IAASTD SSA CHAPTER FOUR

FOOD SYSTEMS AND AGRICULTURAL PRODUCTS AND SERVICES TOWARDS 2050

Coordinating Lead Authors: Daniel N. Dalohoun (Benin), Carol M. Markwei (Ghana)
Lead Author: Washington O. Ochola (Kenya)
Contributing Author: Patrick Avato (Germany/Italy)

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Key Messages

1. **While natural resources and climate factors define the possible farming systems, national and international policies and institutional changes will continue to determine the socioeconomic factors that underscore the actual crop and livestock production systems that will prevail in SSA towards 2050.** Projections toward 2050 do not predict a substantial improvement of the current state of SSA agriculture, characterized by land pressure due to rapidly growing population, declining soil fertility, frequent droughts, low yields, pests, plant and animal diseases, post-harvest losses and poor management practices.

2. **Developing and sustaining competitive crop and livestock production systems in SSA depends on the competitiveness of agricultural innovation- both individual agricultural innovation systems and agricultural innovation taken as a whole.** Developing capacity to exploit market opportunities is a prerequisite for increasing competitiveness and reducing the vulnerability of farm households to natural and economic shocks, both of which are prevalent in sub-Saharan African agriculture. Intensification and diversification, expansion, off-farm and exit from agriculture will be the dominant crop production strategies toward 2050. Elements of institutional improvements for agriculture include credit systems and extension and other services which link production to niche markets and strengthen market institutions, particularly through public-private partnerships. Technological solutions including improved production technologies and product quality will also drive agricultural growth in the region.

3. **Forestry and agroforestry systems could potentially have positive outcomes toward development and sustainability goals. In these systems the provision of food, timber, non-timber forest products, fibers and other goods will be sustainable.** Changes in governance systems that allow for community participation in the management and use of forest systems will lead to both an increase in forest cover and the multiple environmental and economic services they offer. Land tenure reforms and established systems of payment for ecosystems services (PES) will encourage land ownership and stimulate the development of plantations (both forest and agroforest parklands). The development and adoption of AKST for forest and agroforestry species diversity, productivity, pest and disease management, as well as improved access to AKST, will be important for maximizing the benefits from forest and agroforest parklands in the future.

4. **The multiple roles of the fisheries and aquaculture sector will intensify towards 2050. The contribution of the sector to poverty reduction will continue to rely on institutional and conservation frameworks that can guarantee sustainable fisheries diversity,**

improvement in quality and productivity, fish trade expansion, devolution of integrated management of fisheries resources as well as management of invasive alien species. Per capita consumption of fish for food will remain low at less than 7 kg per year, but population expansion and global price increase will sustain growth in capture and aquaculture fisheries. Although capture fisheries will continue to provide the bulk of fish for food in SSA for many decades, multiple pressures will gradually shift the focus to aquaculture, projected to play an increasing role in food security with a 6% rate of expansion by 2020. Local and regional fish trade in SSA will expand through regional cooperation and appropriate national policies, value adding and better market chains. The management of bio-invasion in SSA will have to overcome current challenges of inadequate public- private partnership engagement, apply traditional and local technical knowledge systems, and increase awareness to the environmental, social and economic costs of producing any given species.

5. **The agroecosystems of SSA are diverse and have varying potential for sustainable development goals through benefits from agrobiodiversity, agroecotourism and commoditization of services like carbon sequestration.** As the numerous benefits and multiple functions of agroecosystems to society become recognized and compensated, such as environmental services, continuity of social and cultural heritage, etc., agriculture in SSA is projected to become more integrated. Agroecotourism will propel economic development only if it is socially accepted in SSA, which depends on opportunities for local communities. The carbon trade and carbon sequestration services provided by agro-ecosystems are already picking up in SSA and are expected to be instrumental to poverty reduction strategies in the region. As the long-term value of agroecosystems are recognized and valued, new institutional mechanisms will be developed to realize effective markets for environmental goods and services.

6. **A sub-Saharan Africa with less poverty, greater food security, and a healthier environment is possible, but will not come about without explicit policy steps in that direction**. The costs of not making the necessary investments in sub-Saharan Africa will be tremendous, not only to the region but to the rest of the world. Reversing the tide in sub-Saharan Africa enough to allow for an overall economic sustainability would require an increase in total investments on roads, irrigation, clean water, education, and agricultural research. Crop yields would have to grow at a minimum threshold in order to achieve this. Even more significantly, total gross domestic product (GDP) would have to grow at an annual rate of 8 to 10%.

4.1 The Evolution of SSA Food Systems towards 2050

Projections in this chapter build on past and current trends in SSA food systems and existing projections of agricultural products and services to present an assessment of future agricultural and AKST developments. Both a realistic (evolution of current situation with no major changes) and a pessimistic approach to an assessment of future food systems alternatives would lead to system deficits and greater inefficiencies than reported in literature. Conversely, an optimistic approach equates projected production to projected demands. This presents the assessment with the opportunity to address the challenge of food systems in bridging any gaps in relation to development and sustainability goals. The optimistic approach has been adopted in this chapter to futuristically assess the changing face of agriculture in SSA towards 2050. The overall approach to the assessment dwells on answering the question: "*What drivers including evolutions in food systems will shape the production and provision of agricultural goods and services in order to meet the projected demands towards 2050?*"

4.1.1 Crops and livestock production systems

Climate, land and biodiversity. The climate of sub-Saharan Africa is diverse, and controlled by complex interactions between the oceans, land and atmosphere at local, regional and global scales. On average, Africa is hotter, drier and has less-dependable rainfall than all other regions of the world (ICSU, 2006). Further, considering the high climate dependency at all levels from the individual household to the regional economy, Africa is among the most vulnerable continents to climate change and variability (Fischer et al., 2005; IPCC, 2007). Contemporary sub-Saharan Africa is demonstrably vulnerable to both droughts and floods, with negative impacts on degradation in dry lands and coastal zones. Africa's vulnerability is likely to increase in the future, because the future is likely to be far hotter, and large areas are projected to become drier and even more rainfall-variable than at present (ICSU, 2006). For many regions in Africa, however, the direction of future rainfall trends, as well as the magnitude is debated even to the scale of seasonal rainfall forecasts (ICSU, 2006).

In general, Africa has a harsh and increasingly degraded physical environment which, in addition to climatic variability and marked dry seasons, is characterized by fragile ecosystems and chronically low levels of soil fertility which result in land degradation. Projections remain pessimistic about improvements in land degradations in the absence of appropriate institutional, organizational and technological innovations.

The majority of farming systems in SSA are rainfed and only a small area is irrigated despite the higher yield potentials under irrigation (Rosegrant et al., 2002). Except for soybean, baseline projections to 2025 show no significant changes in the proportions of rainfed and irrigated areas

(IAC, 2005). The causes of accelerating biodiversity loss vary between locations and between the major plant and animal groups. Over-harvesting has contributed to declines in fisheries, forest and wildlife (ICSU, 2006; IPCC, 2007). Climate change is projected to be the dominant driver of biodiversity loss by the middle of the 21st century (Von Blottnitz and Curran, 2007). For example, an increase in the loss and degradation of wetlands, mangroves and forests is projected.

An overview of some projected trends in SSA crop and livestock production

Today, approximately 70% of the SSA population is rural. It is projected that between 2030 and 2050, the agricultural population will decline as a result of the development of other economic sectors (Table 4.1) (Dixon et al., 2001). This has implications for crop and livestock production. The major concern is how to meet the increasing demands of the crop and livestock sectors in an environmentally sustainable way. For the next decades, predictions highlight a reduction in crop yield potentials in most tropical and subtropical regions as a result of climate change and diminishing water resources. With relatively fewer people in the agricultural sector, commercial farming will increase.

[Insert Table 4.1]

It is expected that the information revolution will provide large volumes of technological, market and institutional information to farmers. However, it is unlikely that much of this information will serve the majority of SSA producers without investments in education and training for the rural population. These investments will facilitate the transition to commercial farming. This training will encompass entrepreneurial and technical skills.

4.1.2 Forestry, agroforestry and forestry products

Forests and agroforestry systems and forestry products will continue to fulfill environmental, economic, social, cultural needs as well as important needs for nutrition and health (FAO, 2003). These resources are also projected to continue providing the bulk of energy requirements in the form of fuel wood and charcoal, and would also serve as an energy source for small and medium scale industries. Forests and agroforestry systems will become even more important for protecting watersheds as climate change effects become pronounced in the sub-region (IPCC, 2007). Forest biodiversity will continue to be important for the nutrition (e.g. bush meat as a source of protein), health (medicinal plants) and livelihoods of people in the sub-region. The economies of SSA countries would also be impacted positively, as export of non-timber forest products (e.g. curios, bushmeat and medicinal plants), increases due to increased demand by the large number of sub-Saharan Africans in the diaspora.

There have been various assessments on forests in SSA. The Millennium Ecosystem Assessment (MA) based on the Zambezi Basin case study predicts a continuing decline in forest diversity towards 2050, although the rates of decline vary among scenarios (MA, 2005a,b,c). The main driver for the decline in forest genetic resources is expected to be habitat loss resulting from changes in land use. The causes attributed to future habitat loss include land expansion for agriculture and deforestation.

A projection to 2020 in SSA shows that rates of deforestation in East and West Africa will not change significantly (FAO, 2003). In East Africa the continued deforestation will be associated with population growth, intense land use conflicts and poor economic growth. In West Africa continued deforestation will also be associated with land use conflicts. In both Central and Southern Africa deforestation is expected to occur at a higher rate than now, causing a rapid decline in forests. Deforestation in Central Africa will be caused by increased logging, increased road construction and land use conversion. In Southern Africa land reforms in Zimbabwe and expansion of commercial agriculture in Mozambique and Angola are projected to lead to rapid deforestation (FAO, 2003). In the second Africa Environment Outlook (AEO 2) projections on forest systems towards 2050 were based on forest assessments in Central Africa (UNEP, 2006a). Four scenarios resulted in different outcomes under different policies. Under a *Market Forces* scenario, forests will continue to decline but at a slower rate, due to policies that promote afforestation and sustainable use and management of forests. In the *Policy Reform* scenario, there is also a decline in the rate of loss. This decline however, is due to decreased demand in fuel wood and charcoal. The *Fortress World* scenario predicts high rates of deforestation and degradation of forest lands due to commercial over-exploitation of resources and pressure from the rural poor. However, because of international conventions, some forests remain. In the *Great Transitions* scenario, there is an increase in forest cover and improvement in forest quality. This increase will be brought about by an appreciation of the value of forest resources, improved forest management, sustainable use of forestry and improved livelihoods. There is evidence for both pessimistic and optimistic views concerning forest projections (FAO, 2003; MA, 2005a; UNEP, 2006b)

Forest productivity

The future of forest productivity in SSA remains uncertain (Kirschbaum, 2004). Sub-Saharan Africa's share of global wood production is projected to decline as value-added processing increases. Global trade in processed goods is projected to increase out to 2050; however, in SSA trade will be limited unless there are enabling policies and capital investments in technology and capacity development (FAO, 2003). Over the next decades South Africa will be the leader in exports of high value wood products because of projected capacity development. If West African economies improve, exports of high value wood products will predominate.

The future of non-wood forest products (NWFPs) is uncertain. Currently NWFP including plants used for food, drink, fodder, fuel and medicine and animals and their products, are important in all sub-regions of SSA for subsistence and income generation, and especially for rural livelihoods. NWFPs have potential value in local (Fondoun and Manga, 2000; Sonne, 2001; Adu-Anning, 2004; Ndam, 2004; Ngono and Ndoye, 2004), national (Russo et al., 1996; Tieguhong, 2003), regional (Ngono and Ndoye, 2004) and international trade (Ndam, 2004; Ndoye and Tieguhong, 2004). The discovery of more NWFPs of international value will improve incomes and livelihoods in the sub-region. Good examples include the Batanai Group in the Rushinga District of Zimbabwe, involved in the commercial extraction of marula oil, and the Mapanja Prunus Harvesters' Union in Cameroon, who harvest and trade in *Prunus africana* on Mount Cameroon. The lack of regulatory frameworks has created an environment in which the informal sector and market forces dominate trade in NFWPs and therefore accurate data and projections on their trade are scarce (FAO, 2003). In the case of East Africa, it is expected that the provision of tax incentives would result in value addition to NWFPs by local communities and the private sector.

Although the forestry sector alone will not reduce poverty in SSA, forests will continue to be important to achieving development and sustainability goals. It is projected that value addition of forest resources and community involvement in sustainable forest management will improve livelihoods. (FAO, 2003; Anderson et al., 2004; Mickels-Kokwe, 2006).

4.1.3 Bioenergy

There is a growing potential for the expansion of sub-Saharan Africa energy systems including bioenergy to meet both development and environment goals. Promising opportunities and technologies are being developed including biomass cogeneration and bioethanol. In the medium term (up to 2030), sub-Saharan Africa is projected to remain a net importer of agro-energy technologies and products such as bio-ethanol (IEA, 2005). Developments beyond 2030 towards 2050 are expected to be shaped by agricultural energy production, the interplay between agricultural energy supply and demand as well as the institutional and policy composition towards this period (Smeets and Faaij, 2006). However, these dynamics will also be influenced by supply and demand for agricultural food production and the availability of fertile land and water – both of which will be influenced by climate change. Whatever trends the future of sub-Saharan Africa follows, agricultural energy will remain key to the sustainability of the regions food systems, human well-being, development and environmental goals.

The following questions will be critical for the prospects for bioenergy and comprehensive integration of sustainable agricultural development and the region's energy needs.

- How are biofuels and rural energy for agriculture infrastructure evolving?
- What is the current state of technology and how will it develop?
- What is the tipping point at which bio-fuels will impact the energy, agriculture, industry and automotive markets?
- What are the expectations and limits to growth in the biofuels industry?
- How will developments in bio-fuels impact on sustainable development goals and social as well as environmental well-being?
- What is the potential market for crops to produce biofuels? How will this affect the agriculture sector?

Agricultural energy production. Theoretically, sub-Saharan Africa is one of the regions with the highest potentials for bioenergy production (Woods, 2006). This potential is borne from the large areas suitable for cropland and the low productive and inefficient production systems that offer substantial potential for yield improvements (Sebitosi and Pillay, 2005; Smeets et al., 2007, Smeets and Faaij, 2006). However, there will remain many uncertainties related to this potential (Berndes et al., 2003), including:

- Socioeconomic system dynamics in the region that determine land use patterns and crop yields; and
- Agroecosystems degradation and management regimes that affect bioenergy production capacity from crops and agrobiodiversity.

The "World Energy Outlook" (IEA, 2005) paints a picture of how the global energy system is likely to evolve from now to 2050. If sub-Saharan Africa governments stick with current energy policies, the region's energy needs will be almost 60% higher in 2030 than they are now. A similar trajectory will see this trend persisting until 2050. Whether this rising demand for energy can be met and how it will be supplied will depend on government policies and investment patterns. In any event, fossil fuels will continue to dominate the region's energy mix, meeting most of the increase in overall energy use. However, the contribution of agricultural energy production is predicted to increase, although it will continue to be dominated by the polluting and unsustainable combustion of traditional bioenergy, e.g. fuel wood and agricultural residues burned in inefficient cookstoves (Demirbas, 2007). Given the considerable social and environmental costs (including gender inequality, indoor air pollution and deforestation) of traditional bioenergy, the challenge for the next decades will remain the need to increase energy efficiency (improved stoves and charcoal making techniques) and to promote modern energy sources (to enhance agricultural productivity and for rural services such as electricity.

Modern bioenergy will present one option for improving access to modern and efficient energy services but it will be a challenge to exploit existing agroecosystems efficiently and sustainably without unduly disrupting the food systems.

Bioenergy offers considerable potential for an expansion of electricity and heat production, especially in the form of biomass cogeneration (e.g. from sugarcane bagasse). Some sugar-producing countries (e.g. Mauritius) have already expanded their cogeneration capacity and it is very likely that more African countries will follow this path of efficient and low-cost energy production (IEA, 2005; Woods, 2006). Various technologies are also being developed that could increase the attractiveness of bioenergy for the provision of modern energy in small-scale rural applications. Technologies ranging from biogas to unrefined bio-oils could contribute to meeting local energy needs through the integration of energy production with agricultural and forestry activities (see chapter 6, IAASTD Global Report).

With respect to liquid biofuels, it is highly likely that with the removal or easing of barriers to its trade, the biofuel industry – including ethanol and biodiesel produced from crops – will have far-reaching effects on sub-Saharan African agriculture. It is however difficult to foresee the welfare effects this would bring about. On the one hand, novel development opportunities may arise in countries with significant agricultural resources. The region, with its significant sugar cane and sweet sorghum production suitability, could profit from Brazil's experience and technology (FAO, 2006a). The scenarios by CARENSA indicate a potential for the production of bioethanol from sugar crops in southern Africa (Figure 4.1) in magnitudes that could meet domestic demands and export markets in the region.

[Insert Fig. 4.1]

On the other hand, the comparatively high costs of sugar production in Africa will pose a significant challenge for ethanol development. Moreover, much of the land on which the above scenarios are based is remotely located or not currently suitable for crop production and would require large investments in irrigation and other infrastructure before it could produce crops. In addition to these economic barriers, a large-scale expansion of agricultural production for biofuels would also encounter environmental limits in the form of water availability and threats to natural vegetation and forests (Berndes et al., 2003). Climate change will also affect these factors in the envisioned time frame. Finally, increasing the demand for biomass for biofuels production could have considerable impact on food prices – threatening food security for many poor net buyers of food.

Agricultural energy requirements and consumption. It is highly likely that towards 2050 many countries in sub-Saharan Africa will continue to have some of the lowest per capita energy consumption levels in the world. The projected increase in yields and production in agriculture as a result of energy inputs can lead to important social and environmental gains. Agro-industrial growth will in itself increase energy requirements (Smeets et al., 2007). An assessment of the region's future agricultural energy demand and supply is complex due to unique social and political elements as well as concerns for the food security of millions of people. The past and present energy situation in Africa's agricultural sector has been analyzed systematically, showing that agricultural productivity in sub-Saharan Africa will continue to be closely associated with direct and indirect energy inputs, and there will be continued need for policies to consolidate this relationship for the benefit of farmers and agroecosystems in the region (FAO, 2006a). However, for this to materialize there will be a need, unlike in the past decades, to design and implement agricultural development and extension plans that pay due regard to this synergy. The comprehensive African agricultural development program (CAADP) of the NEPAD is poised to drive the region's agriculture and foods systems toward this goal (NEPAD, 2004).

Various scenario studies have been performed during the past decades to estimate the future demand and supply of bioenergy (Smeets and Faaij, 2006; Smeets et al., 2007; Smith et al., 2007) in sub-Saharan Africa and the world. Published estimates show that the total bioenergy production potential in 2050, for example, would largely come from woody biomass. The demand for food and wood from agroecosystems in sub-Saharan Africa will continue to shape the supply of bioenergy from surplus cropland, forestry as well as crop and animal residues. This will also be determined by the production efficiency of the animal and crop production systems as well as land use decisions to be adopted by the countries towards 2030 and beyond. This will most likely depend on climate change and the adaptive capacities of the continent's agricultural systems (UNEP, 2004). Various factors and elements of agricultural production systems will drive the supply and demand of bioenergy in the region (Figure 4.2).

[Insert Fig. 4.2]

The future relationship between agriculture and energy will largely be shaped by direct and indirect drivers of changing farming systems and patterns (traditional vs. mechanized vs. irrigated) that will alter energy efficiency and production characteristics. The changes in the agricultural yield that will come with an increase in energy and chemical as well as changes in agricultural and post harvest processing technologies like crop curing, drying and processing will also play part. An IFPRI-sponsored assessment concludes that although many questions remain unresolved, there will continue to be synergy between bioenergy, development and agricultural sustainability in SSA (Hazell and Pachauri, 2006). The IMPACT model (Rosegrant et al.. 2002) presents scenarios for biofuels that offer understanding for biofuel growth and productivity specific to SSA. The particular challenge will be reconciling food and fuel demand tradeoffs. In the absence of a solution to this tradeoff, the use of cassava and other agricultural crops as bioenergy feedstock is highly likely to raise agricultural prices leading to sizeable welfare losses - especially for the poorest strata of society.

Future trends in organizational arrangements and support. Current baseline trends show that for energy to be produced sustainably in agriculture the following options may be considered:

- Energy options for specific development goals such as food security and agro-industry development;
- Options for the entire "food chain," assessing energy requirements including the critical linkages between agricultural production, agricultural-based industries (food, beverage, tobacco, and textiles), distribution and commercialization, and the rest of the economy;
- Energy production that would allow sub-Saharan Africa to meet the projected two to threefold increase in agricultural energy requirements by 2010 relative to present levels;
- The energy implications of low-input farming techniques such as integrated pest management, low-tillage cultivation, use of residues, green manures, and other organic fertilizers, which are projected to play an important role in sustainable agricultural development in the region;
- Assess the technical feasibility as well as social, environmental, and economic costs and benefits of bioelectricity (e.g. from cogeneration or biogas).

The current weaknesses in institutional links and responsibilities between the various sectors involved in agricultural policy and technology both as energy consumers and producer will have to be overcome through local, national and regional frameworks. These frameworks will also need coordinated planning at local, regional and national levels by up-scaling local needs and enhancing broad-based participation.

Implications of policies on land tenure for biomass conversion to energy, which include property rights of both land and produce- such as biomass from forests - is generally weak in sub-Saharan Africa and their consideration will be key to sustainable bioenergy production and use in agriculture. Future initiatives expected to broaden technologically sound agro-bioenergy development in sub-Saharan Africa and contribute to the provision of equitable access to sustainable energy from agriculture and for agriculture will have to as a prerequisite:

- raise political awareness among high level decision makers of the important role energy can play in poverty reduction;

- clarify the need for energy services for poverty reduction and sustainable development;
- assess the tradeoffs between food security and biofuels production at the local, national and region level;
- make apparent the need for energy services in national/regional development strategies;
- encourage the coherence and synergy of energy related activities;
- stimulate new resources (capital, technology, human resources) from the private sector, financial institutions, civil society and end-users;
- include institutional capacity building, transfer of knowledge and skills, technical cooperation and market development.

Future implications to development and sustainability goals. Although a feasibility study including food and fuel tradeoffs is needed, the emerging opportunities for biofuel production in the region may be an avenue toward economic development in sub-Saharan Africa. The range of new value addition and agricultural activities created in the production, processing, transport and storage of residues and energy dedicated crops will also increase non-farm economic opportunities (Sebitosi and Pillay, 2005). With the accompanying investment in infrastructure and potential opportunities for local ownership of the conversion industry, options for poverty reduction may improve.

Different development pathways are viable in attempting to achieve the various visions for sub-Saharan Africa bioenergy. The future will largely be dictated by the desire to integrate sustainable agriculture concerns, social development objectives and climate and global environmental change objectives with bioenergy expansion (ICSU, 2006). The most productive bioenergy pathways will be those that improve consumption per capita, in addition to improving or maintaining acceptable social and environmental quality. The rural electrification master plans, for instance, will have to target not only households but also the energy needs for agricultural production, factoring in the energy production potential of agroecosystems. Sustainable bioenergy policies should therefore aim for an agriculture and energy interaction that will provide affordable, accessible and reliable energy services that meet economic, social and environmental needs within the overall developmental context of the society in the region.

4.1.4 Fisheries and aquaculture

The fisheries sector will continue to play multiple roles in SSA economies, and will be instrumental for achieving food security, poverty reduction and sustainable development (FAO, 2006b). Projections indicate that by 2025 over 60% of poor people in SSA will still be rural. This will continue to have significant implications for fisheries as the sector has the potential to contribute to improved livelihoods and food security (Figure 4.3) (Thorpe, 2004; Thorpe et al., 2004; Béné et al., 2006; FAO, 2006c; Isaacs et al., 2005, 2007).

[Insert Figure 4.3]

Fisheries diversity. Projected fish species loss for 13 SSA rivers including the Senegal (52% loss) and Okavango (20% loss) are due primarily to climate change and water withdrawals (Xenopoulos et al., 2005; IPCC, 2007). Freshwater taxa are projected to suffer more from land use changes and invasive species than from climate change. In rivers with reduced discharge, up to 75% of local fish biodiversity will be extinct by 2070.

Capture fisheries will continue to provide the bulk of fish food in Africa for many decades. Hence, SSA will experience increasing pressure on capture fish especially in the large fresh water systems such as Lake Victoria (UNEP, 2006b). Aquaculture will play an increasing role in food security in Africa as small-scale integrated systems provide additional employment for growing rural populations (WorldFish Center, 2005). In periurban areas small-scale enterprises will increase to meet urban demands for higher quality fish products.

Commercial fish farming systems will be characterized by higher levels of management, capital investment, higher levels of quality control and a more complex and structured market (FAO, 2006c, 2006d). These systems will involve different levels of intensification and will be dominated by large scale producers such as Nigeria, South Africa and Madagascar although countries like Côte d'Ivoire, Republic of Congo, Ghana and Kenya will also experience rapid progress. Seaweed and prawn culture is likely to expand in coastal areas and small island states. South Africa and Namibia will lead high value fish farming such as abalone (FAO, 2006c). The region is also likely to see a growth in mussel and oyster culture and an expansion of non-food aquaculture technologies. Cichlids (*Oreochromis* and *Tilapia* spp.) will continue to be most commonly used species, though polyculture with *Clarias gariepinus* and *Cyprinus carpio* will emerge in some countries. It will be important for SSA countries to develop fisheries monitoring and diagnostic tools in order to respond to environmental changes (Neiland et al., 2005).

Local and regional fish trade in SSA has the potential to expand and help stimulate markets at multiple levels. Market expansion at the domestic level will lead to quality and safety measures needed to increase global trade (Delgado et al., 2003). SSA fish producers, processors and marketers will have to increasingly contend with stringent quality requirements and standards set for fish products. The competiveness of fish products from sub-Saharan Africa will remain critical for the survival of the industry (Ponte et al., 2005, 2007). The future of aquaculture and fisheries will also depend on enforcement of eco-labels on marine products (based on FAO guidelines) and certified fish production standards worldwide. The roadmap set by NEPAD (NEPAD, 2005) for fisheries development provide policy guidelines for improvement while local management options exist for ensuring that competitiveness in the world markets is achieved (Raakjaer-Nielsen et al., 2004; Astorkiza et al., 2006; Hegland, 2006; Raakjaer-Nielsen and Hara, 2006; Wilson et al., 2006).

4.2 The Evolution of Agricultural Products and Services towards 2050

4.2.1 Cereals, roots and tubers

Sub-Saharan Africa is projected to have a cereal shortage to 2050. Overall baseline projections to 2020 show an increase in cereal use for animal feed because of increased demand for meat (Rosegrant et al., 2001). By 2020, despite positive growth rates in cereal production (Figure 4.4) and production increases through cultivated land expansion, SSA will not be able to meet cereal demands. High food import levels may be economically and politically unsustainable. If SSA has high population growth and sluggish economic performance, it will likely face food shortages. SSA's projected lack of foreign exchange may weaken their ability to pay for food imports (Rosegrant et al., 2001) (Figures 4.4 and 4.5).

[Insert Fig. 4.4]
[Insert Fig. 4.5]
[Insert Fig. 4.6]

Projections highlight that it is unlikely that sub-Saharan Africa will follow the same path as Asia toward rapid agricultural growth, because SSA faces different constraints, such as higher costs of water exploitation, and limited transportation and communications infrastructure. Future increases in crop production will have to come from more intensive production on existing agricultural land or land expansion (MA, 2005a, b, c). More intensive agricultural production will have to be accompanied by improved natural resources management, substantial investments in agricultural inputs, such as fertilizer and irrigation, and roads, clean water, and education.

Roots and tubers are projected to increase in importance because of their adaptability to marginal environments (IPCC, 2007). Projections of output and consumption patterns for roots and tubers in SSA are based on the end use and show an overall trend toward greater specialization in end use and an increase in the variety of production systems (Scott, et al., 2000). Cassava and sweet potato, for example, will increasingly be used in processed form for food, feed and starch-derived products (Table 4.3, 4.4). Non-food and non-feed uses will grow in volume as a result of technologies that enhance varietal characteristics and reduce production costs. As urbanization increases, more people will purchase processed food.

[Insert Table 4.3]
[Insert Table 4.4]

4.2.2 Meat, dairy and poultry production

Worldwide, demand for meat is projected to rise by more than 55% (Fig. 4.7) between 1997 and 2020, with most of the increase occurring in developing countries. (Rosegrant et al., 2001). Baseline projections towards 2020 indicate that poultry will account for 40% of the global increase in demand for meat, far higher than the 28% it accounted for in 1997, reflecting a shift in taste from red meat to chicken (Fig. 4.7).To meet the rise in demand for meat, farmers will need to grow more cereals, particularly, maize for animal feed rather than for human uses.

[Insert Figures 4.7 and 4.8]

4.2.3 Horticulture and Non-food products

ICT would have to support trade development in the coming decades with information on technologies for handling, processing and marketing (including markets and products) horticultural and non-food products. High quality products coupled with an investor-friendly environment would boost trade in non-food products.

Cotton and fiber products. The cotton textile industry in SSA will require creative and innovative management to be competitive. Government's role will be to create an enabling environment for the private sector through policies involving taxation and marketing. Mill usage in SSA is projected to create additional jobs and generate income for more people.

Floriculture and horticulture. SSA competitiveness in the floriculture sector will depend on successful marketing and use of ICT, including date information on markets and their sizes, product demand, education and extension on production, processing, and handling. This sector will be increasingly competitive (Table 4.5) (Kane et al., 2004; Minot and Ngigi, 2004; CIAT, 2006). The trade in fresh fruits and vegetables with Europe will depend on the level of consumption and population growth (Table 4.6). Exporters from SSA will also have to meet the changing standards and certification requirements, including in the organic market (Collinson, 2001; NRI, 2002; Smelt and Jager 2002; Jaffee, 2003; Hallam et. al., 2004). As eating patterns in the developed world become healthier, (e.g., increased fruit and vegetable consumption), there will continue to be demand for fresh horticultural products year round. A stable economic and political climate will be needed for investor confidence. Infrastructure such as roads, airport facilities, information and communication systems, reliable power and water supply, control, testing and certification services will be required to ensure competitiveness.

[Insert Table 4.5]

[Insert Table 4.6]

Agroecosystem tourism. Tourism and agroecotourism in particular in SSA will remain viable towards 2050. Tourist arrivals are projected to increase at an average annual rate of 7% per year until 2020 (WTO, 2005). Though agroecotourism is believed to propel economic development, its social acceptance in SSA will continue to depend on opportunities presented to local communities. The recognition of agroecotourism's growth potential will have a positive impact on investments in many SSA countries and is poised to contribute to key sustainability and development goals (Giuliani, 2005).

Carbon sequestration and trade. The Kyoto Protocol's Clean Development Mechanism will enable industrialized countries to set up carbon offset projects in SSA. Carbon investments are projected to reduce poverty and protect vulnerable ecosystems. The present carbon trade project in SSA constitutes less than 10% of the international carbon trading. The situation is set to change with the entry of Kyoto compliant projects and numerous voluntary emissions with incentives from the World Bank's BioCarbon Fund (World Bank, 2006).

Payment for ecosystems services. To appreciate the long-term value of environmental services from agroecosystems, new institutional mechanisms will be needed to develop effective markets for ecosystems goods and services. This includes mechanisms for the operationalization of the costs of environmental damage and the benefits of environmental protection into agricultural production and marketing decisions and policy. Such efforts are likely to be most successful in countries where there is a clear, politically expressed perception of environmental scarcity or threat. This will likely happen in areas of population or production pressures, rural and urban poverty, or threatened biodiversity.