of production, and reduce maize importation.
4.6 ENERGY TARIFFS FOR MEDIUM AND COMMERCIAL INDUSTRIES

The cost of agricultural production is often directly linked to energy costs. Energy tariffs in the EAC are highly diverse and depend on rainfall variability. Figure 23 shows that Uganda has the highest tariffs for medium to large commercial sectors, while Burundi and Tanzania have relatively lower tariffs. Kenya was missing data, but what there is shows a trend similar to Tanzania of about US$0.1 per unit cost. The high energy tariffs are due to fuel charges, foreign exchange rate fluctuations, inflation adjustments, hydropower costs, levies, and 16 percent VAT loading. These high cumulative energy costs contribute significantly to the high cost of agricultural production.

![Figure 23: Potential water recharge, irrigated areas and impact on vegetation conditions, 1982–2010 (source: EAC Fact Sheet 2015)](image)

4.7 LESSONS FROM BRAZIL, THE REPUBLIC OF KOREA, AND THE GREEN REVOLUTION

Policy regimes can be decisive for agricultural investments and therefore affect sector performance. It is crucial then to understand how policies have negatively affected agricultural transformation. In several cases, governments have increased agricultural investment, as well as access to support services, to boost production and productivity. These include Brazil, China, India, Indonesia, Mexico, the Philippines, the Republic of Korea, and Rwanda. The experiences of Brazil and the Republic of Korea are documented below, together with some useful lessons from the Green Revolution.

4.7.1 Brazil

Brazil transformed itself from a food importing country into one of the largest food producers and exporters in the world in less than 30 years. Cereal production increased from 15 million tons in 1961 to over 75 million tons in 2010 (FAO 2012), a fivefold increase. Agricultural output grew by 243 percent between 1970 and 2006. The value of the country’s agricultural exports increased from just US$1.2 billion in 1960 to US$62 billion in 2010, making Brazil the second largest exporter globally (FAO 2012). The agricultural trade surplus reached over US$53 billion in 2010, making agriculture a principal factor in trade balance and macroeconomic stability. These changes occurred in an environment where total population increased from 72.8 million in 1960 to 196.7 million in 2011 and without deforesting the Amazon to create more land for agriculture.
and without much government subsidy (The Economist 2010). Three policies were critical to the agricultural modernization process in the country.

- **Credit support to family farm agriculture**: The government supported the National Family Farm Strengthening Program (PRONAF) to bolster the capacity of family farms, especially to promote the use of new technologies, integrate them into agricultural production chains, and expand commercial possibilities. The government provided capital through groups of small producers.

- **Rural extension**: Technical assistance was provided through both public and private channels along with rural credit to better utilize investment in capital goods and modern inputs acquisition.

- **Marketing and income support**: Implementation of the Minimum Guarantee Price Policy (PGPM), which enabled the government to purchase agricultural products at a standard price whenever they exceeded the market price. The Food Procurement Program (PAA) distributed the purchased products to targeted groups, such as school children and vulnerable families.

- **Agricultural research**: In 1973, the Brazilian Agricultural Research Corporation (EMBRAPA) of the Ministry of Agriculture, Livestock, and Food Supply was created. The new policy started paying dividends nearly immediately as new research revealed agricultural development constraints, especially related to soil acidity. In addition, research enabled Brazil to identify new crop varieties adapted to low latitudes as well as soil and climatic conditions.

- **Risk management**: Brazil’s approach to promoting agricultural production included the use of several mechanisms to offer protection to farmers’ investments against adverse weather as well as outbreaks of pests, weeds, and diseases.

### 4.7.2 The Republic of Korea

In the 1950s most of the population of the Republic of Korea lived in rural areas and earned livelihoods from substance agriculture. Until the 1960s, Korea suffered from severe food shortages but it become self-sufficient in rice in the late of 1970s due to implementation of appropriate agricultural policies. Subsequently, agricultural productivity, including rice, has been greatly enhanced with improvements in the agricultural production base and technology innovation. Today, the agricultural sector contributes directly to the development of the Korean economy (Table 4) as well as providing land, labor, and capital to secondary and tertiary industries.

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<th>Table 4: Share of agriculture in the Korean economy</th>
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<td><strong>Agricultural GDP (US$ billion)</strong></td>
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<td><strong>Contribution of sector to GDP (%)</strong></td>
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<td><strong>Population (millions)</strong></td>
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<td><strong>Agricultural employment (millions)</strong></td>
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<td><strong>Share employed in agriculture (%)</strong></td>
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Land reforms: The Farmland Revolution of 1950 was initiated to settle a new landlord-tenant system. The land reforms abolished the old landlord-tenant system, creating incentives to farmers to improve their productivity and production.

Abolition of usurious loans system: In 1961, the government eased farmers’ loan burdens by registering all private loans to farmers and repaying them by issuing an agricultural bond through unit cooperatives. Farmers had to pay back the new loans at lower interest rates to the unit cooperatives.

The Saemaul Movement: A national movement was initiated in the 1970s to improve the rural living environment based on mutual help and self-reliance. The movement also sought to create a “can do” spirit among farmers.

Price support and R&D: To stabilize farm income and increase rice production, a significant proportion of the government’s investment was spent on a price support policy and research and development for a high-yielding variety of rice.

Capital and technology: The creation of the Agriculture Fund and Ministry for Food, Agriculture, Forestry, and Fisheries Fund and other funds in the private sector was instrumental in the development of agriculture.

Good leadership: The Farmland Revolution, the clearing of usurious loans, the Saemaul movement, and the Green Revolution of the 1970s would not have happened without focused leadership. After constructing the agricultural foundation, new leadership invested in improving agricultural productivity and stabilizing farm incomes through irrigation, farm mechanization, facility modernization, and technological innovation.

While each country has traversed its own unique path, there are several common elements:

- The public sector supported stable financing mechanisms in the early stages of economic development, particularly for capital formation.
- Capacity was created within each country to identify, formulate, and implement appropriate policies and react flexibly to structural changes in the agricultural sector and economic environment.
- Technological advancements were complemented by institutional innovations to ameliorate agricultural productivity, allowing smallholder agriculture to grow at a faster pace and achieve poverty reduction as well as food security.

4.7.3 The Green Revolution

What Brazil and Korea experienced is closely related to what the Green Revolution concept was conceived to achieve. The Green Revolution refers to a set of research, development, and technology transfer initiatives that occurred between the 1930s and the late 1960s. It is attributed to geneticist Nazareno Strampelli and 1970 Nobel Peace Prize winner Norman Borlaug. Their combined efforts, along with support from governments, led to increased agricultural production, especially in the developing world, beginning in the late 1960s (Hazell 2009). The revolution started from Mexico in the 1940s and later spread to Asia, the Middle East, Latin America, and Africa. The developing world has witnessed food crop productivity growth since then despite increasing land scarcity and rising land values. Although populations had more than doubled, the production of cereal crops tripled during this period, with only a 30 percent increase in land area cultivated.
The Green Revolution is credited with saving more than a billion people from starvation. In India, for example, the increase in food production surpassed the increase in population, despite high population growth (Figure 24). The revolution involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, equipping farmers with management techniques, distribution of hybrid seeds, and use of synthetic fertilizers and pesticides. In India between 1961 and 2003:

- Population increased by 100 percent
- Food production increased by 150 percent
- India became a net exporter of grain.

Numerous attempts have been made to introduce the successful concepts from Mexican and Indian projects into Africa (Groniger 2009), but the programs have generally been less successful. The reasons cited for the failure include corruption, insecurity, lack of adequate infrastructure, and a general lack of will on the part of the governments (Frison 2008).

In the most basic sense, the Green Revolution was a product of globalization as evidenced in the creation of international agricultural research centers that shared information, as well as transnational funding from groups like the Rockefeller Foundation, Ford Foundation, and USAID.

5. FOOD SECURITY IN EAST AFRICA

5.1 OVERVIEW OF FOOD SECURITY

East Africa has one of the world’s highest levels of food and nutrition insecurity. According to the International Food Policy Research Institute (IFPRI) global hunger index (GHI), 30 to 60 percent of the EAC population is food insecure. The 2015 UN-FAO State of Global Food Security reports that 794 million people are undernourished globally and that 124 million East Africans are undernourished—70 to 80 percent of its total population.
Most populations that are frequently food insecure are becoming chronically food insecure and live within the predominantly pastoral and marginal agro-pastoral areas of Burundi, northeastern Uganda, and northern and eastern Kenya. Rwanda and Tanzania experience similar food insecurity but it is less intense and less frequent.

Food security assessments in the EAC are based on objective analysis of available indicators for food availability, access, utilization, and stability of supplies by multiple agencies on a regular basis. Most of these assessments, are undertaken during pre- and post-harvest periods. The outcomes of these assessments over 2008–2015 were used to determine frequent food insecurity occurrences that required urgent responses by national governments, donors, and response agencies.
Figure 25 shows recurrent food insecurity trends based on analysis of 2008–2015 acute food insecurity conditions requiring urgent assistance based on the FAO/Integrated Phase Classifications (IPC). The map shows the frequency and severity of food security classified as at crisis or emergency levels (IPC level 3 and above). The line between frequent, acute, transitory and chronic food insecurity is often thin. Chronic food insecurity is a long-term or persistent inability to meet minimum food consumption requirements for a period of more than 6-months. This is often associated with chronic or structural poverty, lack of basic social services, appropriate institutions, and infrastructure to mitigate against transitory shocks by local populations. Transitory food insecurity is a short-term or temporary inability to meet minimum food consumption requirements, indicating a capacity to recover. As a rule of thumb, short periods of food insecurity related to sporadic crises can be considered transitory.

Kenya is the most highly food insecure country among the five EAC Partner States. With the worst-affected population living within the arid and semi-arid regions of the country, an area that has high rainfall variability, declining rainfall trends, and increasing surface temperatures.

According to United Nations International Strategy for Disaster Reduction (UNISDR), the main drivers of recurrent food security in the region are as follows:

- Recurrent extreme climatic shocks (droughts, dry spells, and floods) leading to poor agricultural production
- Escalating and highly volatile commodity prices
- High population density and poverty levels
- Increased resource-based conflict and civil insecurity
- Environmental degradation
- Human, crop, and livestock diseases
- Weak institutional capacities and low basic services
- Government policies—agricultural productivity, markets, and trade and disaster risk reduction.

Extremely high chronic food insecurity is born of recurrent food insecurity that requires sustainable long-term interventions and regular, coordinated emergency responses. Understanding the factors that create food insecurity among those with vulnerable livelihoods is critical to strengthening their coping mechanisms. In many cases, those whose ability to cope is stretched are on the brink of collapse. This was observed in the extreme climatic and non-climatic shocks of 2000/1 and 2010/11.

Agricultural production per capita, which is correlated to food availability per person trends in East Africa, show two distinct patterns: Kenya and Burundi show declining trends, while Rwanda, Tanzania, and Uganda have steadily increasing trends (Figure 26). Kenya and Burundi are increasingly in maize deficit and require imports from neighboring countries. Kenya is highly affected by this downward trend due to its high dependence on the production of maize, its main staple food.
Maize is both a food crop and cash crop for Uganda and Tanzania and their national governments have put in place agricultural policies to spur steady growth, despite high rainfall variability and decline per capita as a natural resource. Inter-annual rainfall variability is known to be correlated with variability in maize production, particularly in countries where rainfall amounts are a limiting factor to production, as in Kenya and part of Burundi, where there are no significant government interventions to mitigate the vagaries of weather and climate.

Extreme climatic shocks, such as recurrent poor countrywide climatic conditions over 2000–2011, were associated with poor agricultural production, including reduced and failed crops, as well as poor livestock conditions (Figure 27). The time-series analysis of meteorological drought indicators (based on Standardized Precipitation Index (SPI)) shows that drought drive food insecurity in the region.
Successive negative SPI values related to drought attest to the increased frequency of severe droughts (SPI > -1.5), interspersed with short-lived recovery periods or back-to-back with extreme flooding, such as the 2006, 2009, and 2015 El Niño events, with no sufficient periods for livelihood recovery, especially for the livestock subsectors, which require at least 3–5 years of good rainfall seasons to ensure re-stocking. The severe droughts of 1999/2000 and 2009/11 resulted in the loss of 70–80 percent of livestock and extreme depletion and degradation of rangeland resources among most of the pastoralists living in Kenya, northeastern Uganda, northeastern Tanzania, and parts of Rwanda and Burundi.

Recurrent severe droughts are particularly devastating for these pastoralists, who rely upon livestock or subsistence farming, as shocks continuously erode their means producing food and income, and ultimately result in loss of their meager assets occasioned by regular sales of their livestock or assets to cushion against prolonged droughts, such as 2000/1 and 2009/11. Short-term emergency relief interventions are often inadequate in building the local communities resilience to similar future shocks.

5.2 HIGH FOOD PRICES

Escalating and high volatility on basic food price trends constrain food access for the poor who live in areas that experience food deficits, both rural and urban. These poor populations are becoming increasingly dependent on existing markets to access food and essential non-food items.

Figure 28 shows the escalating and high variability of maize flour and bean prices in EAC countries. Prices for maize flour range from an average of US$0.45 per kilogram in 2006 (with above-normal El Niño rains) to about US$0.75 in 2015. The rapid increase in prices was attributed to the
prolonged drought of 2009/11 (with below-normal La Niña rains), which resulted in high maize prices in both Tanzania and Uganda, the main maize producing countries in the region.

The impacts of the 2009/11 drought also resulted in high bean prices. Average bean prices in the EAC rose from US$0.6 to US$1.2 per kilogram, a 100 percent increase over the past 10 years. The increase has been steady and volatile as compared to maize because maize production is highly dependent on relatively high rainfall amounts and prone to water stress in medium and marginal agricultural maize growing zones.

The current cumulative costs of 1 kilogram of maize, flour, and beans, at about US$2, is unaffordable for most poor households earning less US$2 per day, which is about 50 percent of the EAC population, mostly living in rural areas. This has led to high numbers of undernourished people and high food insecurity in the worst-affected areas. The cost of other cereals and legumes in the region has also increased with each extreme climatic shock, worsened by increased fuel and energy prices, unregulated trade tariffs, and market disruptions due to civil insecurity (such as the 2007 post-election violence) within and across EAC Partner States. Figure 29 shows the interplay between various contributing factors.

Further, there are currently significant price differentials for staple cereals and legumes, owing mostly to cost of production and the prevailing strength of national currencies. For instance, the current price of maize in Kampala is US$25 compared to US$32 in Nairobi and US$44 in Bujumbura (RATIN). Food price differentials drive commodity flows across the region and escalate
during failed seasons, making it impossible for people living below poverty levels (US$1.20 per day) to purchase basic cereals and proteins for healthy living.

The terms of trade for livestock herders often decline following adverse climatic conditions. Adverse conditions are often associated with poor livestock body condition and milk production—a major source of income and food for most small-scale pastoralists. Livestock in poor condition drive prices down, reducing the terms of trade for farmers when the livestock are exchanged for staple food commodities, such as maize and beans.

5.3 Rapidly Increasing Population Density

East Africa has one of highest population growth rates in the world—an average of 3 percent per year—with Uganda leading at 3.2 percent, followed by Tanzania at 3.1 percent, Rwanda 2.9 percent, Kenya 2.7 percent, and Burundi at 1.9 percent. Of the five Partner States, Tanzania leads with 46.2 million people, Kenya 41.6, Uganda 34.5, Rwanda 10.9, and Burundi 8.6 million. The ratio of males and females is almost equal in all countries with slightly more females than males in Rwanda and Burundi according to the latest World Bank report.

The population of the EAC Partner States is likely to double by 2050 according UN Population Development Projections (2012), with corresponding demand for food (Figure 30). This means that for a climatic shock similar in intensity to the event of 2010/11, more than 20 million people are likely to be affected if no sustainable adaptive capacities are implemented in the current decade.

![Figure 30: EAC population and projections for 2050 (source: UN Development Population Projections)](image)

High population density is already a challenge, especially in western and central Kenya, central Uganda, Rwanda, and Burundi, where agricultural productivity is high to medium but arable land is being lost to human settlements. Much of the locally produced food is increasingly being consumed within area of production with little left for sale in food-deficit areas within the country and across the borders.

5.4 Fragile Livelihoods Linked to High Food Insecurity

The livelihoods of pastoralists and marginal agricultural communities rely heavily on rain-fed economic activities and are highly sensitive to climatic and non-climatic shocks. There are five broad-classes of livelihoods over the Greater Horn of Africa. These are pastoral, agro-pastoral,
marginal, medium and high productive agricultural zones, and urban areas (FEWS NET 2015). Most of the acutely and chronically food insecure areas fall within the pastoral, agro-pastoral, and marginal agricultural zones. Successive seasonal rainfall failures in these areas result in serious losses of food and income sources either directly from surplus crop sales or related employment. Droughts that extend over multiple seasons would translate into losses of assets in the form of livestock or land and a downward spiral into deeper poverty levels.

Figure 31 shows the distribution of various levels of food insecurity in the region, and the corresponding livelihoods in the adjacent map, during the severe drought of 2010/11. It is evident that the pastoralists and marginal agricultural livelihoods living over the eastern Horn were affected the worst during this period. Climatic shocks in 2000/01 resulted in almost the same level of food insecurity outcomes.

![Figure 31: 2010/11 Food Insecurity and generalized livelihoods zones map (source: FEWS NET/East Africa)](image)

5.5 Generalized Vulnerability and Food Insecurity in Kenya

The linkage between frequent food insecurity and underlying vulnerabilities is shown in Figure 32. The maps are based on the IPCC framework for vulnerability index mapping, and use available baseline data from various sources that integrate the exposure, sensitivity, and adaptative capacity GIS layers. The results indicate the chronic conditions in parts of northern and eastern Kenya.
5.6 **RECURRENT CONFLICTS**

According to CEWARN, more than 1,700 incidences of violent conflict occurred within the Karamoja cluster (Kenya/Uganda/Ethiopia) during 2003–2006. Cattle raids often followed a seasonal pattern and were particularly high during the months of January–March. However, during drought years the raids were random and thought to be triggered by competition for dwindling rangeland resources. Loss of lives and livestock has large bearing on food insecurity in the region.

Resource-based conflicts have increased significantly in the past decade, owing to recurrent droughts and competition for limited rangeland resources. There were many instances of cross-border conflict and inter-clan incidents were recorded across Kenya and parts of northern Uganda. The map below shows areas of recurrent conflict (based on ACLED data sets); very specific reference is made to geographical locations that have experienced extreme climatic events, food insecurity, and conflict hotspots. Close studies of these patterns have led to better understanding of how these increased incidences may be anticipated and used as an early warning tool by IGADs CEWARN.

In addition to ethnic politics, conflict is often rooted in disputes over land resources, which worsen during severe droughts. Cross-border conflicts have been addressed at several intergovernmental forums; however, the situation seems to persist, often following seasonal patterns due to cultural heritage and the proliferation of small arms.

5.7 **COORDINATION BETWEEN EMERGENCY RESPONSE AND LONG-TERM DEVELOPMENT PROGRAM**

Recent studies show continued weak linkages and uncoordinated activities between emergency response actors and long-term development programs. This has resulted in huge recurrent spending in vulnerable areas with minimal impacts on building the resilience of local communities.

The 2010/11 severe drought is a classic example: US$1.3 billion was spent to respond to a food insecure population of 10 million in East Africa. It was a wake-up call for all EAC governments and policies and strategies were formulated to deal with climate extremes in the region and prevent a recurrence of the disaster.

The World Food Programme and other emergence response agencies have also made deliberate efforts to support resilience building across the EAC with funding from development partners and with the commitment of national governments. The USAID-funded EAC-PREPARED program was
formulated under the same premise and is currently ongoing to support planning for building resilience through policy, research, and economic development.

5.8 Emerging Opportunities and Challenges

It has been very challenging to respond to years of food insecurity, owing to limited technical and financial resources at regional to subnational levels. However, there is a rich history of the chronology of these extreme climatic events from early warning, onset, and progression to humanitarian crisis and subsequent response. The 2010/11 drought cycle and impacts provided valuable information on what worked and what did not. They are well documented challenges with early warning and early responses. Most response agencies and governments acted after field assessments, which was a bit too late and expensive to effectively respond to the large-scale humanitarian crisis. Somalia was particularly challenging to access and provide with aid, which resulted in famine.

The tragic experiences have also lead to improved early warning systems and improved coordination between humanitarian actors and national governments. The response to the 2015/16 El Niño was well coordinated in terms of contingency/response planning and resource mobilization, which mitigated the potential impacts of flooding often associated with enhanced El Niño rains.

The response and resource allocations by national governments have increased significantly in recent years owing to increased awareness of the adverse socioeconomic impacts of extreme climatic events. This has been evident in recent response efforts. Although, the overall numbers of food insecure population are still likely to increase with increased rapid population growth in the region, severe impacts are unlikely to recur.

Ethiopia is another example of high populations (10.2 million food insecure people) affected by the current severe drought. However, long-term safety net interventions by the government, supported by development partners, have ensure that no fatalities occurred and no famine was declared this year, in comparison to the infamous 1984/85 drought-related famine.

Although the general trends indicate an increase in crop production over time, unfortunately the people in the region have remained food insecure and poor. Meeting food security in all dimensions as defined by FAO in East Africa is a major challenge. Questions of food availability, accessibility, adequacy, and safety has not been adequately tackled particularly in rural areas where the majority live. As a result, malnutrition and poverty are on the rise in most East African countries and climate change will exacerbate the situation.

6. Current Vulnerability and Hotspots in the Lake Victoria Basin

6.1 Lake Victoria Socioeconomic Importance

Lake Victoria is one of the African Great Lakes and the second largest lake in the world covering 68,800 square kilometers. The lake is shared by Kenya (6 percent by area), Uganda (43 percent), and Tanzania (51 percent). It has a mean depth of 40 meters, a maximum depth of 84 meters, 3,450 kilometers of shoreline, a water retention time of 140 years, and a catchment area of 194,200 square kilometers, which extends into Rwanda and Burundi.
According to the Lake Victoria Fisheries Organization (LVFO), the lake basin has the fastest growing population in East Africa, of over 33 million, a third of the combined population of the East African States. Much of this population derives its livelihood directly or indirectly from the lake resources. Figure 33 describes the livelihoods and population distribution within Lake Victoria, which are highly dependent on the lake as a natural resource and may be categorized as fishing and agro-pastoral communities.

Figure 33: Lake Victoria Basin Estimated Population Density and Livelihoods

The lake’s fishery is a major source of government revenue and a source of employment. It supports livelihoods for 3 million people who are directly involved in the fishery industry. The annual fish catch from Lake Victoria is estimated at about 750,000 metric tons, generating more than US$400 million per year, of which US$250 million goes to exports.

Lake Victoria and the rivers flowing into it form a major reservoir for hydroelectric power. In Uganda, power generation capacity is 320 MW generated at Nalubaale and Kiira dams. Farther downstream there is a potential for power generation at Bujagali (250 MW), Karuma (100 to 200 MW), and Kalagala (450 MW). In Kenya, there is a potential to generate a total of 278 MW of electricity from the Sondu-Miriu, Kuja, Nzoia, and Yala rivers.

The lake has other value, such as climate modulation in the region and richness in biodiversity. It is experiencing severe threats that are contributing to losses amounting to millions of dollars annually. Key among the threats is declining water levels and prolonged droughts in the entire basin. This means, among other things, that ships cannot dock at the quays in most of the ports; electricity production at Jinja has declined; and the intakes of the water treatment plants in Kisumu, Entebbe, Mwanza, and other riparian towns have been severely affected, resulting in a decrease in the amount of water supply for these large cities.

The three EAC Partner States designated Lake Victoria and its basin as an economic growth zone because of its great economic potential, which includes a productive fishery; freshwater for domestic, industrial, and agricultural use; hydropower generation; aesthetic value, recreation, and tourism; transport; and the unique biodiversity along the shorelines and on the islands.
6.2 Historical Climate Trends

6.2.1 Rainfall

In recent years, the water level of the lake has been dropping, a trend attributed to regional drought and increased flows for hydroelectric power in Uganda. This is not new, as the lake has had a history of completely drying up, thousands of years ago, and then, around 13,000 years ago, the climate changed and heavy rains filled the dry lakebed, sending rushing waters into the upper Nile. Therefore, it is worthwhile, to analyze its historical trends.

This study analyzed the historical trends for the East African region with a special focus on the LVB. Temporal trends in monthly and annual rainfall and temperature for the LVB and for its sections in each of the five countries spanning 1930 to 2014 were modeled and visualized through graphical plots. Statistical tests of significance of trends in rainfall, as well as minimum and maximum temperatures, were carried out to establish whether rainfall or temperature has been increasing or decreasing and to identify the specific components of rainfall or temperature showing patterns between 1930 and 2014. A technical explanation of the methodology is in Annex 2.

Historical trends in rainfall indicate cycles of wet and dry periods and the trends in temporal variability of rainfall at most locations are very similar (Figure 34). Analysis of long-term gridded data from GeoCLIM shows positive (wet periods) rainfall anomalies in the 1960s followed by negative anomalies during the 1970s in the March–June (MAMJ) season. From the analysis, there are distinct 10-year cycles of dry and wet periods; the wet periods occurred in 1940s, 1970s, and 1990s, with wet periods in the 1960s, 1980s, and 2000 to 2010. It is evident that the dry periods are getting prolonged for the long rains (March–June), the main crop production season. The diminished rainfall totals have continued to negatively affect agricultural productivity in the LVB region.

The October–December (OND) season shows positive rainfall anomalies in the 1960s and increased positive anomalies in the 1990s (Figure 35). In the LVB and in each of its sections in Burundi, Kenya, Rwanda, Tanzania, and Uganda the total monthly rainfall for the months of October and November increased significantly between 1930 and 2013. Modeling suggest that this increasing trend is likely to continue. Concurrent with this increase in rainfall in October and November is a significant decrease in rainfall in April, particularly in the LVB, Burundi, Rwanda, and Tanzania and marginally in Uganda, but surprisingly not in Kenya. In aggregate, the temporal patterns in monthly rainfall suggest that the short rains have been increasing whereas the long rains have been decreasing, at least over the past century. After the 1970s, the fluctuations in rainfall are dominated by short cycles of about five years’ duration that normally coincide with the El Niño/La Niña-Southern Oscillation (ENSO).
Figure 34: Lake Victoria Basin MAMJ season standardized rainfall anomalies, 1930–2013 (source: EAC-CHIRPS data set)
Figure 35: Lake Victoria Basin OND season standardized rainfall anomalies, 1930–2013 (source: EAC-CHIRPS data set)

Other studies that analyzed rainfall variability in East Africa have also concluded that the variability in rainfall is closely associated with ENSO phenomenon and sea surface temperatures with variability over 5 to 6 years (Rao 2011). El Niño is associated with above-normal rainfall amounts during the short rains throughout the entire region. This relationship between rainfall and ENSO phenomenon makes the rainfall in the region more predictable. Based on 85 years of GeoCLIM data, Kenya had 56 percent of the seasonal rainfall totals below the long-term average, Uganda 51 percent, Burundi 53 percent, Rwanda 46 percent, and Tanzania 51 percent. A change in seasons implies changes in agricultural activities, in terms of type of crops and the timing of planting.

In addition to trends in mean statistics, for agriculture the onset of the wet season is also important. Kniveton et al. (2008) investigated trends in the start of the wet season over Africa from 1978–2002. The study indicates that in East Africa the trend is mixed, with some isolated
locations showing an earlier start to the rainy season (Kniveton et al. 2008). These studies indicate the complex nature of trends in East Africa, reinforcing the fact that different seasons may see contrasting trends in mean figures over the 21st century.

### 6.2.2 Temperature

Global mean temperatures have increased by 0.74°C (±0.18°C) over the past century (1906–2005) with an accelerated rate of warming of 0.07°C per decade over the past 50 years on average (IPCC AR4 2007). Given the current focus on anthropogenic climate change, it is important to evaluate trends in the climate over East Africa that may be attributable to increases in greenhouse gases over recent decades.

However, a general increasing trend in both minimum and maximum temperatures, especially from about 1990 onwards, is noticed in most months and in mean annual temperature (Figure 36) and the rate of increases are similar to the ones reported by IPCC (2007).

The maximum and minimum temperatures increased, but at rates that differed among months within each region. This supports a conclusion that the region is warming along the lines predicted globally. Unfortunately, the analysis is limited by availability of good quality data. There are very few meteorological stations in the region with good long-term temperature data. For temperature, while there is significant inter-annual variation, the general trend is toward warmer mean temperatures. The increase is especially evident from approximately 1970 onwards.

Statistical analysis undertaken during this study indicated that temperature increases recorded for most of the months were significant for the LVB and across all sections in each of the five countries. The estimated magnitude of the temperature increase between 1920 and 2013 ranged between 0.1°C and 2.5°C for both the maximum and minimum components (Figure 36).

Both the minimum and maximum temperature components averaged across 12 months increased significantly between 1920 and 2013. For the maximum component the magnitude of increase ranged between 0.7°C and 1.2°C whereas for the minimum component it ranged between 1.0°C and 1.1°C within the LVB and in each section of the LVB spanning the five countries.

Figure 36: LVB Tmin and Tmax trends 1930–2013 (IPCC 2007)
6.3 Mapping Vulnerability Related to Climate Change for the Agricultural and Food Security Sector

Vulnerability index mapping may be used to prioritize international adaptation assistance (Füssel 2010), allocate resources (Eriksen and Kelly 2007), and monitor progress over time (Füssel 2010). Previous studies have highlighted that many models have disparate objectives (Preston, Yuen, and Westaway 2011), methodologies (Schröter, Polsky, and Patt 2005), and scales (Adger and Kelly 1999), resulting in inflated assessments of climate risk (Busby et al. 2013, Füssel 2010) besides the challenge of limited data availability. Existing problems of natural disasters, climatic variability, land degradation, socioeconomic issues, and food insecurity combine to create complex vulnerability in East Africa where intersecting processes drive social instability. Understanding the complexity of these relationships is critical.

Vulnerability can evolve as a system’s adaptive capacity to a set of risks and shocks evolves and as its exposure and sensitivity to shocks evolves. This is especially important in the context of climate change, which drives changes in the vulnerability of systems in two ways: (i) by introducing new risks and (ii) by changing the context and systems’ responses to previously existing risks (including climate-related ones). Climate change exposure and the system’s sensitivity to it determines the severity of the potential impact. However, vulnerability to that impact also depends on the system’s adaptive capacity.

The vulnerability of the agricultural sector in the LVB was assessed and mapped using the German GIZ (Gesellschaft für Internationale Zusammenarbeit) framework for assessing climate change-related vulnerability and GIS techniques. The framework distinguishes between four components of vulnerability: exposure, sensitivity, potential impacts, and adaptive capacity. According to this framework, a system is vulnerable if it is exposed and sensitive to the effects of climate change and at the same time has only limited capacity to adapt. On the contrary, a system is less vulnerable if it is less exposed, less sensitive, or has a strong adaptive capacity.

The critical exposure parameter for all three subsectors is precipitation, which is critical for livestock survival, reproduction, and productivity. Water affects pasture germination, growth, and regeneration. When rainfall is adequate to support annual and perennial crops, pasture grasses and legumes can also grow well to nurture livestock. Key indicators are the quantity, frequency, variability, minimum, maximum, onset, and delays of rainfall seasons.

Temperature is another critical parameter that affects all three subsectors. Average, minimum and maximum, and seasonal variations are crucial in defining, growth, reproduction, and survival of crops, pastures, livestock, and fisheries. Very high temperatures, beyond 30°C, lead to losses in crops and pastures, livestock, fisheries, and aquaculture. The temperature ranges also determine suitable crop zones, livestock habitation, and climate-related parasites and diseases like East Coast Fever, Rift Valley Fever, and others. Several indicators were identified to be used in vulnerability analysis as detailed in Table 5.
### Table 5: Vulnerability indicators for the crops, livestock, and fisheries subsectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Adaptive Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Natural / Biophysical</td>
<td>Services</td>
</tr>
<tr>
<td>Crops</td>
<td></td>
<td>Soil type</td>
<td>Poverty index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cereal suitability map</td>
<td>Market access</td>
</tr>
<tr>
<td></td>
<td>Rainfall</td>
<td>Coefficient of variation (CV) annual rainfall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long-term average rainfall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>CV Max and Min Temp</td>
<td>Social</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market Access</td>
<td>Education – schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human Population density</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Livestock</td>
<td>Rainfall</td>
<td>Natural / Biophysical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil type</td>
<td>Poverty index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human Population density</td>
<td>Market access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vegetation types – grasslands or rangelands only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>CV Max and Min Temp</td>
<td>Social</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market Access</td>
<td>Education – schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human Population density</td>
<td>National parks within LVB</td>
</tr>
<tr>
<td></td>
<td>Fisheries</td>
<td>Rainfall</td>
<td>Natural / Biophysical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drainage – river systems</td>
<td>Fish farming/aquaculture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land Use and Land Cover</td>
<td>– areas within EAC or LVB with fish farming</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>CV Max and Min Temp</td>
<td></td>
</tr>
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<td></td>
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</tbody>
</table>

The GIS data for identified indicators for sensitivity and adaptive capacity factors were obtained from the Regional Centre for Mapping of Resources for Development (RCMRD), while data for exposure mainly came from USAID FEWS NET. The exposure layer comprised of the coefficient of variation for annual rainfall and the coefficient of variation of minimum and maximum temperature for the LVB for the period 1900–2013. The rainfall coefficient of variability shows how rainfall varies over time. For example, if an area has lower a rainfall coefficient of variability, it means rainfall will tend to be more consistent from one season to another. A higher coefficient of rainfall variability means rainfall is likely to be irregular. Arid and semi-arid areas tend to have this kind of rainfall variability pattern. Depending on the indicator, levels of vulnerability were assigned and ranged from 3 to 5.

Indicators were chosen according to their suitability; where the data set was not very good alternatives had to be sought. Each indicator was normalized between zero and five using statistical software, with zero representing the worst condition for a household and five the best condition. Weighting values were also based on the confidence that indicators were characteristic of the total population. Indicators that were not representative across the region or with the potential for redundancy in the explanatory power of the model were reduced in importance through weighting, but they were not always excluded. All work was conducted using ArcGIS and QGIS software to map and visualize the data. Each theme was imported from statistical database files into separate layers in ArcMap. Each theme layer was then converted to raster format and the overall score was calculated using map algebra and the appropriate weighting. Both adaptive capacity and livelihood sensitivity were modeled as positive conditions of resilience, while exposure risk was modeled as a negative condition. The vulnerability map was produced by combining the exposure, sensitivity, and adaptive capacity layers using spatial analyst tools in QGIS. All layers were given equal weight resulting in the vulnerability map for the agricultural sector shown in Figure 37.
The resultant composite vulnerability map for the agriculture and food security sector represents a static view of the current vulnerability in the LVB. They are not projections or predictions of future outcome. Areas that indicated high levels of vulnerability in Tanzania include Shinyanga, Mwanza, and the Mara; in Kenya they include Bondo, Nandi, and Bungoma; in Uganda Kabale area; and Kayenzi and Buyuga in Rwanda. Other areas within the LVB have low and medium vulnerability levels. It is worth noting that interpretation of these maps needs to take into consideration the limitations and assumptions.

7. GENDER AND YOUTH CONSIDERATIONS IN RELATION TO THE AGRICULTURE AND FOOD SECURITY SECTOR IN EAST AFRICA

Gender is an important determinant of adaptive capacity. In most cases, women, youth, and children are the most vulnerable to climate change, as they are highly dependent on natural resources, but they lack both access to information about climate change and the authority to make decisions about natural resources management. The vulnerability of women and youth to climate change is underscored by institutional frameworks that compromise their land tenure security and cultural practices that reinforce household patriarchal power dynamics, limiting their access to capital and decision-making power (COHORE 2004). In addition, women remain overburdened with reproductive roles. These activities reduce the time available to participate in income generating and leadership activities within the community (Demetriades and Esplen 2008).
7.1 Gender and Crop Production

In all the EAC Partner States, women play a critical role, contributing between 48.6 percent (in Kenya) and 57.0 percent (in Rwanda) to the total agricultural labor (Table 6). They are more involved in the agricultural sector compared to the industry and services sectors, partly due to lack of adequate skills (Figure 38). Women are the primary producers of the world’s staple food production (50–80 percent), but own less than 10 percent of the land and have minimal or no control over income from the agriculture sector (EAC 2011, UNDP 2009). As climatic factors become more variable, so does the reliability of the food supply on the household, community and national level, thereby increasing the burden on women to produce adequate food levels. This vulnerability could be minimized if women and youth were provided access to technology and innovations that would reduce their reliance on traditional labor-based production techniques.

Table 6: Agricultural Share of Economically Active Population and Female Share, 2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Population in Agriculture (%)</th>
<th>Females in Agriculture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>89.2</td>
<td>56.0</td>
</tr>
<tr>
<td>Kenya</td>
<td>70.6</td>
<td>48.6</td>
</tr>
<tr>
<td>Rwanda</td>
<td>89.4</td>
<td>57.0</td>
</tr>
<tr>
<td>Tanzania</td>
<td>75.9</td>
<td>55.0</td>
</tr>
<tr>
<td>Uganda</td>
<td>74.8</td>
<td>49.5</td>
</tr>
</tbody>
</table>

Source: FAO 2011

Figure 38: Percentage share of sector employment for women

7.2 Gender and Livestock

Pastoralism is an integral part of East African cultural heritage and a large contributor to the local economy. Caring for livestock is divided between men, women, and youth. Women and youth are responsible for most livestock nurturing activities, such as feeding, watering, fodder collecting, stable cleaning, milking and milk processing, caring for young and sick animals, and poultry raising. Men are generally responsible for financial aspects, such as marketing, purchasing feed, procuring veterinary services, and herding (youth also participate in herding). While men’s tasks are seasonal, most women’s tasks are daily (Nassif 2008). The submissive role of women pastoralists in the household and lack of ownership of livestock and land, makes them wholly dependent on men to support their livelihood, and thus more vulnerable to both climatic and non-climatic changes. Table 7 shows that fewer women (39–54 percent) owned land sole and joint, compared to men (55–64...
percent) in the EAC region (without considering Kenya). Further, fewer women owned land solely (8–14 percent), compared to men (25–50 percent). Uganda has the greatest percentage of women owning land and Tanzania the smallest percentage.

Table 7: Percentage of women and men (of reproductive age) who own land

<table>
<thead>
<tr>
<th>Country (year)</th>
<th>Household</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>percent owning land</td>
<td>percent (sole or joint)</td>
<td>percent (sole only)</td>
</tr>
<tr>
<td>Burundi (2010)</td>
<td>86</td>
<td>54</td>
<td>11</td>
</tr>
<tr>
<td>Rwanda (2010)</td>
<td>81</td>
<td>54</td>
<td>13</td>
</tr>
<tr>
<td>Tanzania (2010)</td>
<td>77</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Uganda (2011)</td>
<td>72</td>
<td>39</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: Adapted from Doss et al. (2013).

Extreme weather events, prolonged drought, and variable rains, have affected herd size in many pastoralist communities and caused men to migrate to urban areas to seek wage employment. This adaptive strategy has imposed additional burden on women and youth to maintain the household and their livelihoods (Minority Rights Group International 2004). In several pastoral communities, male youth are under cultural pressure to demonstrate strength as warriors and to find ways to pay high bride prices, increasing the likelihood of joining cattle raids or armed conflict while female youth are susceptible to violence associated with cattle raids and armed conflict.

### 7.3 Gender and Fishery

In the LVB region the fishing industry is dominated by men; they are the primary owners and leasers of boats (Table 8) and fishing gear and they retain the profits from fish sales. Women are involved in trade but usually their scale of operation is constrained by limited capital and skills. Cultural beliefs—the idea that if you have a woman in your boat you will have a low catch—and social norms act as barriers to women’s participation in fishing activities. The lack of access to capital in the formal sector of the fishing economy has forced women to engage in the informal sector to secure their livelihoods, such as prostitution or bartering sex for fish (Pearson et al. 2013). Women living in fisher communities are largely deprived of economic opportunities and as a result are more vulnerable and have less adaptive capacity to respond to climatic and non-climatic change.

Table 8: Gender participation in the fisheries subsector

<table>
<thead>
<tr>
<th>Occupation</th>
<th>(percent) of respondents by gender (n=119)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Boat owners/ fishers</td>
<td>86</td>
</tr>
<tr>
<td>Trader / processor</td>
<td>14</td>
</tr>
<tr>
<td>Other (petty traders)</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Lwenya et al. (2006).

### 7.4 Conclusion

The risks and vulnerability to climate change and gender inequality are intricately linked. Therefore, gender needs to be mainstreamed in all development projects/programs to facilitate
the identification of gender gaps. A gendered situational analysis on vulnerability of communities and sectors to climate change is important. It is evident that closing the gender gap in access to resources can increase the adaptive capacity of vulnerable groups by improving incomes and productivity. The social norms and institutional framework that constrain women and youth access to agricultural resources can be minimized by promoting gender equity in land ownership, access to and ownership of resources, and participation in the formal and informal sectors (FAO 2011, USAID 2010).

8. SECTOR INSTITUTIONAL PREPAREDNESS TO CLIMATE CHANGE ADAPTATION IN EAST AFRICA

Efforts have been made to create centers of excellence and relevant institutions to address climate change through research, information dissemination, and policy advocacy. Those efforts have been rather slow due to (i) slow appreciation of the magnitude of the problem and (ii) an inclination toward priorities such as poverty eradication that could not make the link with climate change (EAC 2011). These institutions are highlighted in Table 9 along with their roles.

Table 9: Climate change agriculture sector stakeholders in East Africa

<table>
<thead>
<tr>
<th>Level/country</th>
<th>Stakeholder/institution</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)</td>
<td>Funding research and capacity building on climate change</td>
</tr>
<tr>
<td></td>
<td>Food and Agricultural Organization (FAO)</td>
<td>Adequate funding and capacity building on climate change</td>
</tr>
<tr>
<td></td>
<td>International Fund for Agricultural Development (IFAD)</td>
<td>Research in climate change</td>
</tr>
<tr>
<td></td>
<td>International Institute for Tropical Agriculture (IITA)</td>
<td>Research and policy</td>
</tr>
<tr>
<td></td>
<td>World Wide Fund for Nature (WWF)</td>
<td>National support on research, policy and practice</td>
</tr>
<tr>
<td></td>
<td>International Union for Conservation of Nature and Natural Resources (IUCN)</td>
<td>National support on research, policy and practice</td>
</tr>
<tr>
<td></td>
<td>International Food Policy Research Institute (IFPRI)</td>
<td>Well-funded, development of cases on practice</td>
</tr>
<tr>
<td></td>
<td>International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT)</td>
<td>Research and capacity building</td>
</tr>
<tr>
<td></td>
<td>United States Agency for International Development (USAID)</td>
<td>Research, up scaling and funding practice</td>
</tr>
<tr>
<td></td>
<td>Famine Early Warning System – Network (FEWS NET)</td>
<td>Collect, analyze and use climate data to forecast changes</td>
</tr>
<tr>
<td></td>
<td>Intergovernmental Authority for Development (IGAD)</td>
<td>Legislation, research and training</td>
</tr>
<tr>
<td></td>
<td>IGAD Climate Prediction and Applications Centre (ICPAC)</td>
<td>Legislation, research and training</td>
</tr>
<tr>
<td></td>
<td>NEPAD</td>
<td>Regional policy on climate change, NRM and Agriculture</td>
</tr>
<tr>
<td>Burundi</td>
<td>Burundi –Israel German Project on climate change Adaptation</td>
<td>Scaling up adaptation, research, early warning, policy</td>
</tr>
</tbody>
</table>
While the above institutions are established, have been undertaking work on various aspects of climate change, and are prepared to undertake more work, several gaps hinder their full contribution. These are as follows:

- **Climate information for East Africa**: The science of climate modeling is complex and efforts to communicate this science to users remains rudimentary with contradictory and unreliable messages (Ziervogel et al. 2004).
- **Inadequate financial resources**: Climate change response activities are huge financial undertakings, which most of EAC states cannot afford (EAC 2011).
- **Nature of climate data used in East Africa**: Most data being used is highly aggregated.
- **Developing multi-disciplinary adaptation capacity**: There is lack of synergy among scientists and research output users.
- **Climate change awareness**: Climate change awareness is inadequate among the relevant institutions, which compromises planning, investment, and implementation (Caffrey et al. 2013).
- **Central database**: A central and comprehensive database for the relevant value chain analysis is lacking (Manyala 2011).
- **Modeling**: Modeling studies are needed to facilitate accurate prediction of the impacts of climate change on aquaculture sector within the East African states.

**OPPORTUNITIES**

Uncertainties about the pace and extent of climate change and the impacts on different subregions and sectors in the LVB make policy decisions difficult and magnify the need for the region to improve its knowledge and analytical base. While national level information and analysis on climate change risks, vulnerability, and impacts has improved substantially over the past decade, well-synthesized information and an established knowledge base, at a basin, sub-basin, or even national level, is often absent. This is particularly critical to decision-making processes, providing policy guidance, and considering transboundary responses to climate change. Some key opportunities include:

- Mainstreaming/integration of climate change and climate change adaptation in national poverty reduction strategies, development plans, and other economic plans.
- Implementation of the Maputo Declaration to achieve 6 percent growth in the agricultural sector.
- Building platforms and cooperation and coordination mechanisms to make sure that synergies in the programs and initiatives are adequately used and activities are coordinated to maximize the related outcomes and benefits.
- Enhancing functional capacities to access international and national climate change funds and increase additional private contributions and improve investment conditions in target countries.

**9. POLICY-RELEVANT RECOMMENDATIONS**

**9.1 Background**

The phrase “adaptation needs” is often used but rarely defined in the relevant literature. In the wider literature, a need is typically considered a problem that can be solved (McKillip 1987) or a gap between current outcomes and desired outcomes (Kaufman and English 1979). Adaptation involves reducing risk and vulnerability, seeking opportunities, and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions (Tomkins et al. 2010).

Various policy, institutional, and legal frameworks have been developed in the EAC region to address adaptation to climate change. Several policies, laws, and frameworks guide agriculture production systems and food security sector across East Africa. At the regional level, these include the following:

- Agriculture and rural development policy and strategy for the East African Community (EAC 2006)
- East African Community Climate Change Policy (EACCCP) (EAC 2007)
- The International Food Policy Research Institute (IFPRI) strategy on climate change
Cognizant of the importance of agriculture, the EAC CAADP Compact was developed in line with the objectives of the EAC Treaty and operationalized through the EAC, which has an Agricultural Rural Development Policy (ARDP), Agricultural Rural Development Strategy (ARDS), and Food Security Action Plan (FSAP). The compact sets the parameters for long-term partnership in the agricultural sector, specifies key commitments of the African Union/NEPAD, EAC Secretariat, Partner States, development partners, private sector, farmer organizations and cooperatives, civil society organizations, nongovernmental organizations (NGOs), and institutions of higher learning, research, and think tanks. It also defines expectations from all stakeholders on their investments and contributions toward successful implementation of the EAC Food Security Action Plan and Climate Change Policy and Master Plan.

The compact contains sector policies, investment niches, and commitments of stakeholders to align their long-term development goals to the agricultural sector programs. The compact operates in tandem with the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. The compact provides a commitment framework for transforming East Africa’s agriculture sector (crops, livestock, capture fisheries and aquaculture, apiculture, wildlife, and forestry) for shared prosperity and improved livelihoods through capturing opportunities for inclusive growth and sustainable development.

### 9.2 Agriculture and Food Security Sector Preparedness

Agriculture is the most vulnerable sector and the major livelihood option for a majority of the population in the region. Therefore, it is necessary to develop and implement location- and context-specific plans for action to enhance the adaptive capacity and resilience of climate-vulnerable communities, including through the active participation and ownership of local communities in adaptation planning. To achieve this goal, EAC countries have prepared NAPAs, which were endorsed by their respective governments for implementation and are tailored to implement prioritized areas of intervention in each country, except Kenya. Kenya instead developed the National Climate Change Action Plan (KNCCAP) since it was not considered among the least-developed countries.

Broad agricultural adaptation strategies in agriculture in East Africa (as synthesized from the counties’ NAPA, National Climate Change Response Strategy (NCCRS), National Climate Change Action Plan (NCCAP), and EAC Climate Action Plans) are summarized below.

- **Improvement of agronomic management.** In East Africa, farm yield gaps tend to be very large. This necessitates the improvement of agronomic management and input use efficiency. Climate information that reduces the uncertainty that farmers face during a given season has potential to improve the effectiveness of production technologies and input use efficiency. Reducing uncertainty would enable farmers to adopt improved technology, intensify production during better years, and reduce risks during the bad years. Climate information services enable farmers to adopt new technology and thus
sustainable intensification of production by understanding spatial and temporal climate variability.

- **Environmental conservation.** This focuses on efforts geared toward the sustainable use of natural resources. Use or misuse of water, land, soils, forests, and marine resources can have negative or positive effects on the agricultural sector. For example, the encroachment of agriculture on forestry resources affects not only the immediate forest but also alters the hydrologic cycle. This in turn affects agricultural production initiatives downstream. Agriculture solely depends on the integrity of the natural ecosystem. Some of the adaptive actions include agroforestry, soil and water conservation, reforestation, water harvesting, soil and plant nutrient management, and grazing management.

- **Dissemination of climate information.** An advance in climate prediction, analysis, and synthesis of climate knowledge has the potential to enhance livelihood opportunities in agriculture (Selvaraju, Gommes, and Bernardi 2011). This is important in risk management and sustainable production. The climate information and likely decisions are (i) climate change scenario to understand the trend and alter system-level decisions (cropping or grazing); (ii) seasonal climate information to make strategic decisions (such as crop type, marketing, forward selling, livestock herding rate); (iii) intraseasonal forecasts to schedule tactical operations (such as fertilizer, water, and other adjustable inputs); and (iv) weather forecasts for day-to-day operations.

- **Crop monitoring and yield forecasting.** Analysis of meteorological and climatic data allows for the provision of near real-time information about the crop state, with the possibility of early warning. Crop monitoring and yield forecasting allow timely government interventions to avoid crisis. The strategies include contingency plans, alternate livelihood options, and response plans for food aid. Large-scale monitoring of agriculture and crop yield forecasting generally rely on (i) regionalized analyses of cultivated areas, crop type distribution, and crop condition based on near-real-time satellite imagery merged with available in situ observations; (ii) meteorological monitoring and midterm forecasts based on observation networks and model outputs; and (iii) regionalized knowledge of agricultural systems and their sensitivity to meteorological conditions. The crop monitoring and yield forecasting capabilities in East African countries are weak and need strengthening at the national level with more emphasis on collection of data such as meteorological, agro-meteorological, soil, remote sensing, and agricultural statistics.

- **Agricultural insurance.** Index-based insurance products for agriculture represent an attractive alternative for managing weather and climate risk (Skees 2008). Agricultural insurance is growing due to increased commercialism and the availability of new types of insurance products. For the government, insurance mechanisms provide some predictability for weather-related risk financing and offer enough lead time for emergency responses to manage livelihood crises. This lessens the weather/climate effects by securing needed resources sooner to protect livelihoods. Provision of localized and needs-based climate information to promote index-based weather insurance requires strengthening of weather observation networks, monitoring of extreme climate events, standardization of indices, data sharing, early warning systems, and capacity building. Index-based weather insurance systems require the support of national meteorological and hydrological services to ensure high-quality weather data, monitoring instruments, and procedures to downscale weather information to produce real-time crop yield indices covering specific agro-ecological regions.
Strengthening technical and institutional capacities. Strengthening the capacity for agrometeorological observation, the development of customized forecasting products, the management of data and modeling for climate impact assessment, and application of climate information at the farm level, and strengthening of decision support systems at the institutional level are the priority (Selvaraju et al. 2011). Agricultural extension services need to be strengthened to address climate risks and plan for adaptation if these are to provide an efficient interface between policy-makers and the farming community. Strengthening of community networks, local institutions, and norms and relationships is critical for managing climate risks. Local networks shape farmers’ social interactions leading to better participatory decisions.

Strengthening seed systems. Seeds are a core resource of crop production systems and carry the genetic potential for crop adaptation to changing environments. Increased abiotic and biotic stresses will directly impact food production. The system that will provide adapted varieties to farmers has three parts: plant genetic resource conservation and distribution, variety development and seed production, and delivery. The stronger the links among these different parts, the better the whole system will function.

a. Conserved and improved materials need to be available for a diverse portfolio of varietal development to meet changing demands and requirements.

b. Timely delivery to farmers of suitably adapted materials, of the right quality and quantity, at an acceptable cost, is essential.

c. The system needs an appropriate institutional framework as well as policies and practices that support its component parts and the links between them. The time required to develop and release new varieties is lengthy compared with the pace of environmental changes under pressure from climate change. Urgent action is needed to ensure that a local genetic resource base, adequate capacities, and effective collaboration among policy, research, and users are available to face new needs.

d. Intensification of the conservation of plant genetic resources in situ and ex situ, since the survival of crop wild relatives (an important source of genetic diversity for crop improvement) could be threatened.

e. Discrepancies among seed regulations remains a barrier to seed trade and exchange of varieties in East Africa. Facilitating seed exchange among countries will be necessary to cope with seed shortages. Harmonization of seed regulatory frameworks is key to ease administrative procedures for cross-border seed trade. At the same time, the establishment of regional variety release procedures and variety catalogs will bring access to a wider diversity of varieties with the potential to adapt to climatic changes.

f. Agricultural diversification, crop and variety relocation based on mapping agro-ecological zones, and variety characterization will be necessary to provide farmers with the germplasm (landraces and modern varieties) adapted to shifting agro-ecologies. Improved ways of transmitting information about crop variety adaptation through market and non-market channels are also needed.

Capacity building/skill development. In the past, rural communities have worked to adapt to change in climate as it gradually occurred over centuries, but now changes appear to be faster and more dramatic. Therefore, farmers would benefit from support to help develop sound and location-specific adaptation strategies. Farmers with knowledge of local ecosystems, and with critical thinking skills, would stand a much better chance of
coping with the effects of climate change. Skills not only might help to reduce vulnerability in future generations but also add to overall human capital. This would be helpful in reducing vulnerability in post-disaster recovery. Theoretically a population that is skillful is more likely to be resilient due to their ability to draw on alternative entitlements following a shock.

A summary of highlights on sector preparedness by country are in Table 10.

Table 10: Reflection on NAPA in agriculture sector within East African countries

| Burundi | 1. Improve the seasonal early warning climate forecasts  
2. Popularize rainwater harvesting techniques for agricultural or domestic use  
3. Set up erosion control mechanisms in sensitive areas  
4. Identify and popularize dryness-resistant forest species  
5. Popularize short-cycle and dryness-resistant food crops  
6. Popularize the zero grazing techniques  
7. Train and inform the decision makers and other partners, including local communities, on methods of adaptation to climate variability  
8. Identify and popularize the breeding of species adapted to local climate conditions |
|---|---|
| Tanzania | 1. Promote indigenous knowledge  
2. Change planting dates in some agro-ecological zones  
3. Increase irrigation to boost maize production in selected areas  
4. Adopt drip irrigation for specific regions  
5. Reduce reliance on maize as staple food by growing short-season and drought-tolerant crops such as sorghum and millet  
6. Shift crop farming to more appropriate agro-ecological zones  
7. Change crop rotation practices  
8. Adopt integrated crop and pest management  
9. Make better use of climate and weather data, weather forecasts, and other management tools  
10. Create awareness of the negative effects of climate change  
11. Introduce/expand sustainable water management to boost food crop production  
12. Strengthen early warning system  
13. Follow standard agronomic practices  
14. Promote annual and short-term crops  
15. Change land use patterns  
16. Control tsetse flies  
17. Adopt integrated pest and disease control  
18. Introduce/expand sustainable range management  
19. Fund research and development  
20. Educate farmers and livestock keepers  
21. Advocate zero grazing  
22. Control movement of livestock |
| Rwanda | 1. Promote non-rain-fed agriculture  
2. Increase agricultural techniques  
3. Introduce species resistant to drought in arid and semi-arid zones  
4. Introduce precocious varieties in arid and semi-arid zones  
5. Promote stocking techniques of agricultural products after harvesting  
6. Reinforce early warning and rapid intervention systems  
7. Reinforce animal husbandry in permanent stalling  
8. Promote veterinary and phytosanitary services  
9. Preparation and implementation of land development plan  
10. Introduce/expand integrated water resources management (including rainwater)  
11. Promote non-agricultural activities  
12. Prevent and fight against vectors of water-borne diseases |
Integrate NAPA in policies and national development plans

Uganda

**Priority agriculture coping mechanisms**
1. Exploitation of aquatic resources
2. Food preservation
3. Alternative livelihood systems
4. Under-utilized and non-conventional foodstuffs
5. Water harvesting
6. Soil conservation
7. Change in husbandry practices
8. Self-help initiatives
9. Traditional vector control
10. Indigenous approaches to rainmaking and thunderstorm prevention
11. Increased law enforcement
12. Hygiene and sanitation strategies
13. District disaster management committee
14. Renting land Bush burning

**Agriculture intervention projects**
1. Land Degradation Management Project
2. Strengthening Meteorological Services
3. Water for Production Project
4. Drought Adaptation Project

**Table 11: Excerpts from the Kenyan CAP**

KENYA NATIONAL CLIMATE CHANGE ACTION PLAN (KNCCAP)
1. Improve coordination and mainstream climate change into agricultural extension
2. Establish and maintain climate change–related information for agriculture
3. Up-scale specific adaptation actions
4. Promote drought-tolerant varieties of traditional high-value crops
5. Promote water harvesting for crop production
6. Promote index-based weather insurance
7. Promote conservation agriculture and agro-forestry
8. Promote integrated soil fertility management
9. Promote climate-smart agriculture
10. Develop and apply Performance Benefit Measurement methodologies for adaptation, mitigation, and development
11. Adopt livestock grazing management systems, fodder banks, and strategic reserves
12. Establish price stabilization schemes and strategic livestock-based food reserves
13. Select and breed animals to adapt to climate change
14. Diversify livelihoods (camels, indigenous poultry, beekeeping, rabbits, emerging livestock, such as quails, guinea fowls, ostriches etc.)

10. **CASE STUDY—KENYA NATIONAL LEGAL AND REGULATORY FRAMEWORKS RELEVANT TO CLIMATE CHANGE ADAPTATION**

Policy reforms are cited as a driver of productivity gains experienced in the agriculture sector. These policy reforms substantially improve the economic environment for agriculture through improvements in better policies on pricing policies, trade, exchange rates, institutions, and markets. The Government of Kenya has developed policies and strategies to enhance agricultural
growth, natural resource management, and climate change interventions. Table 12 summarizes the key policies and strategies the government has ratified and implemented, and which, through their objectives and action plans, have an impact on climate change and adaptation.

Table 12: National legal and regulatory frameworks and policies with impact on climate change and adaptation in Kenya

<table>
<thead>
<tr>
<th>Level</th>
<th>Name of policy Instrument</th>
<th>Key policy thematic areas relevant for climate change adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental</td>
<td>Comprehensive African Agriculture Development Programme (CAADP), 2010</td>
<td>Main pillars included: land and water management, capacity building, food security and research and technology dissemination/adoption, livestock, forestry, and fisheries. CAADP now also incorporates climate change adaptation, which includes sustainable intensification and resiliency of production systems and the reduction of greenhouse gas emissions caused by agriculture. Kenya’s CAADP Compact (formed of government representatives, development partners, private sector, NGOs, CBOs, research institutes, producers, etc.) commits the government to implementing the common vision of the sector, as described in the Agricultural Sector Development Strategy (ASDS), to address the agricultural development agenda in the country.</td>
</tr>
<tr>
<td>Regional</td>
<td>East African Community Climate Change Policy (EACCCP)</td>
<td>Focused on improving the adaptive capacity and resilience of the East African region to the negative impacts of climate change. Under the agriculture and food thematic areas, the objective is to improve sustainable land use systems that enhance agricultural production and ensure food security under the changing climate.</td>
</tr>
<tr>
<td>National (macro-economic)</td>
<td>Constitution of Kenya 2010</td>
<td>In line with climate change adaptation principles, the Constitution promotes sustainable approaches to natural resource management, establishes the right to food security and to live in a clean and healthy environment, while emphasizing sustainable and productive management of land resources (e.g., maintenance of 10 percent of tree cover of the county’s land area). Introduces two levels of government with specific functions for each level, thus providing guidance on climate change response and climate change adaptation implementation.</td>
</tr>
<tr>
<td>National (macro-economic)</td>
<td>Kenya’s Economic Blueprint—Vision 2030</td>
<td>Represents the country’s development blueprint for 2008–2030, identifying agriculture as a key sector to boost economic growth. It aims to transform smallholder agriculture from low-productivity subsistence activities to an innovative, competitive agricultural sector. Operationalized in a series of five-year Medium-Term Plans, the current one of which (2013–2017) is the second and emphasize devolution, socioeconomic development, equity, and national unity.</td>
</tr>
<tr>
<td>Sectoral (agriculture)</td>
<td>Agricultural Sector Development</td>
<td>Provides a framework for transforming agriculture into a modern and commercially viable sector. The current medium-term plan lays emphasis in addressing challenges of food and nutrition security, over dependence on rain-</td>
</tr>
<tr>
<td>Level</td>
<td>Name of policy Instrument</td>
<td>Key policy thematic areas relevant for climate change adaptation</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>--------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sectoral (environment and climate change)</td>
<td>NCCRS, 2010</td>
<td>Adaptation measures suggested for agriculture in NCCRS include: changes in land use or activities, changes of location, restoration of degraded ecosystems, provision of downscaled weather information and farm inputs, water harvesting for irrigation, protection of natural resource base (soil and water conservation techniques), research and dissemination of superior (drought-tolerant, salt-tolerant, pest- and disease-resistant) crops.</td>
</tr>
<tr>
<td>Sectoral (environment and climate change)</td>
<td>National Climate Change Action Plan (2013–2017)</td>
<td>Within this framework Kenya planned for a low-carbon Nationally Appropriate Mitigation Actions pathway for energy, transport, industry, agriculture, forestry, and waste management. Selected practices for mitigation in the NCCAP included restoration of forest on degraded lands, REDD+, agroforestry, increase tree cover to 10 percent of total land area, conservation tillage, limiting use of fire in cropland, rangeland management; improved cook stoves, biogas, management of agricultural wastes.</td>
</tr>
<tr>
<td>Sectoral (environment and climate change)</td>
<td>Draft National Climate Change Framework Policy. 2014</td>
<td>Includes policy statements to enhance climate resilience and adaptive capacity, to promote low carbon growth, and to mainstream climate change into planning processes, while developing incentives to promote climate-resilient actions through appropriate policy reforms.</td>
</tr>
<tr>
<td>Sectoral (land, land use and forestry)</td>
<td>Sessional Paper #3 of 2009 on National Land Policy, 2009</td>
<td>Encourages sustainable intensification of land use in high-potential, densely populated areas, through the application of efficient methods, improvement of the condition and productivity of degraded lands, and through application of cost-effective irrigation methods.</td>
</tr>
<tr>
<td>Sectoral (land, land use and forestry)</td>
<td>Farm Forestry Rules, 2009</td>
<td>Require farmers to establish and maintain farm forestry (i.e., woodlots) on at least 10 percent of every agricultural land holding. Likewise, species of trees or varieties planted must not have adverse effects on water sources, crops, livestock, soil fertility, and the neighborhood and must not be of invasive nature. Moreover, agriculture authorities at the district (now county) level are required to identify land at risk of degradation and establish measures necessary for ensuring its conservation, including planting of trees.</td>
</tr>
</tbody>
</table>
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