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Understanding African Farming Systems

Science and Policy Implications

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PREPARED FOR

FOOD SECURITY IN AFRICA: BRIDGING RESEARCH AND PRACTICE

Sydney, 29–30 November 2012

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Contents

Figures and Tables

Acknowledgements and Data Sources

The authors gratefully acknowledge the material for the subsections on the five principal farming systems that was obtained from the draft book chapters led by John Lynam (Highland Perennials), Malcolm Blackie (Maize-Mixed), Amir Kassam, (Cereal Root and Tuber Crops), Gandah Mahamadou (Agropastoral), and Tilahun Amede (Highland Mixed). Special thanks are due to the reviewers, in particular the detailed inputs of Rosemary Lott, and the assistance in preparation of the manuscript from Sid Mohan and Alice Muller of ICRAF. Financial support is gratefully acknowledged from ACIAR through the Australian International Food Security Centre.

The maps and data tables were prepared by Christopher Aurich based on datasets provided by the following sources:

Figure 2-3 The farming systems of Africa - GAEZ FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion

Figure 3-1 Map of the Highland Perennial Farming Systems in East Africa. - GAEZ ver. 3.0 FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion

Figure 3-2 Maize mixed farming systems of Africa - GAEZ ver. 3.0 FAO/IIASA, FAOSTAT, HC and expert opinion

Figure 3-3 Cereal-Root Crop Mixed Farming Systems in Africa - GAEZ ver. 3.0 FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion

Figure 3-4 Agro-Pastoral Farming Systems in Africa - GAEZ ver. 3.0 FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion

Figure 3-5 Highland Mixed farming systems in Africa - GAEZ ver. 3.0 FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion.

Figure 4-1 Map of the density of undernourished people by farming system. - Original Data sourced from van Wesenbeeck and Merbis (2009) Data repository of the food economy of Sub-Saharan Africa. Centre for World Food Studies, VU University, De Boelelaan, Amsterdam, the Netherlands.

Figure 4-2 Map of the trend in biomass productivity by farming systems in Africa. - Original data sourced from Bai ZG, Dent DL, Olsson L and Schaepman ME 2008. Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC – World Soil Information, Wageningen

Figure 4-3 Map of tree cover in Africa by farming system.- Original data sourced from Zomer RJ, Trabucco A, Coe R and Place F. 2009. Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry. ICRAF Working Paper no. 89. Nairobi, Kenya: World Agroforestry Centre.

Figure 4-4 Time to reach a market town of greater than 20,000 population - Harvest Choice

Figure 4-5 Map of yield gaps in Africa by farming system. - GAEZ ver. 3.0 FAO/IIASA

Executive summary

Economic growth in Africa has accelerated recently, enhancing confidence in the continent's future. Positive developments have taken place in the liberalisation of trade and markets, the strengthening of institutions and policies, the sharing of information and knowledge, and in investments in human and social capital. But they have not yet lessened food insecurity among the third of the population that is experiencing chronic or crisis-driven hunger. Improving smallholder agriculture is now widely seen as fundamental to overcoming the challenging problem of African hunger and poverty.

Increases in farm-household income generate as much as two to four times additional income in the rural non-farm economy. However, national decision makers face the challenge of identifying and investing in specific agricultural and rural development opportunities where the greatest impact on food security and poverty will be achieved. Experience has shown that policy analyses must be better grounded in context-specific analysis, and complemented by innovative ways of thinking about future pathways for agricultural development.

This paper explores why agriculture is contributing to poverty reduction and livelihood improvement in some places, but not in others, and the implications. It presents the interim results of an ongoing project that is updating the classification, analysis and mapping of the farming systems of Africa to support priority-setting and policy making. Thirteen multi-disciplinary teams were engaged in analysing major farming systems across the region. The findings will be published in a full-length book in 2013. By mapping similar farming systems across Africa, the project identified areas with similar constraints and investment opportunities – but also realized that the different policy instruments will be needed to stimulate growth in the different farming systems. The farming systems framework used was anchored in the analysis of individual farm systems with broadly similar patterns of livelihood and consumption patterns, and constraints and opportunities, and for which similar development strategies and interventions would be appropriate.

Close to 70% of the rural poor in Sub-Saharan Africa reside in five farming systems for which the constraints and potentials are summarized in this paper. These are the Highland Perennial, Maize-Mixed, Cereal Root and Tuber Crops, Agropastoral, and Highland Mixed Farming Systems. Current conditions and the drivers shaping the evolution of these farming systems are presented, and the options in science and technology, institutions and policy are examined.

With extremely high population densities, but high development potential (soils, rainfall, markets), the Highland Perennial Farming System has been a natural experiment in the interaction between population growth, declining farm sizes, and the intensification of farming systems. These challenges will be faced by many other farming systems in the coming years, as sustainable intensification encounters extreme limits to minimum farm sizes, as well as the possibilities and limits of farming systems commercialization.

The Maize-Mixed Farming System has a greater agricultural population and more poverty than any of the other farming systems. It is the potential food basket with good potential for diversification, and can be a driver of agricultural growth and food security in the east and southern African region. The overall challenge of reducing hunger and poverty in this system demands strategic, inter-linked initiatives aimed at improving access to agricultural resources, smallholder competitiveness and household risk management.

Local livelihoods in the Agro-Pastoral Farming System have adapted to rainfall variability, low ecosystem productivity, and economic risks for generations. Strategies to cope have included labour mobility, diversification of activities and income, food security, intensification, and collective resource management. Strategic priorities should aim to enhance adaptation capacities and food security, focusing on integrated, multi-scale participatory approaches, flexible tenure regimes, agro-ecological intensification, locally

adapted information systems, and government support for the supply of agricultural services.

The Cereal-Root Crop Mixed Farming System is considered to have one of the highest agricultural growth potentials in Africa, both through expansion of cropping area and through mechanization and higher crop and livestock productivity. The development of the system will benefit from sustainable and efficient labour-saving patterns of resource management through conservation agriculture to address current land degradation (nutrient mining and soil erosion), and promotion of smallholder-led commercialization, along with the reduction of deficiencies in transport, processing, and storage infrastructure.

Challenges experienced in the Highland Mixed Farming System, the largest part of which occurs in Ethiopia's highlands, include high population density and declining land per capita, fragmented and eroded farms, insecure land tenure, and poor market infrastructure. Yet, this system represents an agricultural growth pole for this country and is supported by a strong policy environment, and the availability of improved crop and livestock technologies. An important investment priority lies in the development of private-sector commercial agriculture supported by improved road connectivity, and input markets.

Across farming systems, the drastic reduction in arable land availability related to the rural population explosion requires a shift of household priorities from large families, as a labour reserve, to education of children for maximizing income from off-farm employment. Pro-active policies for moderating overly-rapid population growth in culturally-sensitive ways are an imperative in achieving food security goals at both the household level and national levels.

Reversing the trend of soil fertility depletion in all farming systems has become a major development policy issue. Technical options include the optimization of crop-livestock interactions, integrated use of organic and inorganic nutrient sources, fertilizer trees and other conservation agriculture practices. Public intervention should target input market development, infrastructure, agrodealer networking, strengthening farmer group institutions, provision of credit, smaller-sized fertilizer packaging, and in some cases fertilizer subsidies. The right mix of interventions depends very much on the local context, particularly between high potential areas and remote dryland areas.

Because of the rapid rate of urbanization, the greatest growth potential in markets is in domestic and regional markets, linking urban centres where demand in some areas already far exceeds supply, and the surrounding hinterlands. Enhancing these markets and removing barriers to intra-regional trade will drive both the intensification and diversification of farming systems.

The effectiveness of interventions can only be assured if there is a deep understanding of the kinds of interacting drivers and how they play out at the local level. Path dependency of farming systems reinforces the explanatory power of a farming systems classification and its effective utilization. Perhaps the most important research challenge is organizing and delivering mission-directed systems research that better frames and guides policy decisions in more concrete and nuanced ways. The international and national agricultural establishment must think more creatively about the problem-solving process in African agriculture, and consider more deeply what models of innovation and policy formation are actually appropriate.

Two limitations of the liberalization are now recognized: the lack of government capacity in basic agricultural research and extension support, and the bi-polar development of the agricultural sector. As a result, there is renewed emphasis in poverty reduction as the core challenge for development, and agriculture is once again seen to be central in meeting this challenge. The Millennium Development Goals (MDGs) provide a framework within which ambitious targets are set, supported by the African Union's CAADP and national strategies. Success requires investments in local, national and regional innovation systems and in policy analysis and implementation. Methodological development for such work – and the building of capacity of researchers and policy-makers– requires substantial investment, both from public and private sector within Africa and from donor countries.

1 Introduction

Africa has witnessed an extraordinary rebound in economic growth over the past decade (UNDP 2012).

Today, most of the fastest growing economies in the world are in Africa. They have accomplished this remarkable feat despite the ongoing period of turmoil in the global economy. This has inspired more confidence in the continent's future, and the promise of a much-needed reduction in poverty in the region. But economic growth has not created food security for the third of the population experiencing chronic or crisis-driven hunger.

Most of Africa's poor are rural, and most rely largely on agriculture for their livelihoods. The now widely-shared view is that improving agriculture, particularly smallholder agriculture, is fundamental to overcoming the seemingly intractable problem of African poverty. But how? During the past decade Africa has also experienced several episodes of acute food insecurity, with tragic loss of lives and livelihoods. Recently, the Sahelian region and the Horn of Africa encountered yet another food crisis that has severely affected millions of people. Droughts, crop failures and other disasters often trigger these crises. But the real causes go deeper and they are diverse.

There have been some notable achievements in African agriculture during the past decade. The question is whether these successes are exceptional, and limited to particular settings and times, or whether they are replicable across wider areas, benefiting much larger numbers of people. Exploring why agriculture is contributing to poverty reduction and livelihood improvement in some places, but not in many others, requires identifying, understanding and building on current successes, and encouraging new and innovative thinking about future pathways and opportunities.

This debate comes at a critical time. The Comprehensive Africa Agriculture Development Programme (CAADP), developed by the African Union's New Partnership for Africa's Development, is gaining traction. National governments and the international donor community, including Australia, are committed to accelerating investments in agriculture. But how to translate the good intentions into reality? How to avoid the recycling and repackaging of failed ideas? How to generate effective new thinking, rooted in African contexts and sobering realities that will make a real difference in alleviating hunger and poverty?

A decade ago, an analysis was published that examined the issues from the perspective of the farm and farming systems of the world (Dixon et. al. 2001; www.fao.org/farmingsystems/). It produced a map and classification of the major farming systems for Africa, probed the drivers of change in each system, and identified strategic priorities unique to each one. But it had only a single chapter on the farming systems of Africa. Nevertheless, that chapter proved to be a valued tool in targeting and prioritising agricultural research and development in recent years. It has been used repeatedly in studies and planning for large-scale international research and development efforts such as the InterAcademy Council report on Africa, the Millennium Villages Project, the CGIAR Collaborative Research Programs, and others.

In the decade since its publication much has changed. The African population has increased by a third, dynamism has returned to many African economies, and there has been a series of external shocks, such as the food price crisis of 2007-08. Consequently, it was proposed to do a thorough update of the 2001 analysis focusing on Africa, expand the scope to an entire book, and accompany this with a portfolio of new maps and expanded datasets on resources, trends and drivers in African agriculture. The Australian International Food Security Centre agreed to support this initiative, which was in line with its own efforts to build a strategy for its investments in Africa. The work is coordinated by the World Agroforestry Centre (ICRAF) in Nairobi.

The effort began early in 2012 with a reclassification of Africa's farming systems under the direction of an experienced advisory group. Thirteen multi-disciplinary teams were engaged to analyse each major farming system across the region. They have now compiled their analyses, and they will be published in a full-length book in 2013. This paper is an interim examination of the some of the highlights and implications of that work.

Broad positive and negative trends have been shaping African agricultures: population, food insecurity and poverty are growing, while the natural resource base is under severe threat of degradation. This is compounded by climate change, which is forecast to have some of its most severe impacts in parts of Africa. As a result, household vulnerability is increasing, while access to technology, markets, and inputs is often very limiting. At the same time, an expanding array of options in science and technology, institutions and policy has emerged. Positive developments have taken place in the liberalisation of trade and markets, the strengthening of institutions and policies, the sharing of information and knowledge, and in investments in human and social capital. As a result of both the internal and external drivers behind these trends, farming systems are evolving dynamically.

The CAADP provides a framework for agricultural development in Africa, emphasising that agriculture lies at the heart of any resolution of the rural development crises. The challenge is to identify specific agricultural and rural development needs and opportunities, and to focus investment in areas where the greatest impact on food security and poverty will be achieved. This identification and resource allocation process can be facilitated by analysing farming systems, to identify, quantify and integrate the driving forces and interactions that shape and constrain them. In the course of this effort, it is helpful to use the farming systems framework to aggregate locations with similar constraints and investment opportunities, identify common natural resource management issues, and provide options for managing risk and enhancing productivity.

Two workshops were convened in Nairobi in the process of implementing the work. A wealth of production, marketing, nutritional and natural resource spatial data were assembled. Whereas only 10 years ago there was limited spatial data describing African agriculture, there is now a large volume of data available to support improved analysis of systems, thanks to the FAO, Gates Foundation, International Institute for Applied Systems Analysis (IIASA) and other strategic investors. As a result, the challenge has moved from searching for data to selecting the best data for the purpose from a broad spectrum of available datasets.

The study will therefore produce a comprehensive, forward-looking synthesis on African farming systems for decision makers in research and development endeavours, both public and private, to better address rural poverty and food security. A sister study on African Agricultural Foresight (Siwa et al. 2012) examines the drivers of and future vision of agricultural development.

Our perspective has been to bridge the gap of understanding between professions. We were inspired by the words of William Allen in his monumental study of African farming systems a half century ago (The African Husbandman, 1965), who said "We must try to see the situation through the eyes of the farmer, and put aside for the time being our own preconceived ideas, prejudices, and conceptions of good land-use, which derive from very different societies and environments." We believe that this notion is no less cogent today than it was then. For some degree of humility about the fallibility of diagnoses and solutions to the food security crisis is certainly in order, given the record of past decades.

The history of technical interventions in Africa has indeed been a saga of many discouraging and well-documented failures. Too often the technical recommendations have been derived from generic assumptions rather than a detailed analysis of local farm-level constraints and the livelihood settings within which rural people make decisions, and evolve their farm systems. The prescriptions have all too often been based on poor analogy, for instance, that Asia's green revolution can be replicated in Africa; or on inappropriate evolutionary models, for example that Africa will progress through the same stages of development that Europe or North America followed (Cowan and Shenton 1996).

But it is now quite clear that the African context is unique, in its geography, agro-ecology, history, politics and culture. And it is immensely diverse. This will require bold but original initiatives, and new ways of organising and governing the innovation process, from upstream research to downstream implementation. Thus, rebuilding African agricultural research and development capacity to deal with diverse farming systems is an urgent need, in order to enable innovation that faithfully serves the needs of the majority.

As Scoones *et al* (2005) have noted, unfortunately, it is often assumed that technologies are neutral. However, interventions have differential impacts: there are winners and losers, and unexpected consequences. Social relations, politics, institutions, power relations, and the interaction of interlocking constraints, all affect how inputs (technologies and development interventions) and outputs (development outcomes, including poverty reduction) are related. There is an extensive literature on African agrarian systems that highlights how social and cultural relations shape agricultural production and investment, the type of technologies adopted and the operation of agricultural markets. For example, cropping patterns or marketing choices are not the result of a single economic calculus, but are the outcome of negotiation between husbands and wives, between co-wives and between them and their children (Guyer and Peters 1987). Rethinking is needed in a number of ways, including: Challenging inappropriate assumptions about what farming is about, avoiding simplistic versions of modernisation theory, emphasising the social, political and institutional dimensions of technical change, highlighting agro-ecological questions and environmental impacts and influences, drawing more on understanding of complex local contexts, and recognising the challenge of governing technical change, from design to delivery and regulation.

Past debates have often been framed (unhelpfully) in terms of policy choices between dichotomous oppositions (Scoones et al 2005), e.g., questions such as: smallholder or large-scale commercial agriculture, subsistence or market-oriented agriculture, cash crops or staple food crops, subsidised inputs or the free market, state-delivered services or private sector delivery, international export trade or domestic and regional trade. These either-or debates are sterile because the answers usually depend on the local situation. Instead of developing policy solutions from top down arguments and models, they should emerge out of the diversity and variety of contexts. Analyses need to ask, what patterns are emerging? What trajectories, pathways or scenarios can be drawn out?

Central to all solutions are social, cultural and political factors, and the rural household and its context. A new emphasis therefore needs to be on understanding and influencing the processes of innovation, intervention and policy from a farming systems context, based on local patterns of resources management, production and marketing. Such an approach requires cross-disciplinary or trans-disciplinary thinking – bringing the best of socio-economic and bio-physical analysis together. It also requires a thoroughly grounded approach, allowing for scenarios and options to be elaborated and debated by the multiple stakeholders involved in the future of African agriculture.

These realizations were the basis for this study on African Farming Systems, and for this publication. The next section provides more context for the study, discusses the systems perspective that was deployed, and presents the updated classification of Africa's farming systems. Section 3 highlights key issues from analysis of five of the principal farming systems of Africa, ones that have the vast majority of rural household food insecurity. The final sections review the trends and drivers in African farming systems on the basis of the analyses, draw some of the major implications, and discuss the options for science and policy investments that have emerged.

2 Africa through the Farming Systems Lens

2.1 African Drama: The Hunger for Resilient and Equitable Growth

A SubSaharan Africa (SSA) without hunger or poverty is the vision that underpins this analysis. But today, almost half the African population lives in extreme poverty, of whom more than two-thirds live in rural areas and generally make a living by producing rain fed crops, livestock, trees and other agricultural activities (World Bank 2008). In addition, African cities contain substantial numbers of poor.

Food security still eludes nearly one in three Africans. The SSA region has a global hunger index (GHI) of 20.6, similar to that of South Asia (**Table 2-1**). Poverty and hunger have been aggravated by the volatility of food prices and especially their recent surge since 2008. Such high prices force many households into poverty because food represents a large proportion of their total expenditures.

Household food insecurity and poverty are not distributed uniformly across Africa. There are a number of hotspots, often in areas of high population density, slow economic growth and land degradation. And yet it has been claimed that more than half of the unutilized cropland in the world lies in the region; and foreign governments and corporations have begun negotiating access to large tracts of land in the less densely populated areas of Africa.

Such poverty and food insecurity stands in marked contrast to the richness of the mineral and agricultural resources that SSA possesses. Africa has yet to benefit substantively from these rich resources: Agricultural productivity is lower than for any other region. Land, water and forest resources vary markedly across the African region. Although there are some areas with deep fertile soils that are naturally suited to annual cropping, a large proportion of African soils face severe constraints that require careful land management. Widespread land degradation, including water and wind erosion, soil mining and overgrazing, aggravates the natural limitations of African land resources.

The diversity of natural resources is overlaid by a mosaic of human settlement patterns that reveals a milieu of very diverse farming systems, each with its own rationale and structure (Allan 1965; Ruthenberg 1971). From some perspectives, the diversity of farming systems in Africa is greater than in any other part of the world – ranging from productive banana-maize-coffee systems in the east African highlands, to nomadic pastoralism of the West African Sahel.

2.2 Comparison with Other Regions

The slumbering giant is awakening, and there is widespread recognition that African development may be at a tipping point. Six of the ten fastest-growing economies in the world are currently found in Africa, not Asia. And after many centuries of stagnant per capita income, African average Gross National Income per capita has now reached US $ 1165 (see **Table 2-1**) compared with $ 1213 – 7802 in other developing regions. Despite strong recent economic growth, Africa still has a much higher rate of severe poverty than any other region.

Table 2-1 Regional agriculture, economic development, food security and poverty (2010)

Source: WB, UN, FAOSTAT (various years)

	SSA	LAC	MNA	ECA	SAS	EAP
GNI/capita	1165	7802	3839	7214	1213	3692
Global hunger index (GHI)	20.6	4.9	4.8	2.7	22.6	8.0
Extreme poverty ($1.25) (%)	47.5	6.5	2.7	0.5	36.0	14.3

2.3 Key Characteristics of the Region

Sub-Saharan Africa had a total population of 854 million people in 2010, of whom 476 million (i.e. 56 percent) are classified as agricultural. In 2008, 47% of the population consumed less than US $ 1.25 per day -- more than double the average prevalence of poverty (24%) in developing countries as a whole (UN 2012). In East and Southern Africa, it is estimated that rural poverty accounts for more than 80 percent of total poverty. Agriculture accounted for 13 percent of the region's GDP in 2009, down from around 20 percent through the 1980s and 1990s, but the sector employs 58 percent of the total labour force and is the main source of livelihood for poor people. Sub-Saharan Africa depends for its food on livestock, fish, vegetables and fruits, and a relatively small number of food crops (**Figure 2-1)**.

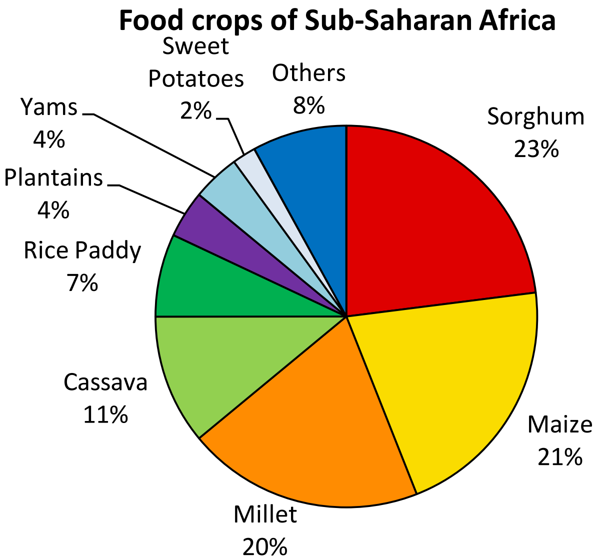

Figure 2-1 Food crops of sub-Saharan Africa (based on harvested area).

The region's main agricultural export commodities are cocoa, coffee and cotton. In the region as a whole, agricultural exports make up about one-sixth of total exports, while agricultural imports - mainly cereals - account for more than one-tenth of total imports. During the past three decades, the region has suffered massive decline in its share of world trade, aggravated by substantially worsening terms of trade.

2.4 The Promise of Agriculture

African food systems have developed in an entirely different way from other economies in recent decades. Production increases have stemmed mostly from area expansion (extensification), which contrasts with the yield intensification in Asia. Sometimes this contrast is explained by the overly simplistic notion that the Green Revolution has not yet reached Africa. However, the reality is far more complex. Looking forward four decades to 2050, African food systems face the triple challenge of a doubling of the number of African consumers, rapid urbanization, and the growth of consumer purchasing power and associated changes in food preferences.

Several generations of development economists have recognized the fundamental role of agriculture in economic development. Many authoritative publications have shown empirically that increases in farm-household income generate as much as two to four times more income growth than the rural non-farm economy. This multiplier effect is much greater for smallholders than for large commercial farms. Because agriculture is so central in the livelihoods of millions of poor farm households, there is also a prima facie case for agricultural development being an engine of rural poverty reduction (World Bank, 2008).

Gender roles in household decision making and the management of household income greatly shape the poverty and food security outcomes. Farm size and wealth also count: normally smallholders spend a higher proportion of additional income on local goods and services, whereas larger farmers tend to spend less locally. Farm household income growth and livelihood improvements influence household food security. But in some circumstances, increased cash crop income has actually led to the worsening of nutritional outcomes.

2.5 Farming systems revisited

As noted in the Introduction, the diversity of agricultural conditions across Africa invites a deeper understanding and analysis of the farming systems to inform evidence-based policy and decision making. There is a long tradition of systems thinking among analysts of African agricultural development. One of the earliest comprehensive studies of this type was by Allan who brought to bear a socio-economic perspective on the rationality of small farmers during the 1930s (1965: The African Husbandman). While a large body of subsequent farming systems applications was directed towards technology development, Dixon et al (2001) and our current analysis have applied the farming systems perspective to framing strategies and priorities for investments in science, policy and other sectors.

From a conceptual viewpoint, it is useful to distinguish the analysis of farm systems, i.e., individual farms, from the analysis of farming systems, in the sense of populations of farms with recognizable group characteristics or patterns. Each individual farm or farm system has its own specific characteristics arising from variations in resource endowments and family circumstances within the context of local institutions and policies. These are translated into productive activities, and household consumption and decision making activities (**Figure 2-2**).

Farmers typically perceive their farms, whether small subsistence units or large corporations, as complex and risky 'systems' and actively manage the farms to achieve family goals, including household food security and livelihoods. Each family has a variety of natural resources, such as different types of land, water sources and access to common property resources in the context of climate and biodiversity, as well as human, social and financial capital. Generally farm household activities are interdependent and diverse, e.g., cropping, agro-forestry, animal husbandry, fishing, hunting and gathering, as well as acquiring inputs and market and production intelligence, marketing products. Working off-farm is also an important and growing source of livelihoods for many African smallholders.

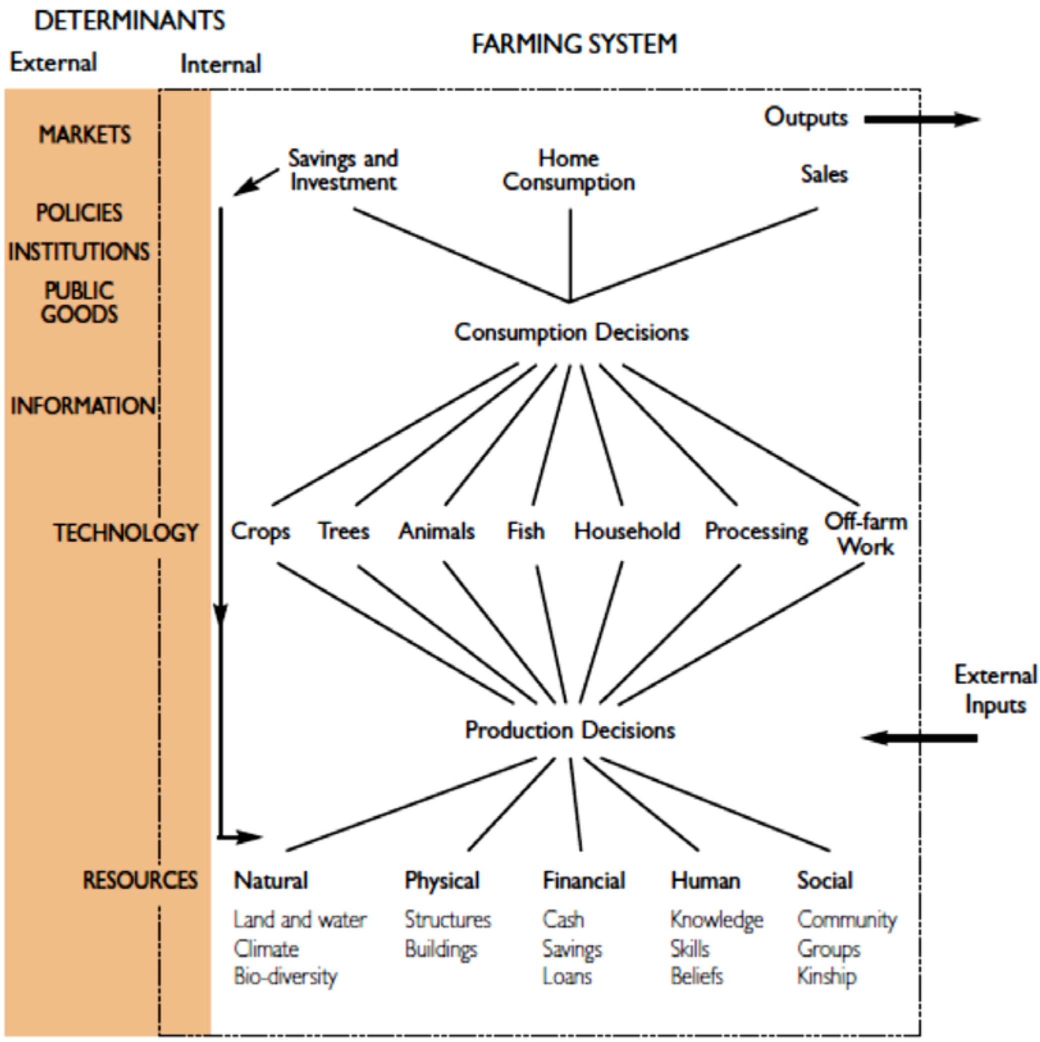

Figure 2-2 Farm household decision-making: Connecting resources, production, consumption and investment

(Source: Dixon et al. 2001).

The functioning of any individual farm system is strongly influenced by the local external rural environment, including local institutions, land, labour and input markets and information linkages. In fact, it is important to include closely-linked aspects of local institutions into the analysis of the farming system. The farm household system boundaries are thus defined by the limits of the sphere of household decision-making, for example, including decision making and income flows connected to off-farm work activities.

In this analysis, a farming system is defined as a population of farm households, often a mix of small and larger farms, that as a group have broadly similar patterns of livelihood and consumption patterns, and constraints and opportunities, and for which similar development strategies and interventions would be appropriate. Often, such systems share similar agro-ecological and market access conditions.

2.6 Major Categories of Farming Systems

The delineation of the major farming systems provides a useful framework within which to examine agricultural development strategies and interventions. We followed a similar approach to Dixon et al (2001) in classifying African farming systems, taking into account the following factors:

- The available natural resource base, including water, land, grazing areas and forest; climate, particularly length of growing period (LGP) and altitude.
- The dominant pattern of farm activities and household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities; and taking into account the main technologies used, which determine the intensity of production and integration of crops, livestock and other activities.

The length of the growing period (LGP) was used as the primary classifier. It was a surrogate for agro-ecological zones and farm natural resource endowments. The travel time to the closest substantial market, such as in a town with a population of 20,000, was the second shaper of farming systems. The year 2010 was selected as the base year. Where the spatial data layers referred to earlier years, linear extrapolations were used to estimate 2010 figures and anchored to FAOSTAT country and regional statistics. The initial definition of farming systems was refined by consideration of several additional generally-available classifiers, notably population density; elevation (for example in the case of highland systems); environmental criteria such as soil type for the tree crop system, and crop and livestock distribution. The major sources of spatial data were IFPRI's Harvest Choice, FAO's and IIASA's Global Agroecological Zones databases and CIESIN for population. On statistics, FAOSTAT was invaluable, supplemented by statistics from the UN and World Bank. Household surveys from the World Bank were also used.

Our classification settled on 13 types of farming system, which were delineated on the map of Africa (**Figure 2-3**). This is naturally a generalization of the vast diversity of African agriculture. Each of the broad farming systems, however, has a unique core concept or "central tendency", and each of the categories contains a substantial degree of subsystems heterogeneity. The alternative of identifying numerous, discrete, micro-level farming systems would have resulted in hundreds or even thousands of types of agriculture, which we surmised would be of limited value to policy makers for the identification of strategic responses. The classification therefore represents a pragmatic approach to showing farming system areas in a geographical manner for easier presentation of the analytical results to policy makers. We are cognizant that sharp boundaries between farming systems on the ground rarely exist, and thus the boundaries are actually soft gradations. The approach has facilitated the generation of many rich datasets that enabled us to characterize the agricultural populations and resource bases of each of the broad systems. Each of these systems is characterised by a typical farm type or household livelihood pattern, and significant sub-types are described where appropriate. The 13 major farming systems of Africa are as follows:

- **Maize Mixed Farming Systems.** In sub-humid and humid areas, dominated by maize with legumes. Located in East, Central and Southern Africa. Livelihood derived principally from maize, tobacco, cotton, legumes, cassava, cattle, goats, poultry and off-farm work.
- **Agro-Pastoral Farming Systems.** In semi-arid areas, dominated by sorghum, millet and livestock. Located in West, East and Southern Africa. Livelihoods derived from sorghum, some maize, pearl millet, pulses, sesame, cattle, sheep, goats, poultry, off-farm work.
- **Cereal-Root Crop Mixed Farming Systems.** In sub-humid areas, distinguished by two starchy staples alongside roots and tubers. Located in West and Central Africa. Livelihoods derived principally from sorghum, maize, millet, cassava, yams, legumes and cattle.
- **Root and Tuber Crop Farming Systems.** In lowland areas where systems are dominated by roots and tubers without a major tree crop. Located in West and Central Africa. Livelihoods are derived principally from yams, cassava, legumes and off-farm work.

- **Highland Perennial Farming Systems.** In moist highland areas with good market access above 1400m asl, with a dominant perennial crop, either food or commercial. Located in East Africa. Livelihoods are derived from diverse activities including tea, coffee, banana (or enset in Ethiopia), maize, beans, sweet potato, cassava, livestock (including dairy) and off-farm work.
- **Highland Mixed Farming Systems.** In cool highland areas above 1600 masl with temperate cereals and livestock. Located in East and Southern Africa. Livelihoods are derived from wheat barley, tef, peas, lentils, broadbeans, rape, potatoes, sheep, goats, livestock, poultry and off-farm work
- **Humid Lowland Tree Crop Farming Systems.** In humid lowland areas where commercial tree crops have replaced forest and provide more than one quarter of household cash income. Located in West and Central Africa, Livelihoods are derived from coffee, cocoa, rubber and oil palm, as well as yams, cassava and maize, and off-farm work.
- **Pastoral Farming Systems.** In arid areas, dominated by livestock. Located in West, East and Southern Africa. Livelihoods derived from cattle, camels, sheep, goats, some cereal crops and off-farm work
- **Fish-based Farming Systems.** Proximity to major water bodies and fish a major source of livelihoods. Located in all parts of Africa, predominantly along the coast and around major lakes. Livelihoods derived from fish, coconuts, cashew, banana, yams, fruit, goats, poultry and off-farm work
- **Forest-Based Farming Systems.** In humid lowland heavily forested areas. Located in Central Africa. Livelihoods are largely derived from subsistence food crops including cassava, maize, beans, cocoyams and taro, and off-farm work.
- **Irrigated Farming Systems.** Large scale contiguous irrigation schemes, with virtual absence of rain fed agriculture. (Small scale schemes are visualized as part of the above systems). Predominantly located in low rainfall areas. Livelihoods are largely derived from commercial crops notably rice, cotton and vegetables, as well as cattle and small ruminants.
- **Sparse Arid Pastoralism and Oases Farming Systems.** Arid areas with average length of growing period less than 30 days. Located in West, North-east and Southern Africa. Livelihoods derived from date palms, cattle, small ruminants and off-farm work, with some scattered irrigated crops and vegetables,
- **Urban and Peri-Urban Farming Systems.** In the centre or the fringes of cities. Located in all parts of Africa. Livelihoods are derived from diverse activities including vegetable and dairy production.

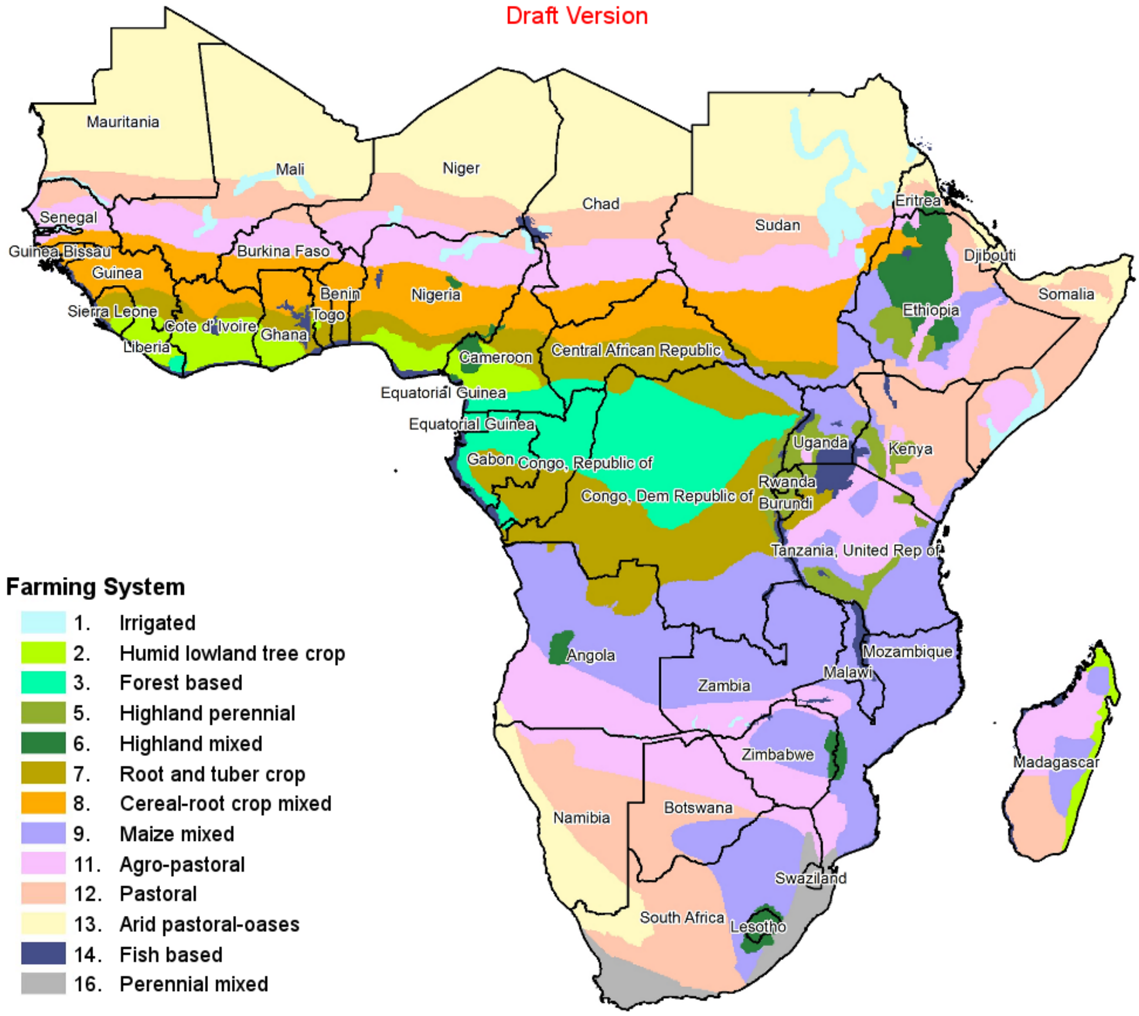

Figure 2-3 The farming systems of Africa

Source: See Acknowledgements

2.7 Pathways out of Poverty

It is instructive to examine the distribution of rural poverty across the farming systems. **Table 2-2** shows that the major part of rural poverty -- and food insecurity – is located in six farming systems, each of which have greater than 20 million severely poor and a total of more than 200 million severely poor households. The greatest concentration is found in the maize-mixed system with more than 50 million desperately poor.

In broad terms, there are five main strategies to improve farm household livelihoods:

- intensification of existing production patterns;
- diversification of production and processing;
- expanded farm or herd size;
- increased off-farm income, both agricultural and non-agricultural; and
- a complete exit from agricultural production within a particular farming system.

Table 2-2 Rural poverty by farming systems.

Farming Systems	Rural population 2010	% rural poor < $1.25 / Day	Total poor <$1.25/day
Maize mixed	95,598,077	53.4	51,001,574
Agro-pastoral	92,808,103	48.0	44,520,047
Highland perennial	65,058,183	59.4	38,631,549
Root and tuber crop	53,055,297	52.8	28,002,585
Cereal-root crop mixed	50,696,502	47.0	23,807,077
Highland mixed	43,502,506	47.6	20,689,792
Humid lowland tree crop	40,541,097	41.1	16,650,228
Pastoral	34,917,550	33.2	11,589,135
Fish-based	19,081,137	46.9	8,945,237
Forest-based	12,626,153	51.6	6,515,095
Irrigated	12,932,118	22.4	2,901,967
Perennial mixed	10,370,712	23.3	2,420,524
Arid pastoral-oases	5,714,580	20.0	1,143,487
Urban and peri-urban			

These strategic options are not mutually exclusive, even at the individual household level; any particular household will often pursue a mixed set of strategies. Intensification is defined here as the increased biophysical or financial productivity of existing patterns of production; including food and cash crops, livestock and other productive activities. Although intensification is frequently associated with increased yields as a result of greater use of external inputs, it may also arise from improved varieties and breeds, deployment of unused resources, improved labour productivity, and better farm management – for example improved irrigation practices or better pest control.

Diversification is defined as an adjustment to the farm enterprise pattern in order to increase farm income, or to reduce income variability. It exploits new market opportunities or existing market niches. Diversification may take the form of completely new enterprises, or may simply involve the expansion of existing, high value, enterprises. The addition or expansion of enterprises refers not only to production, but also to on-farm processing and other farm-based, income generating activity.

Some households escape poverty by expanding farm size. In this context, size refers to managed not necessarily fully-owned resources. Beneficiaries of land reform are the most obvious examples of this source of poverty reduction. Increased farm size may also arise through the expansion of the annually cultivated area of a farm, or incursion into previously non-agricultural areas, such as forest. This option is not available within many systems, but it is relevant in those parts of SSA where population densities are still low. Increasingly, however, such expansion lands are marginal for agricultural purposes, and may not offer sustainable pathways to poverty reduction.

Off-farm income represents an important source of livelihood for many poor farmers. Seasonal migration has been one traditional household strategy for escaping poverty and remittances are often invested in land or livestock purchases. In locations where there is a vigorous off-farm economy, many poor households augment their incomes with part-time or full-time off-farm employment, often on the farms of their neighbours. Where opportunities for improved livelihoods are perceived, a proportion of farm households will abandon their land altogether, and move into other farming systems, or into off-farm occupations in rural or urban locations. This means of escaping agricultural poverty is referred to as an exit from agriculture, or a shift to a non-agricultural livelihood.

Table 2-3 considers the potential magnitude and implications of the five poverty escape pathways for the severely poor farmers in each of the selected farming systems.

Table 2-3 Some implications of the poverty escape pathways by farming system

Farming system / pathways	Intensification	Diversification	Increased farm/herd size	Increased off-farm income	Exit from agriculture
Maize mixed	Considerable potential	High potential, with resource, technology and potential markets	Some scope but land somewhat limiting	High potential with proximity to cities and mines	Some, depending on pull factors
Agro-pastoral Often remote crop-livestock system, low and variable rainfall, weak markets except for livestock, low food crop and range productivity, high population pressure, weak communities and local conflict	Some: technologies available to increase productivity but markets weak	Lack of local markets for different livestock or crop products	Limited scope to increase herds, but local elites control spare crop land	Some seasonal migration of men to distant mines and cities	Forced emigration to other farming systems or cities in search of livelihoods
Highland perennial Good soils, rainfall and markets, small farm size, traditional of cash cropping, relatively strong communities	Limited potential (yields already high)	Good scope, existing markets for a range of new high value crops, experience with production for market	Limited because of population pressure and little spare land	Plenty of jobs and opportunities in rural towns and the city	Some give up land and migrate to towns and the city – most hang on because of strong communities
Cereal root crop Moderate soils, rainfall and markets, one of future breadbaskets of Africa, some distance to ports	Major potential to increase productivity	Limited opportunities to add new enterprises	Considerable opportunities to increase farmed areas with greater labour productivity	Limited opportunities	Modest migration opportunities
Highland mixed Poor soils cool climate, small farm size	Limited opportunities due to production constraints	Modest opportunities	Very low potential for any expansion	Modest opportunities only	Modest opportunities at present

3 Some Principal African Farming Systems: Trends and Implications

This section provides a brief description of five of the most important farming systems, and the key questions and issues driving their evolution from a policy perspective.

3.1 Highland Perennial Farming Systems: Sustainable Intensification and the Minimum Limits of Farm Size

The highland perennial (HP) farming system has a unique ecology, and this has caused it to play a considerably larger role in the agricultural economies of African countries than its limited geographical scope might suggest. Essentially located in East Africa (**Figure 3-1**), the highlands have long rainy periods so that agriculture is not usually water limited and often have relatively fertile soils of volcanic origin. Also, these areas were relatively free of human diseases and were often first settled.

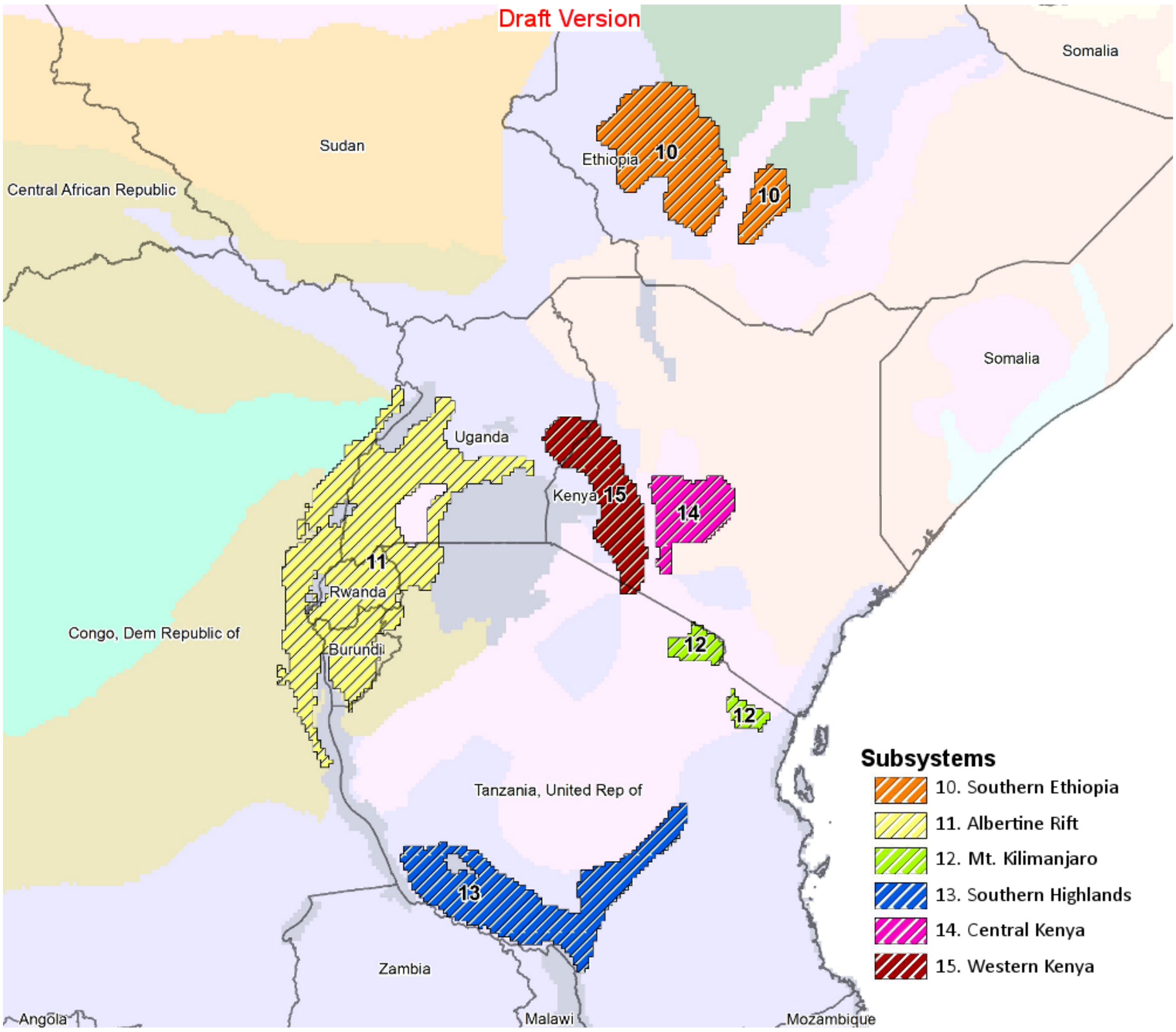

Figure 3-1 Map of the Highland Perennial farming systems in East Africa.

Source: See Acknowledgements

Thus, the highlands thus have some of the highest rural population densities in sub-Saharan Africa. They also exhibit some of the highest agricultural potential, as this ecology is suitable for horticulture, floriculture, coffee, and tea, as well as for dairy. The basic statistics related to the system are listed in **Table 3-1.**

Table 3-1 Basic systems data: Highland Perennial farming system

Data item	Data year	Data
Total human population	2010	76.6 m
Rural population	2010	65.1 m
Agricultural population	2010	61.4 m
Females active in agriculture	2010	14.7 m
Total area	2000	42 m ha
Average length of growing period (LGP)	2012	267 days
Market access (to town of 20K inhabitants)	2005	6 hrs.
Cultivated area*	2009-10	5.4 m ha
Irrigated area	2000	0.2 m ha
Cattle population	2009-10	20.1 m
Small ruminant population	2009-10	22.3 m
Chicken population	2009-10	40.7 m

**FAOStat data calibrated based on Harvest Choice 2000 footprint. Figure includes crop area of only 10 crops (maize, millet, sorghum, cassava, rice, potato, soy bean, sugarcane, wheat and sweet potato).*

Source: FAOSTAT, Harvest Choice

The HP system has been a natural experiment in understanding the interaction between population growth, declining farm sizes, and the intensification of farming systems. The challenges it faces are instructive, considering that they are a harbinger of those that will be faced by many others, as sustainable intensification runs up against extreme limits to minimum farm sizes, and as well as the possibilities and limits of farming systems commercialization.

It was one of the first ecologies for the introduction of cash crops, particularly coffee. Expanding markets are now a critical driver in the development pathway. HP farming systems have evolved in response to very rapid growth in rural population. They are now characterized as permanent systems and fallowing for soil regeneration is no longer possible (Carswell, 2002). There is a sense of unsustainable pressure on the natural resource base. However, the liberalization of markets in the late 1990's now offers a principal pathway for further intensification of these farming systems.

The HP system is made up of six, separate agricultural zones, reflecting the very heterogeneous topography and market access in East Africa (**Figure 3-1**). Each sub-region has perennials as the basis of the farming system. But they have very different market contexts. The East African Highland Banana (EAHB) is the basic staple in most of the HP system, and elsewhere it is a principal secondary staple. Both culturally and in terms of ecological adaptation, EAHB have contributed to the sustainability of these permanent farming systems. However, as the systems have moved toward selling marketable surpluses, there has been a significant increase in nutrient exports from the system, since marketing is done in the form of bunches. This depletes soil fertility and leads to the decline of growth, increased leaching, and enhanced susceptibility to pests and diseases.

Maize is now the principal staple crop within the Kenyan and southern Tanzanian highlands, although still within highly diversified farming systems. The highlands are also characterized by the early introduction of cash crops, especially coffee. They have the highest rural population densities in sub-Saharan Africa and associated with that some of the highest densities of rural poverty and malnutrition. The semi-subsistence sub-regions of the highland perennial systems stand out in Africa as having the highest density of malnourished children, including Southern Ethiopia, Western Kenya, and the Albertine Rift.

For farming systems in the East African highlands the last decade has been a period of consolidation after periods of insecurity in many countries and redirection through liberalization of agricultural markets. While improved access to markets has been the principal driver of change in farming systems in the region, what is also striking is the continued primacy of subsistence objectives and the maintenance of the basic structure of the farming system around the principal food staple(s).

Possibly the most significant question in highland farming systems is the minimum farm size required to be economically viable and to generate marketable surpluses (Hazell, 2011). Growth will need to come from improved efficiency, shifting the production frontier through improved technical change and improved productivity, and moving to higher value crops. Larger farms, and in the East African highlands, these are usually anything over 1.8 hectares, have an inherent advantage in achieving these conditions. However, since the largest percentage and density of rural poor are also in the highland areas, raising the productivity of small farms, even if they remain net buyers of food staples, will contribute to reducing rural poverty and malnutrition. The question is whether commercialization will be an avenue to reducing poverty or further marginalizing those with limited resources other than their labour.

Intensification pathways and outcomes in the six sub-regions will vary, in major part due to market access and the current pressure on farm size. An assessment of these pathways is presented in **Table** 3-2 and strategic interventions for the development of commercializing versus diversifying systems in **Table 3-3.**

Table 3-2 Market-driven intensification pathways

Intensification pathways	**Commercializing (C. Kenya; N. Tanzania)**	**Diversifying (S. Tanzania; Albertine Rift, W. Kenya)**	**Stagnating (S. Ethiopia)**
Cash crop growth or diversification	Specialization Differentiation	Diversification	Static
Staple crop intensification	Increasing yields	Livelihood dependent	Static to declining
Soil fertility management	Fertilizer	Integrated soil fertility management	Organics
Potential rural non-farm economy (RNFE) growth	Significant	Emergent	Limited
Exit from agriculture	Push and pull	Limited pull	Push

Table 3-3 Summary of strategic interventions for Highland Perennial farming systems

Drivers of farming system evolution	Interventions for Commercializing systems	Interventions for Diversifying systems
Population, poverty, hunger	Balancing rural poverty and increasing marketable surpluses particularly for urban markets	Further diversify cash crops and improve productivity of staple crops to deepen market-driven intensification.
Natural resources and climate	Maintain environmental services of water towers; maintain dry season stream flow at lower elevations	Improve soil fertility management as pre-condition for improving staple food productivity.
Human capital, gender and agricultural knowledge	Education, safety net and employment programs (RNFE) for low-resource population section to avoid migration	Lower but existing potential for RNFE
Technology and science	Intensify; promote smallholder irrigation for increased productivity and timing of marketing	Develop nutrient and pest and disease management for starchy staples; improve farmer management of crop nutrition (inorganic fertilizers, manure, N-fixing legumes; adapt reduced tillage and conservation agriculture.
Markets and trade	Reduce transaction costs in land markets; facilitate land consolidation for expanding farm size for high-resource population section	Develop agrodealer networks for retail and distribution of inputs
Institutions and policies	Credit programs to support small and medium enterprise development and expansion into crop activities generating employment up in the value chain	Integrate diversifying systems into larger regional markets through the East African Community and for S. Tanzanian Highlands through COMESA for effective cross-border input delivery, opening up of regional feed markets, better price integration across urban markets, and for exploiting agroecological comparative advantage of highlands.

3.2 Maize Mixed Farming Systems: Engine for rural growth?

The Maize Mixed Farming System extends over much of east and southern Africa, of which some 91 million ha is cultivated (with small scale irrigation on 1 million hectares). It has a greater agricultural population (just under 91 million in 2010) and more poverty than any of the other farming systems in Africa. It serves as the food basket as well as driver of agricultural growth and food security in the region. Geographically, the core of the system extends across plateau and highland areas at altitudes of approximately 800 to 1500 metres, from Ethiopia, Kenya and Tanzania to Zambia, Malawi, Zimbabwe, South Africa, Swaziland and Lesotho with extensions into central Africa (including DRC) and Madagascar. The system embraces heterogeneity in the form of typical sub-systems. These can be illustrated by particular countries or groups of countries (**Figure 3-2**). Smallholders account for more than 90 % of cultivated land and agricultural population of the maize mixed farming system. Originally most of the area was heavily forested. Over decades, farmers have pushed the agricultural margin into the forests; and in addition forests have been thinned or clear cut for commercial species.

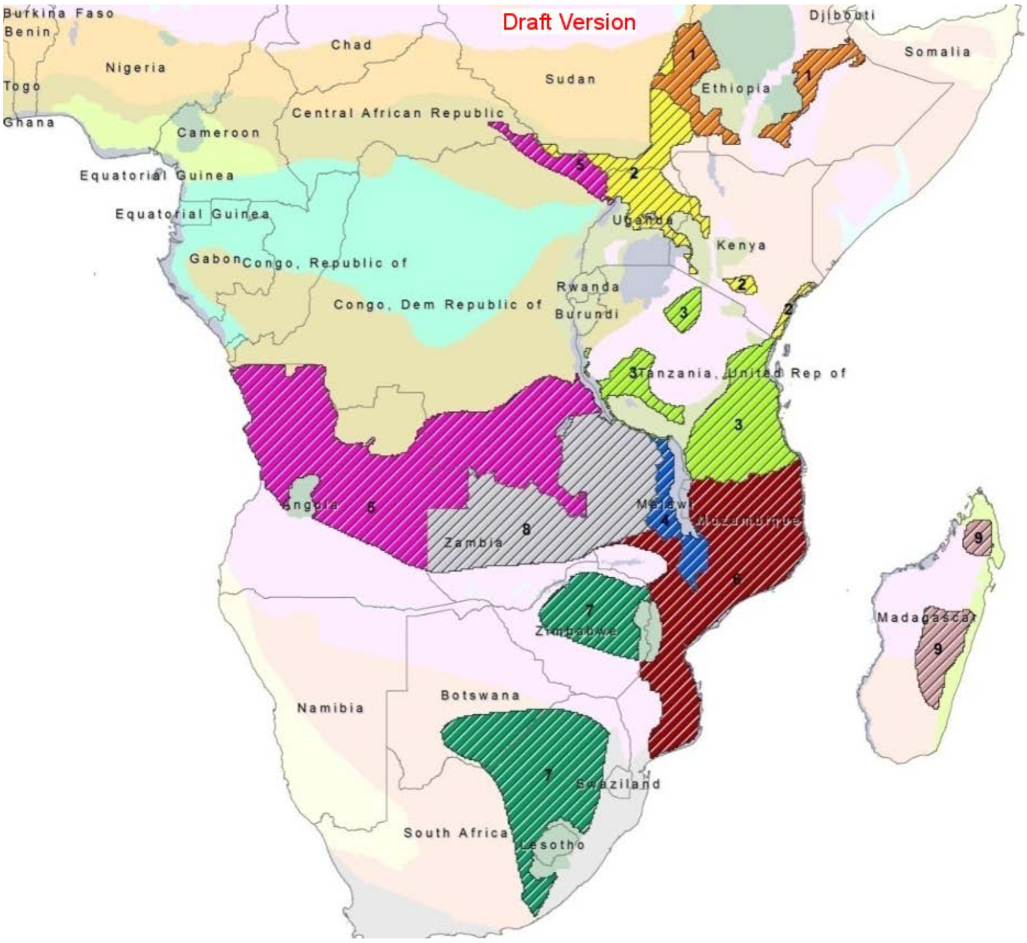

Figure 3-2 Maize mixed farming systems of Africa

Source: See Acknowledgements

The farming system is a crop-livestock system lying largely in the sub-humid zone with a medium season length of averaging 191 growing days (about six months), termed length of growing period (LGP). The basic statistics related to the system are listed in **Table 3-4**. Cropping is dominated by the staple maize, but is typically a diversified system incorporating significant areas of pulses, oil seeds, cotton, sorghum and millet. Beans, other legumes, and cassava are often planted as intercrops. Maize has been successfully introduced into previously cassava dominated farming systems, such as in central Africa. Both local and hybrid maize are grown, although the taste of the former is sometimes preferred.

Legumes are an important source of protein and often attract good prices on the market. Legume species vary across the region; the most common species are beans (*Phaseolus vulgaris*), cowpeas (*Vigna unguiculata*), pigeon pea (*Cajanus cajan*), groundnuts (*Arachis hypogea*), chickpea (*Cicer arietinum*) and soybeans (*Glycine max*). Intercrops with beans, cowpeas and pigeonpeas are more common where land-holdings are small, whereas sole legume crops such as groundnuts and soybeans in rotation with maize are more common where there is less pressure on the land. As noted above, sorghum and cassava are also grown by farmers in this system—the former increasingly for home-brewed beer or for sale to commercial breweries, and the latter as drought insurance. Cash crops include coffee, tobacco, cotton, groundnuts and sunflower. Most households will sell any maize surplus to home requirements.

Table 3-4 Basic systems data: Maize Mixed farming systems

Data item	Data year	Data
Total human population	2010	142.5 m
Rural population	2010	95.6 m
Agricultural population	2010	90.7 m
Females active in agriculture	2010	22.4 m
Total area	2000	395.6 m ha
Length of growing period (LGP)	2012	191 days (range 312 to 113)
Market access to 20 k town	2005	7.4 hrs.
Cultivated area	2009-2010	91 m ha
Irrigated area	2000	1.2 m ha
Cattle population	2009-10	29 m
Small ruminant population	2009-10	37 m
Chicken population	2009-10	225.3 m

Source: FAOSTAT, HC (data refer to 2010 except where noted)

The basic cropping pattern is complemented by cattle, small ruminants, poultry and off-farm employment, trading and small businesses. Cattle are the major livestock type, supplemented by sheep and goats. Free range poultry are prevalent across the region. The development of road networks in the past few decades has given most of the rural population in this system moderate or good access to input and produce markets. This has opened new income earning opportunities, and, for the majority of farm households, off-farm income is a significant contributor to household livelihoods. Off farm earnings may derive from either migrant work in neighbouring towns or even countries, or else from working (often for food) on nearby farms. Typically it is adult males who seek work away from the household, which has the effect of leaving farming responsibilities in the hands of women and those less able to undertake outside work.

Box 1 Typical smallholder farm household profile

A typical smallholder five-six person family farm would have a cropped area of 1.5-2 ha of which 0.5-1.0 ha would be planted to maize, about half as much to other cereals such as sorghum, millet, rice or wheat. Small areas of cassava and sweet potatoes are grown. Beans, groundnuts and other legumes are cultivated on another 0.25 ha. Small areas are planted to cotton and coffee, and the rest to a wide range of other crops. The family owns 2 or 3 cattle and use oxen to plough the land. As the availability of cattle (and grazing) declines, cows are increasingly used for draft power – a task for which they lack strength and which serves to reduce significantly their fertility. Typical yields are low -- around 1.2 t/ha for maize and 500 kg/ha for beans or other pulses. Maize and other cereals would account for 80 percent of total food production. Pulses, cassava, and oilseeds each contribute around 5% of total food production. The household would be food self-sufficient in average to good years and in deficit during drought years. One son works in the city or on the mines and sends occasional remittances which are used to pay for school and medical fees and clothes. Home-grown maize is the main source of subsistence and, cash is obtained either from off-farm activities or from the sale of agricultural products, such as maize, cotton, coffee and milk. Although household income would be above the poverty line in average seasons (but would fall below the poverty line in drought years), lack of cash is a major `constraint on the purchase of improved inputs.

Area expansion (extensification) has underpinned most past growth in food production. Despite the several decades of sound agricultural research, food crop productivity (which averages 1-2 t/ha for maize and 0.5 – 1.0 t/ha for grain legumes) is low. Both biotic and abiotic constraints limit the productivity of agriculture in general, and maize and legumes in particular. Despite improved market access, institutional and socioeconomic constraints make it difficult for smallholder farmers to access seeds, inputs and output markets in order to respond to market price signals.

There are bright spots of success across the system where developments of the farming system have led to improvement in household food security and to reduction in poverty. Of the five major household strategies or pathways to improved livelihoods, intensification offers the most promise. The intensification of maize through the distribution of subsidized seed and fertilizer in Malawi is notable, although a sustainable financing model has yet to be found. Diversification and off-farm income are also important.

Food insecurity, hunger and poverty are extensive, especially among the 80 percent of the poor who depend on farming for their main livelihood. In the midst of the poverty, there are islands of successful intensification and diversification. Thus, a reduction of poverty in the maize mixed system is feasible. Policy and institutional environments within the system do not, in general, create the required incentives to boost agricultural productivity – especially broad-based inclusive growth to benefit the poor. There is still an urban bias in development programmes, agriculture is over-taxed and the supply of rural public goods is less than in other farming systems, while transaction costs remain high. The performance of past investments in agricultural research and extension has been mixed and, overall, disappointing, while terms of trade have been declining. Moreover, poor governance, civil strife, a degenerating law and order situation, gender inequality, low levels of schooling and HIV/AIDS are all of deep concern.

The abundance of natural resources in the region provides the basis for pro-poor agricultural development if the appropriate incentives are created by the adjustments in national policies, reorientation of institutions and provision of public goods and services. The overall strategic goal should be broad-based inclusive agricultural growth occurring in poorer communities and the poorer sections of each community. In order to halve hunger and poverty by the year 2015, massive efforts are required to stimulate such agricultural growth, which ultimately depends on the initiative and effort of individual farm families within each farming system. Although it is impossible to prescribe specific national actions, the overall challenge of reducing hunger and poverty in the region demands strategic, inter-linked, initiatives:

Access to agricultural resources by poor farmers is intended to create a viable resource base for small family farms. Components include: market-based land reform; adjustment of legislation; strengthened public land administration; and functional community land tenure. Increasing competitiveness of small and poor farmers will build capacity to exploit market opportunities. Components include: improved production technology; diversification; processing; upgrading product quality; linking production to niche markets; and strengthening support services, including market institutions based on public-private partnerships. Household risk management will reduce the vulnerability of farm households to natural and economic shocks, both of which are prevalent in African agriculture. Components include: drought-resistant and early varieties and hardy breeds; improved production practices for moisture retention; insurance mechanisms; and strengthening traditional and other risk spreading mechanisms.

Table 3-5 Summary of strategic interventions for Maize Mixed farming systems

Drivers of farming system evolution	Intervention	Implementers	Implications for farming system structure and function
Population, hunger and poverty	Improved labour markets Market mechanisms for famine relief, rehabilitation and recovery	Ministries WFP and NGOs	Wider access to off-farm income Increased demand for food in the farming system for relief in neighbouring areas
Natural resources and climate	Integrated participatory NRM, e.g., CA and Landcare	Extension; NGOs	Increased productivity and resilience
Human capital, gender and agricultural knowledge	Target women farmers in agricultural knowledge communication	Extension; NGOs	More knowledgeable farm managers
Energy	Reduced tillage/CA Improved storage	NGOs	Release of labour for other activities, e.g., cash crops or dairy
Technology and science	Systems research approach Involve private sector; emphasise labour reducing technologies including soil fertility management and CA; emphasise legumes research; use IPs to promote scaling out	NARS; farmers groups	Better system fit of new technologies, and more integrated farming systems
Markets and trade	Support market information including ICTs and credit/financing, e.g., M-PESA	Agribusiness; extension; NGOs	Wider choice and better informed production and marketing decisions therefore increased eco-efficiency
Institutions and policies	Reduced barriers to cross border agricultural trade; land tenure	Ministries	Lower cost and wider choice in inputs; increased farm gate grain prices; sustainable land management

3.3 Cereal-Root Crop Mixed Farming Systems: West Africa's future breadbasket?

This farming system has long been seen as a major source of agricultural growth for Africa (Dixon et al 2001). It is the West African extension of the Guinea Savannah Zone, which was the focus of a recent World Bank Report on 'Awakening Africa's Sleeping Giant' (World Bank 2009). The Guinea Savannah Zone supports three main farming systems: (a) the mixed cereal-root crop farming system, (a) the root and tuber crops farming system, both in West Africa, and (c) the maize mixed farming system, which is dominant in eastern and southern Africa (see **section 3.2**). The zone features a warm tropical climate with 800–1,200 mm of annual rainfall, allowing for a growing period of 150–210 days (**Figure 3-3**). Basic statistics related to the system are listed in Table 3.6. The system is one of the major underutilized resources in Africa, accounting for about one-third of the land area in Sub-Saharan Africa and underpinning the livelihoods of more than one-quarter of all African farmers. During the past decade, strong agricultural growth has been occurring in several African countries in the zone, and the recent increases in international prices of agricultural commodities have opened up new opportunities.

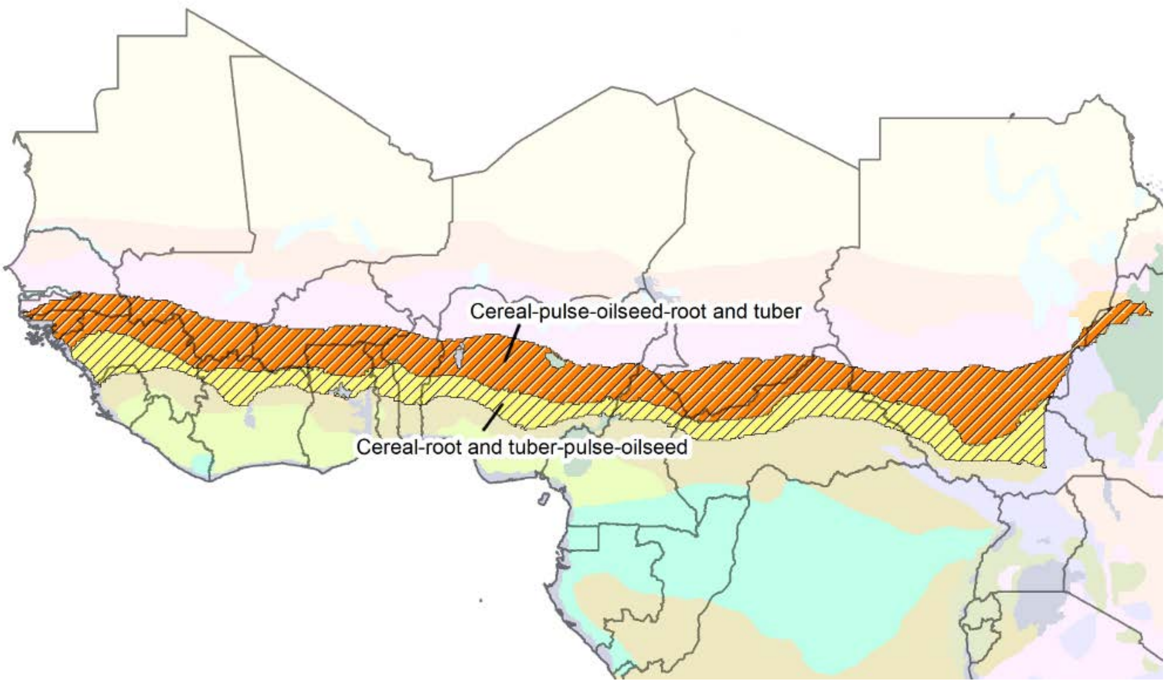

Figure 3-3 Cereal-Root Crop Mixed farming systems in Africa

Source: See Acknowledgements

The variable annual rainfall and poor soil quality make this a challenging agroecological environment. However, what has created great interest in this farming system is that during the past half century, two other relatively backward and landlocked agricultural regions with similar agroecological conditions —the Cerrado region of Brazil and the northeast region of Thailand—developed at a rapid pace and have now become leading agricultural exporters. The success of those regions defied scepticism that their challenging agroecological characteristics, remote locations, and high levels of poverty would prove impossible to overcome. Similar perceptions have also fuelled pessimism about the prospects for African agriculture in general, and this farming system in particular. This may now be changing. The Bank now contends that with sustainable and inclusive growth, particularly of a more commercialized smallholder agriculture, this region has the potential to become a food production powerhouse that could feed Africa, and eventually create a booming export business.

Table 3-6 Basic systems data: Cereal- Root Crop Mixed farming systems

Data item	Data year	Data
Total human population	2010	73.5 million
Rural population	2010	50.7 million
Agricultural population	2010	42.1 million
Females active in agriculture	2010	7.4 million
Total area	2000	205.3 million ha
Average length of growing period (LGP)	2012	186 days
Market access (to town of 20K inhabitants)	2005	6.3 hrs.
Cultivated area*	2009-2010	16.6 million ha
Irrigated area	2000	0.23 million ha
Cattle population	2009-10	38.8 million
Small ruminant population	2009-10	73.4 million
Chicken population	2009-10	150 million

**FAOStat data calibrated based on Harvest Choice 2000 footprint. Figure includes crop area of only 10 crops (maize, millet, sorghum, cassava, rice, potato, soy bean, sugarcane, wheat and sweet potato).*

Source: FAOSTAT, Harvest Choice

However, the immediate realities within the Cereal Root and Tuber Crops System are still pretty grim. In 2005, about 47 per cent of the rural population had a per capita daily income of less than US $1.25 compared with 41 per cent for SSA as a whole. Thus, about half the population in this farming system zone still lives in abject poverty. The average annual increase in the agricultural population in this particular system is relatively low (1.1% per year during the 2005-2010 period) because rural-to-urban migration has been very rapid.

The total harvested crop area in the systems was 20.9 M ha in 2000, which includes cereals (sorghum, millet, maize and rice on over half the area) root and tuber crops (cassava, sweet potato, and yam on about one-tenth) with annual leguminous crops or pulses (cowpeas, pigeon peas, dry beans) on 6%, and oilseed crops (groundnut, soybean, sesame) on about 10 percent. Cotton occupies just under 5 percent and other crops about 15 percent of the cropped area.

In much of this farming system, labour is the limiting constraint on the expansion of production, not land. Thus, expanding the cultivated area of the small farm by increasing the efficiency and returns to labour is a critical opportunity. Thus, this farming system is considered to have one with the highest agricultural growth potentials in Africa. It has ample opportunity for growth through expansion of the cropped area as well as through higher yields per ha.

In the long run, there could be scope for extension of the cropped area per household in connection with tsetse eradication and mechanisation (either through animal traction or small tractors), as well as through agricultural industrialisation. Better management of resources could be achieved through conservation agriculture, which involves the introduction of reduced tillage, and through improved land husbandry that could increase labour returns. There is substantial tree cover on croplands in major parts of this farming system, for example the cultivation of shea nut for oil and cosmetics. Further expansion and intensification of these agroforestry parklands is a key pathway to higher incomes and the regeneration of soil health.

Box 2 A 'typical' household of the cereal-root and tuber crop mixed farming system

A typical household in the farming sub-system 1 zone (dry sub-humid) using hand cultivation and organic manure grows sorghum, maize, millet, cassava, yam, cotton, and minor crops such as groundnut, cowpea, beans, sweet potato and squash. A substantial part of the manure is provided by Fulani herds which pass through the area grazing on crop stubble and residues. Some farm household do not own cattle, but nearly all keep a few chickens and goats. In the cotton growing areas minimal doses of purchased mineral fertiliser and pesticides are used in spite of their high cost. Some of the cotton farmers, particularly in the Francophone areas, are part of a scheme operated by a cotton company, either private or parastatal, and follow a recommended package of practices with seed, fertilizer and pesticides made available to them by the cotton companies. Although a decade ago little fertilizer was used on maize or other food crops, increasing numbers of households apply fertilizer to the maize crop and sell surplus production. The household is largely food self-sufficient and has a surplus to sell. The main sources of cash are cotton, maize, cowpea and vegetables, and increasingly, soybean is found in the cropping system, as a cash crop in addition to some cassava and yam. Poorer households in the farming sub-system 1 do not grow cotton due to a lack of cash for purchased inputs, and experience 2-3 months of food insecurity towards the end of the dry season and early part of the rainy season (the so called 'hungry season or gap'). They alleviate this problem by working for food on other farmers' fields although this has a detrimental impact on the potential productivity of their own farms for the rest of the growing season. During the dry season, many male household members often migrate south to the forest zone to do casual labour for plantation farmers (in Hausa known as 'cin rani').

In farming sub-system 2 zone (moist sub-humid), a typical household also uses hand cultivation to grow maize, rice, cassava, yam, sweet potato, soybean and minor crops such as cowpeas, pigeon pea and beans. There would is no cotton in the cropping system and sorghum and millet is replaced by maize and rice. The household is largely food self-sufficient and generally has a surplus to sell. The main sources of cash are maize, rice, cassava, yam, soybean, cowpea and vegetables. The linkage between agriculture and off-farm work is reasonably well developed, enabling the poorer households to engage in casual labour for larger or plantation farmers.

Source: Updated from Dixon et al. (2001) based on new information

In the foreseeable future, the target of production should be domestic and regional markets, which are expanding rapidly, and where producers enjoy a certain degree of natural protection. Later, as they become more competitive, they will be able to expand into international markets. The Bank's analysis indicates that the best way to achieve broad-based, poverty-reducing agricultural growth is by promoting smallholder-led commercialization models, rather than by focusing exclusively on large-scale commercial agriculture (World Bank, 2009). Despite significantly lower yields in the African countries, farm-level unit production costs are comparable to or lower than those in the Brazilian Cerrado and in northeast Thailand, due to very low labour costs and limited use of purchased inputs.

Although low unit-production costs help to make African producers competitive in the short run, they do not represent a sustainable path out of poverty in the long run, because at current, low productivity levels, agriculture is economically impoverishing and technically unsustainable. The competitiveness of Africa's producers at the farm level makes them generally competitive in domestic markets relative to imports. However, the same logistical barriers that protect the domestic markets also make the produce of African countries uncompetitive when it comes to exports. These barriers stem from widespread deficiencies in transport, processing, and storage infrastructure.

On balance, the economic and social evidence suggests that the smallholder-led commercialization strategy pioneered in Thailand is more compatible with the inclusive growth policies being pursued by most African governments than the Brazilian model. The increased incentives for family farmers to work hard and manage their enterprises efficiently are at the root of the productivity advantage of the family farm. Compared to large commercial farms, family farms and emerging commercial farms typically have lower costs at the farm level and at the final distribution point.

3.4 Agro-Pastoral Farming Systems: Achieving resilience under duress?

The Agro-pastoral farming system is found throughout the belt of Sahelian West Africa stretching from Senegal to North Sudan, as well as stretches in Eastern and Southern Africa (**Figure 3-4**). It is mainly characterized by low and unreliable rainfall, a length of growing period of 90 to 150 days and a rainfall regime of 300 to 800 mm, which is monomodal in western and southern Africa and bimodal in eastern Africa. For generations, populations have adapted their farming systems and way of life to the spatial and temporal (seasonal and inter-annual) rainfall variability and its resulting uncertainties on production of crops, trees, and grazing resources. Drought is a regular phenomenon in this farming system. Not only are farmers used to it, it is central to their economic planning. Thus, the primary concern of agro-pastoral farm households is to ensure their survival and to minimise the risk of failure to produce their means of subsistence. Following a production failure households also seek to limit their losses and maintain or recover their productive capacity (Swinton, 1988).

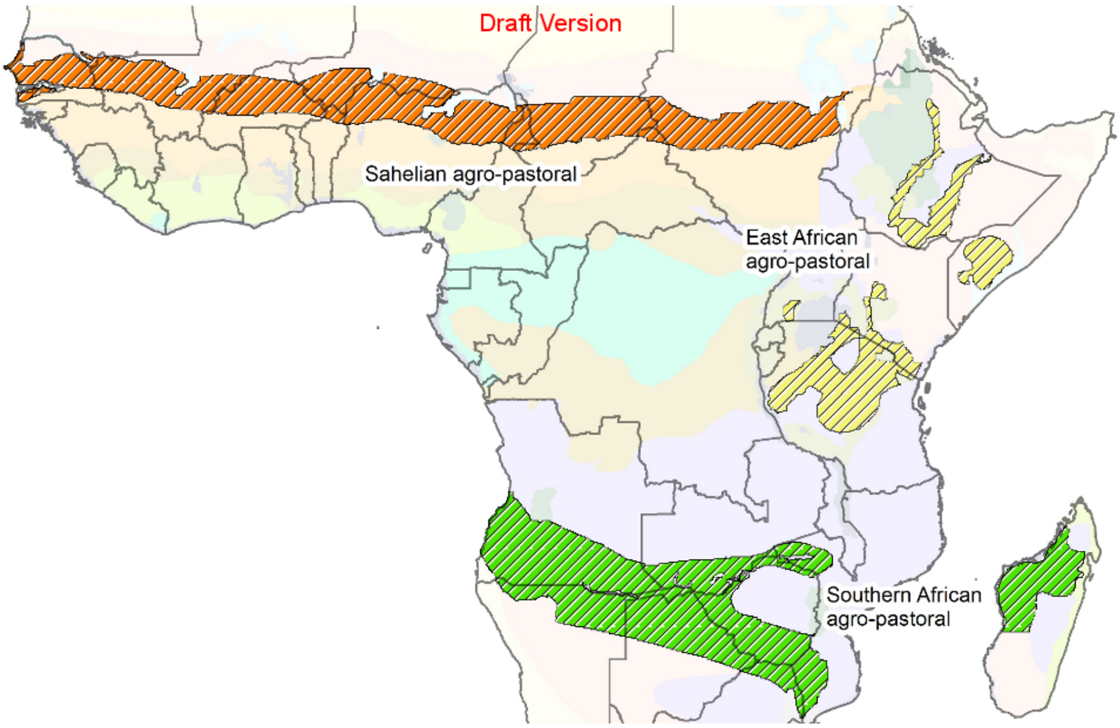

Figure 3-4 Agro-Pastoral farming systems in Africa

Source: See Acknowledgements

A relatively short growing period underpins the importance of millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) as the dominant cereal crops for farmer livelihoods and grass pasture as a pastoral component of the system. Between 2000 and 2010, however, the area of maize increased by 48%. This is due to the existence of accessible and well developed markets for maize, lower labour requirements for its production and processing, and its suitability for preparing the staple dish. In comparison, the area increases of both millet and sorghum were only 17% during the same period. Basic statistics related to the system are listed in

Table 3-7**.**

Table 3-7 Basic systems data: Agro-pastoral farming systems

Data item	Data year	Data
Total human population	2010	134.4 million
Rural population	2010	92.8 million
Agricultural population	2010	81.8 million
Females active in agriculture	2010	15.8 million
Total area	2000	365 million ha
Average length of growing period (LGP)	2012	129 days
Market access (to town of 20K inhabitants)	2005	6.8 hrs.
Cultivated area*	2009-2010	29.3 million ha
Irrigated area	2000	0.86 million ha
Cattle population	2009-10	79.4 million
Small ruminant population	2009-10	137.4 million
Chicken population	2009-10	174.5 million

**FAOStat data calibrated based on Harvest Choice 2000 footprint. Figure includes crop area of only 10 crops (maize, millet, sorghum, cassava, rice, potato, soy bean, sugarcane, wheat and sweet potato).*

Source: FAOSTAT, Harvest Choice

Households in this mixed crop-livestock system typically integrate the growing of food or cash crops with parkland agroforestry and a pastoral-type of livestock production. Livestock activities involve cattle, sheep, goats, donkeys, camels and poultry. In places affected by long cycles of drought, there has been a shift from cattle to small ruminants as they are less costly, better adapted to drought, easier to feed and reproduce faster than cattle (Mortimore and Adams, 2001). The integration of crop and livestock enterprises pursued separately by sedentary farmers and nomadic herders has traditionally supported functional links through systems based on exchanges of grain, crop residues and water for manure. In these systems, livestock, rangeland, and cropland productivities are closely linked. During the dry season livestock graze on crop residues and manure enhances soil fertility for crop production. Rangelands and fallow lands provide livestock forage which transform to nutrients for cropland through manure. Livestock provide a source of food and income (milk and meat), draft power for field activities, crop processing and transport. They are also a self-reproducing asset used for savings, contingencies, and meeting social and religious obligations.

Box 3 A typical household of semi-arid Mali

In Mali, a typical household size is approximately 6-9 persons consisting of the family head with one or more wives, several children and a few extended family members (brothers and sisters). The farming system is extensive with dominant crops being millet, sorghum, groundnut, cowpea, cotton, rain fed rice and maize. Millet and sorghum are grown for home consumption. Overall climatic conditions are not favourable to crop production. In dry areas, the average farm size would be about 6.5 ha per household, of which about 4.5 ha would be under cereals (3 ha millet, 1.5 ha sorghum), 1.8 ha under legumes (0.8 ha groundnut, 0.7 ha cowpea and 0.3 ha Bambara nut), 0.2 ha under minor crops such as sesame. Cowpea is generally intercropped with cereals. Groundnut is cultivated as a sole crop in rotation with cereals. In more humid areas, farm size may be smaller (5.5 ha) because soils are more fertile and weed pressure is much higher. Main crops are sorghum (0.9 ha), maize, (0.6 ha) millet, (0.6 ha) rain fed and lowland rice (0.6 ha) cotton (2.2 ha). In Southern Mali cotton is the main cash crop with an average yield of 1.2 tons per ha. Women are generally more involved in lowland rice cultivation on plots of 0.25 ha average size. Mean yields of dominant crops are about 600 – 800 kg/ha for millet; 600 – 900 kg/ ha for sorghum; 1500 – 4000 kg/ha for rice and 1000 – 2000 kg/ha for maize. Legumes may be intercropped with dryland cereals and these will yield less than 500kg/ha. Vegetable gardens crops are cultivated on farms around cities.

Almost all households own some type of livestock. The average number of animals owned by a household may vary between 3 and 5 ruminants. In general small ruminants (sheep and goat) are important sources of income. Cattle and donkeys are the most important source of draught power. Typically livestock freely graze on communally owned lands. Rangelands are a major source of feed for cattle though this is supplemented by conserved fodder and cereal stover, cowpea and groundnut straws in the dry season. Sources of water for livestock during the rainy season would include rivers/ponds/dams and during the dry season boreholes and perennial rivers and wells.

Chickens are owned by more than 98 % of households with an average of about 15 per household. Sheep are more popular in the northern part of the country while goats are more common in the southern part. A rural woman generally owns some goats, sheep and chicken. A family member, either the son, daughter or husband may be engaged in non-farming activities such as carpet making, tailoring or small trade. Generally, per capita income of a household is far below the poverty line ($2 a day). Typical sources of income would include sale of non-agricultural products, crops and livestock, casual employment, remittances and regular employment. To meet typical household expenditures, a typical farmer would sell a sheep, goat or chickens but not cattle.

Poverty is widespread in the agro-pastoral system with 44.5 million poor people earning less than $1.25 a day. This represents the second largest population the poorest people among the farming systems of Africa. However, agro-pastoral societies respond rationally to the demands of their environment. Mobility in response to economic opportunities has opened them to the outside world and allowed them to react to labour demand in towns. Between 2000 and 2010, the total annual population growth rate in the system was 2.8%. Agricultural population grew relatively slowly at an annual rate of 1.6%. Demographic pressure on land and stagnating revenues from agricultural production severely limit prospects for further increases. This partially explains the significant rural to urban migration and relatively high annual urban population growth rate of 6% over the same period which is expected to continue growing in coming years.

As land becomes more limiting, livestock management practices based on transhumance and communal grazing and cropping systems based on shifting cultivation are rapidly transforming to more sedentary forms of mixed production (Powell et al. 2004). Relations between farmers and herders evolve and may range from complementarity to competition and conflict. As farming communities are exposed to the world economy through technical development interventions and an increasing household dependence on off-farm income and remittances, mutualistic relations weaken (Ickowicz et al. 2012).

At the same time, current trends of urbanization and increasing disposable income in urban areas are foreseen to more than triple urban demand in foodstuffs especially high value foods including dairy and meat in the next 40 years. Thus, a major challenge facing agro-pastoral societies is how to achieve sustained increases in crop and livestock production to respond to this growing demand. Farmland saturation should stimulate intensification with appropriate access to inputs, credit and technology as well as markets providing a return on investment. This implies optimized crop-livestock interactions, integrated soil fertility replenishment approaches combining the increase use of inorganic fertilizer in addition to animal manure, greater reliance on livestock feeds and veterinary products, a sustained agroforestry environment as well as conducive policies for the increased production of traditional food crops. **Table 3-8** further explores interventions to address these challenges.

One of the bright spots observed in this farming system during the past two decades has been the widespread farmer-to-farmer diffusion of regreening practices. Over five million hectares of farmer-managed natural regeneration of indigenous trees croplands has been mapped in Niger and Mali. Trees are cultured in the crop fields to provide biofertilisers for increased cereal yields, enhanced fodder production, fuel wood and timber, and other environmental services. This has been called the most dramatic positive environmental transformation recently seen in Africa.

The economic rationality of rural communities has weighed positively on the regional food balance. Before the recent food crises, FAO and Club du Sahel data show that per capita food availability and production (in kcal/inhab/day) in the Interior Sahel countries (Mali, Burkina Faso and Niger) rose over a period of 30 years. While food imports peaked during the drought years of the 1970s and 1980s, they were consistently held at 10% of the available food (Cour, 2001). National and regional public authorities also have a role in supporting local production and access to social services for rural populations through appropriate price and services policies. The current level of the Economic Community of West African States (ECOWAS) import taxes is among the lowest in the world, and prices of exported crops are not protected (Nubukpo, 2011) so that SSA countries were not able to shelter regional rural populations from food price volatility of market in the recent food crises. Food security is not only linked to climate risks or price volatility, but also to public regulations of goods and services (Janin et Suremain, 2005).

Table 3-8 Summary of strategic interventions fot Agro-Pastoral farming systems

Drivers of farming system evolution	Intervention	Implementers	Implications for farming system structure and function
Natural resources and climate	Promote individual and collective actions at watershed scale, multi-stakeholder transhumance corridor management, agroforestry parkland regeneration, water harvesting and anti-erosion designs, and field boundary plantings.	Extension; NGOs	Reduced resource use conflicts; increased system productivity and resilience
Human capital, gender and agricultural knowledge	Promote full literacy for boys, girls, and adults; reduce women's domestic burdens (water and firewood collection, cereal pounding) and promote education, health and economic diversification (poultry production, vegetable gardens, artefacts)	Extension; NGOs	Better managed labour bottlenecks; increased capacity and diversified income sources.
Energy	Scaling up of agroforestry interventions; promote alternatives to firewood in urban zones first; optimize crop-livestock synergies.	NGOs	Increased local supply of fuel wood and urban demand of fuel wood.
Technology and science	Optimization of crop and livestock associations (crop residues as feeds, manuring, animal traction, cross-financing). Intensification targeting improved production (improved cultivars, micro dosing, water harvesting, livestock feeds, veterinary products, etc.), institutional development and marketing; diversification (poultry, small fattening schemes, dairy, reproductive herds); build capacity and support technical and extension services and research.	NARS, NGOs, farmers groups	Optimised seasonal labour use; non-farm income generation; social ties with urban residents; improved farming system advice.
Markets and trade	Facilitate access to inputs (N P fertilizers, seeds, feeds, animal traction, and adapted implements); improve storage and processing of sorghum and millet; Promote Warrantage or inventory credit programs; facilitate development of farmer organizations; favour development of competitive intra-rural markets; market information systems.	Agribusiness; extension; NGOs	Realised potential for productivity increase; expanded demand for food crops; farmer ability to capture greater profits and meet pressing post-harvest expenses and engage in dry season income generating activities; reduced private sector costs of dealing with farmers.
Institutions and policies	Invest in infrastructure to link Sahelian and coastal states; free national and regional movement of goods and people; promote shifts in demand from unprocessed grains to processed food and from food grains to feed grains; gradually shift policy focus from subsidizing food staples (that reduce farmer income) to raising income of the urban poor; develop crop insurance programs; improve land tenure and access rights of pastoralists to rangeland resources.	Ministries, NGOs, NARS	Mobility of goods and people across the region; lower local vulnerability to crop failure; profitability and demand for traditional food crops increased resulting from available processed foods and feeds; reduced disincentives to invest in productivity increase; increased mobility and tenure security of pastoralists.

3.5 Highland Mixed Farming Systems: Focus for national growth and development

The Highland Mixed Farming System is found in the highlands of Ethiopia, Eritrea, western Cameroon and Lesotho and Angola (**Figure 3-5**). The largest part of the system is located in Ethiopia, where it occupies about 40% of the country's surface area, including some of the water towers of the Nile River. This farming system occupies 47.3 million ha of land area in the region and supported an agricultural population of 40 million in 2010. In Angola, the farming system corresponds to high plateaux lying to the east of the mountain range, including the Benguela Plateau and the Humpata Highland region of the Huíla Plateau, with altitudes rising to 2500 m asl. In Lesotho, most of the agricultural landscape, including the water towers feeding the economies of the surrounding countries is categorized under this Highland Mixed Farming System.

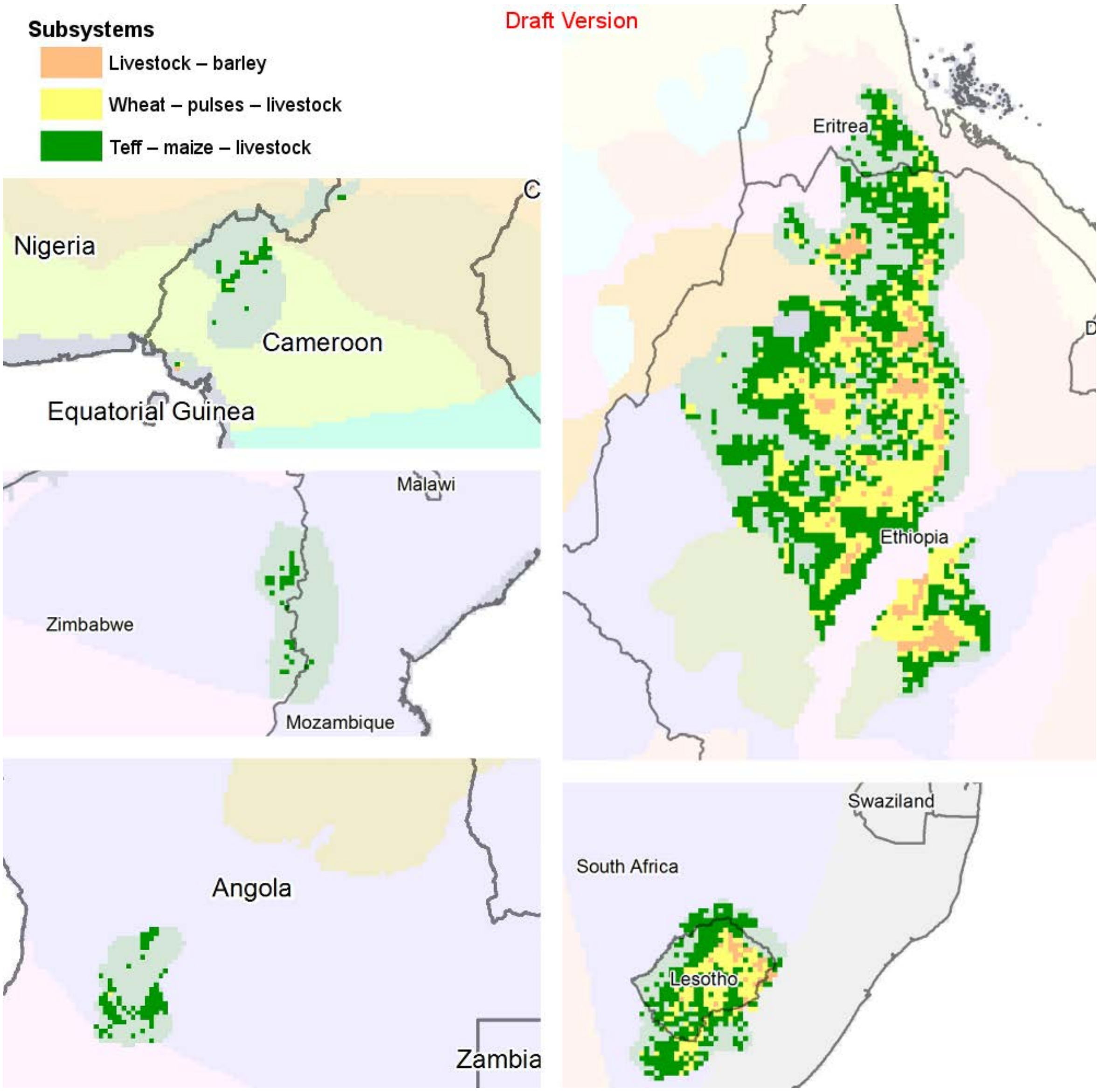

Figure 3-5 Highland Mixed farming systems in Africa

Source: See Acknowledgements

The system is classified as highlands with an altitude of above 1700 m above sea level and length of growing period ranging from 120 to 240 days. It is dominated by mountainous and rugged terrains with valley bottoms and steep farming practices. The system is constrained by poor market access, with about 7.4 hrs. required to reach the nearest town of 20,000 inhabitants. Annual rainfall ranges from about 600 mm in the relatively drier northern highlands of Eritrea, to over 2200 mm in the more humid highlands of Ethiopia and Angola. The highlands are characterized by mild temperatures (18-22°C) in the lower elevations and 10-12°C in the higher elevations (> 3,000 m asl). The basic statistics related to the system are listed in **Table 3-9**. Due to their cooler and humid climate, their role as water towers, relatively good agricultural potential and lower incidence of pests and diseases affecting both humans and livestock, the highlands are preferred ecosystems over the lowlands, and attract a high population density. They represent hopes for national growth and development. Three subsystems are recognized (

Table 3-10).

Table 3-9 Basic systems data: Highland Mixed farming systems

Data item	Data year	Data
Total human population	2010	56.6 million
Rural population	2010	43.5 million
Agricultural population	2010	40.0 million
Females active in agriculture	2010	9.0 million
Total area	2000	47.3 million ha
Length of growing period (LGP)	2012	193 days
Market access (to town of 20K inhabitants)	2005	7.4 hrs.
Cultivated area*	2009-2010	4.0 million ha
Irrigated area	2000	0.17 million ha
Cattle population	2009-10	27.4 million
Small ruminant population	2009-10	29.5 million
Chicken population	2009-10	35.4 million

**FAOStat data calibrated based on Harvest Choice 2000 footprint. Figure includes crop area of only 10 crops (maize, millet, sorghum, cassava, rice, potato, soy bean, sugarcane, wheat and sweet potato). Source: FAOSTAT, Harvest Choice*

Table 3-10 Main characteristics of subsystems of the Highland Mixed farming system

Subsystems	Biophysical characteristics (elevation (E), rainfall (R), LGP)	Structure (crops, livestock)	Key features
Livestock-barley sub-system	E: >3000m R: >2000mm LGP: 180-240 days	Barley, potato and wheat. Cattle, sheep and equines	Low crop diversity; limited fertilizer use; strong importance of livestock; land degradation; limited off-farm income; remoteness; low market infrastructure and institutional support; highest food insecurity.
Wheat-pulses-livestock sub-system	E: 2300-3000m R: 1200-2000mm LGP: 120-240 days	Wheat, barley, faba beans, oats, potato, peas, lentils and flax. Cattle, less equines and shoats	Higher crop diversity; increasing fertilizer use and mechanization; increasing market orientation and diversification; better institutional support.
Teff-maize-livestock subsystem	E: 1700-2300m R: 800-1300mm LGP: 120-180 days	Teff, maize, wheat, faba beans, chick peas and beans. Cattle, shoats, equines.	High crop diversity; common fertilizer use; declining livestock due to feed shortage; high population density; Ethiopia's bread basket; fruit and vegetable growing; most advanced intensification and market orientation levels.

A high population growth rate and associated increase in food demand has led to agricultural area expansion placing pressure on forest areas. In Ethiopia, land has remained state-owned for the past four decades, and farmers have only usufruct rights, resulting in a disincentive to land investment and significant resource management. These two factors as well as the mountainous nature of the system have contributed to significant land degradation and soil erosion, and impede substantial agricultural productivity increases. Twenty-five percent of the highlands are considered as seriously eroded. However, aggressive sustainable land management government programs, including construction of terraces and water harvesting structures, rehabilitation exclosures of degraded landscapes as well as watershed management schemes have been implemented. Results have been mixed, but those using incentive mechanisms including food-for-work arrangements, safety net programmes as well as negotiation with local communities for free labour, the development of local bylaws and enforcement mechanisms have had positive impact. Success stories need to be replicated to the wider highland communities, and an emphasis is also needed on integrated rainwater management at landscape scale to reduce water losses and increase the water productivity of agricultural enterprises (Amede, 2012). A land certification program through decentralized elected Land Use and Administration Committees has made a step in the right direction for addressing concerns about tenure insecurity. Ninety-four percent of energy comes from wood fuel. Because of scarcity, cow dung is increasingly used as fuel, thus not replenishing soil fertility. Alternative energy sources including electric grid connectivity and local wind and solar energy production are recommended in addition to increased biomass at farm and landscape levels.

Box 4 Wheat-pulse-livestock based farming sub system in the Northern Ethiopian highlands

Bulti has a family of 7 and a farm size of about 1.8 ha, where he predominantly grows wheat and barley in rotation with pulses such as faba beans, field peas, lentils and oil crops. The fields are dispersed and allotted for different crops, including 40% of the cereal area to wheat during the (long rains) Meher growing season. He owns 6.2 livestock including oxen, cows, donkey, horse and shoats. He uses oxen for ploughing and threshing while transport of produce is either by donkey or mule. High input costs and decline in soil fertility are major constraints. He experiences food deficit once in three years for a month or two and fulfils the deficit by selling livestock, retail trading or through food aid in the worst years.

The major source of growth of cereal production in the last decades was due to expansion of cultivated area. However, since 2000 area expansion has slowed down to about 3% per year while crop yield has increased by about 7% per year, partly due to a steady increased use of fertilizers which continues to be supported by recent government policy (Spielman et al., 2009).

The use of improved seed and inorganic fertilizers has increased significantly yet with inconsistent results, which may be due to intermittent policy changes and the shifting roles of the public and private sector (EEA, 2000). State support in the form of direct fertilizer subsidy or facilitated access to financial credit is advocated. New varieties of maize, wheat, barley and teff developed by the national and regional research systems yield up to 3 times more than local germplasm. However, their high cost and low availability constrain uptake or do not reach their full potential because farmers cannot apply the required fertilizer inputs and agronomic practices. Seed systems linking community seed growers and commercial seed producers need improvement. Similarly, the use of improved livestock breeds is low.

While small-scale farmers are keen to intensify and diversify their subsistence production systems, they are currently constrained by limited access to input, output and credit markets. Some of those at close distance from markets have diversified their cereal-dominated systems into higher-value enterprises including fruits, livestock fattening, honey and vegetables. However, participation of the majority is small. Infrastructural investment for better road connectivity will link surplus producers to demand, allow the commercialization of diversified marketed products including perishables and off-farm employment, and stimulate better farmer group organization and lower transportation costs. A summary of strategic interventions is presented in **Table** 3-11 to address challenges experienced in the Highland Mixed Farming System.

Table 3-11 Summary of strategic interventions for Highland Mixed farming systems

Drivers of farming system evolution	Intervention	Implementers	Implications for farming system structure and function
Population, poverty, hunger	Continue to support population policies targeting lower fertility rates, higher use of contraceptives, lower morbidity and mortality rates, human welfare and education on family size.	Ministries, NGOs	Relations between increasing population and resource use and national economy.
Natural resources and climate	Institutionalize soil and water conservation structures and exclosure of degraded landscapes; landscape-scale integrated rainwater management; replicate local successes in integrated watershed management using combination of strong national policy, external donor support, and local buy-in.	Farmer groups, NGOs, Ministries	Water losses reduced and increased water productivity of enterprises.
Human capital, gender and agricultural knowledge	Increased access to elementary and secondary schools	Ministries	Increased human development.
Energy	Promote alternative energy sources (electric grid connectivity and local wind and solar energy production); promote regreening of hillsides, gullies with agroforestry; increase farm-level biomass production through use of inputs, irrigation and agronomic practices.	NGOs, NARS, farmer groups	Reduced negative impact of energy crisis on food production (deforestation, farmland degradation).
Technology and science	Potential in re-afforestation, SWC, irrigation, upscaling, biotechnology;	Farmer groups, NARS, NGOs	Support agricultural transformation; landscape rehabilitation.
Markets and trade	Better road connectivity for market linkages; support of community seed systems and linkages with private sector; provide credit access for fertilizers; experiment with crop and livestock insurance.	Ministries, NARS, private sector	Increased market participation (high-value perishable products), off-farm employment, agricultural knowledge flows; strengthening of farmer cooperatives; easier access to rural credit.
Institutions and policies	Develop and enforce land use policy to control free grazing; encourage private-sector commercial mechanized agriculture.	Ministries; private sector.	Disincentive to improved farm management alleviated; improved production efficiency and market linkages.

4 Common challenges and policy implications across farming systems

Farming systems are not static: they are continuously evolving. Part of the change is visible, but part is the invisible change of internal economic and biological relationships which build up pressure for change – the pressure points can be identified by careful analysts and the associated changes anticipated. The path dependency of farming systems evolution is one important reason to classify and analyse current farming systems. In fact many of the changes can be anticipated after analysis of the farming systems.

Ultimately, the key is how the drivers effect farm household decisions to change practices, adopt new crops or livestock, and market the produce in different ways. There is a hierarchy of drivers. External drivers, e.g., international consumer preferences, global agribusiness decisions, information technology, are mediated through intermediate variables at different stages along market and policy chains until eventually they reach the farm gate. An example would be international or urban demand which influences farmer decisions via local markets. In a similar way, infrastructure per se does not influence farmers' or business decisions, but rather the costs of transportation or storage affect farm gate price (and risk) and thus shape farmers' decisions.

We identified seven drivers which shape the development of farming systems in the region:

- Population, food security and poverty
- Markets and trade
- Natural resources and climate
- Energy
- Technology and science
- Human capital/knowledge sharing/gender
- Institutions and policies

The following sections highlight some of the key implications for policy to be drawn from the farming systems analyses.

4.1 The Population Explosion: Food security, poverty, and land

People lie at the heart of sustainable development and farming systems options, and very rapid population growth is dramatically shaping the possibilities and the limits of farming pathways in all parts of the continent today. This is a very recent phenomenon. Humankind first evolved in Africa. For hundreds of thousands of years, the population growth rate was infinitesimally low, and has been estimated to be no more than 0.00001 percent. From Africa, *Homo sapiens* emerged to spread to all other parts of the world about 80,000 years ago. At that time, there were an estimated 1 million humans in all of Africa. By AD 200 the sub-Saharan African population had increased to some 10 million. By AD 1500 it was about 20 million, and was seen to be fulfilling the potential of the environments that people occupied (Reader, 1999). Meanwhile, the out-of-Africa population had risen to over 300 million. Thus, even a century and a half ago, at the time of European exploration, Africa's population was quite small, particularly in comparison to other parts of the world.

During the past century, however, and particularly during the past 50 years, Africa's population growth rates have accelerated tremendously, and became the highest in the world. SSA now has 850 million people and is projected to be over 2 billion by 2050. The aggregate effects of this population explosion impinge upon all aspects of development. Many factors have influenced this remarkable transformation. These include the advent of more effective peace among peoples, improved health care, and the better management of food crises during times of famine. These successes have, however, also helped create the difficult situation of ensuring enough employment, food, and income for a rapidly growing and youthful population.

Decisions on family size are made, and always have been, at the level of the household. Labour for agricultural work had always been the all-important limiting factor to increased prosperity at the household level, because abundant land was generally available. Thus, having as large a family as possible was the rational approach to follow. A high female fertility rate has thus been historically embedded in cultural attitudes.

The big change that has recently disrupted rural society in many farming systems across the continent has been the abrupt closure of the land frontier. Suddenly, within a generation or two, abundant land has disappeared. Families (and communities) that had generally always had access to local sources of uncultivated land have found that expansion is no longer possible. Families that had successfully raised six or more children no longer were assured that more than one or two of them could live off of the family farm. The majority of sons and daughters would have to find off-farm employment to sustain themselves and their own young families. But with inadequate or no education, they found themselves competing with a massively growing population of other offspring who found themselves in the same situation.

Urban populations have expanded due to rural displacement. The highland perennial farming systems of eastern Africa, described above, are a classic case of the build-up of extreme pressure on the land, even under comparatively favourable agroecological conditions. But the pressures are by no means confined to this farming system. They are also prevalent in the highland mixed farming systems of Ethiopia, the vast maize-mixed farming systems, and even the agropastoral systems of the severely climate-constrained drylands (see **section 3** above).

This process has happened so rapidly that governments have been unable to accommodate it effectively. They have struggled to expand the availability of schooling, health care, and other infrastructure in the face of this a demographic explosion. Meanwhile, there has been a lag effect in the cultural mores governing family size at the household level. Whereas, in urban environments there has been a transition toward smaller family sizes, in the rural areas such a transition has hardly begun.

The rural household’s path to social security had always been to have many children, who were then able to farm an expanding family homestead, or to establish themselves on other properties in the neighbourhood. Suddenly, the new path to such security is limited to educating a small number of children, the majority of whom will find their own way in an extremely competitive job market. This shift is occurring in one or two generations, that is, in the blink of an eye in historical perspective, making it an exceptionally challenging transition. Rural family sizes are only beginning to respond to the new realities.

Asia experienced a similar population explosion and food security crisis forty years ago. To the surprise of most observers, it has responded to it rapidly and definitively. Female fertility rates plummeted during recent decades all across Asia, providing clear evidence that it can occur on a vast scale. Rapid economic growth has played a role in inducing smaller family sizes, and in cushioning the process of making the transition. But pro-active government support for family planning services has also been instrumental.

For example in Bangladesh, the world’s most densely populated country, and one of its poorest, until recently economic growth rates were paltry at around 2%. But since independence in 1972, its government recognized the positive role of reduced population growth rates would have on its human development, and supported family planning vigorously. Birth control was made free of charge, and rural health workers and clinics were staffed and provided family planning services. The fertility rate has plummeted, from

6.3 children per female, to 2.3 during this 35 year period. This remarkable feat has contributed to a vast reduction in rural misery, and a much more rapid rate of per capita growth. The future narrative of Africa's farming systems will be influenced enormously by how fast rural population growth rates can adjust to the new realities of extreme land scarcity.

4.1.1 The lower limits to farm size, agricultural commercialization, and land acquisition.

As discussed in **section 3.1** above, the Highland Perennial Farming System is experiencing an extreme interaction between population growth and declining farm sizes. However, parts of many other farming systems are now also experiencing fairly extreme circumstances of farm size collapse, and the attendant stresses that they have occasioned. This includes the cases of the Highland Mixed System in Ethiopia, the Maize-Mixed Farming System in Malawi, and even segments of the Agropastoral System in south-central Niger. In large swaths of African agriculture, the average the family farm has declined to a truly marginal size. The densest populations of under-nourished people are associated with farming systems where farm sizes are smallest **(Figure 4-1)**.

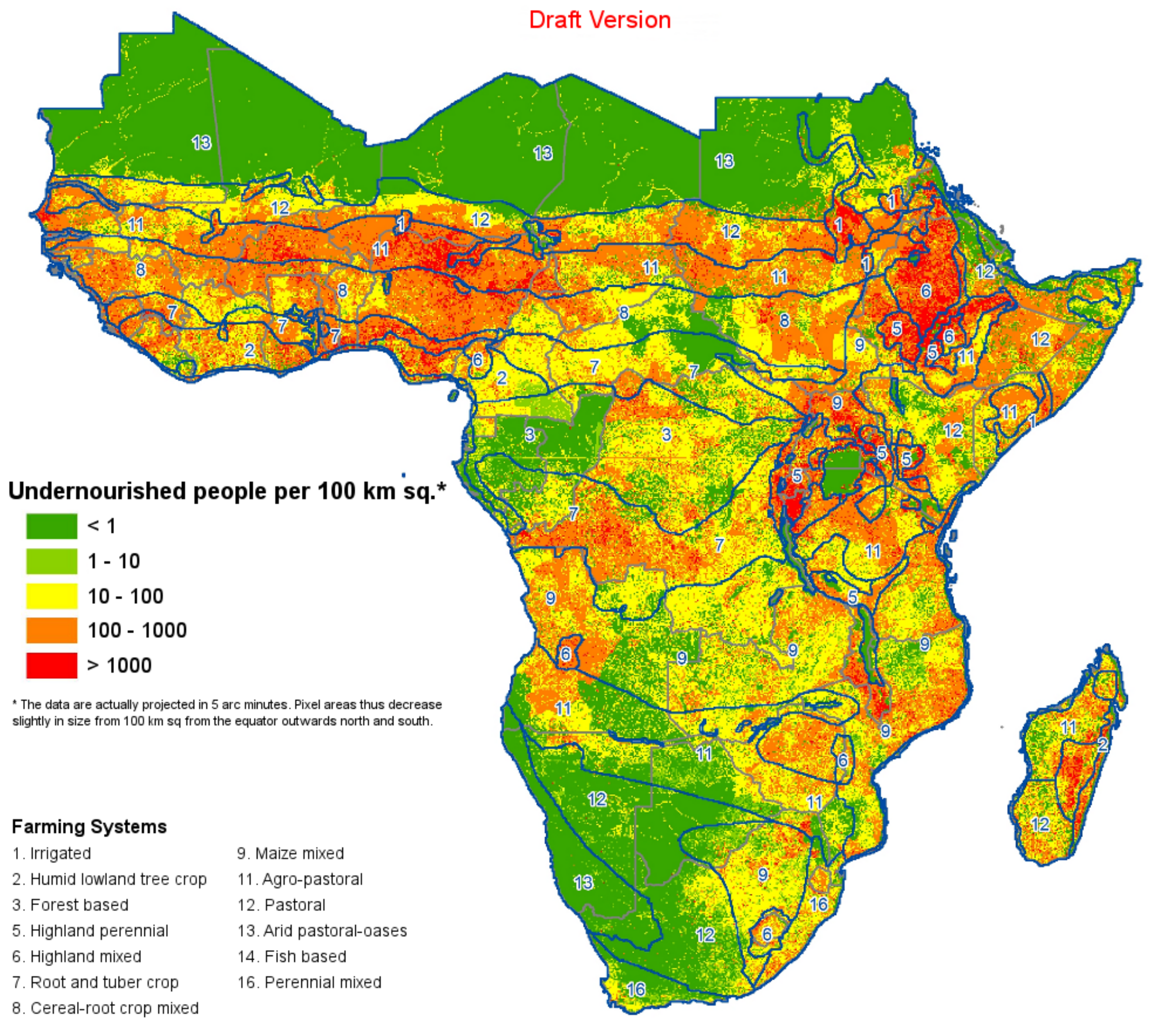

Figure 4-1 Map of the density of undernourished people by farming system.

Source: See Acknowledgements

4.1.2 Large Scale Corporate Farming

The implications of smallholder farm size cannot be discussed without touching on the issue of foreign investment in land and commercial farming in Africa, a phenomenon that has burst into policy debates with great force and impact since the 2008 food price spike. The vast majority of land acquisition by foreign entities in Africa has been driven by two objectives (Schoneveld, 2011):

- the production of biofuels for the European market, mainly by European investors
- the production of food crops for transhipment to food deficit countries to help ensure their food security in an uncertain global food marketplace, mainly by Middle Eastern and South Asian countries.

The momentum underlying the first objective has been undercut by recent changes in the European Union's biofuels policies, resulting from a re-evaluation of the net carbon benefits of such production and utilization systems. Realizing the second objective is dependent upon constant producing food in Africa and transhipping it to the investing countries. It is also influenced by the opportunity costs of ramping up investment in direct food production in Africa versus investing in increasing food production in the host country itself.

Currently, the investing countries have little experience in the realities of producing food in the often remote locations where they obtained land. As with the infamous failed British Groundnut Scheme in the early 1950s, there are bound to many surprises. These include: Greater than expected crop yield fluctuations due to climate variability, and eventually, climate change itself; greater than expected challenges in managing the local soils with mechanized systems (e.g. problems with soil capping and setting phenomena), and unanticipated crop disease and pest outbreaks. These, and the sheer scale of the necessary sunk capital investment needed in developing the basic infrastructure (farm roads, communications, etc.) are all factors whose difficulties and costs are often underappreciated.

For the host African countries, the economic benefits of such investments may be over anticipated as well. The major presumed positive benefits are improved economic multipliers in the input supply markets for the schemes, expansion of the transport systems and an attendant reduction in commodity transport costs in the area, and more jobs for local people. But these may be offset to a considerable degree by the increased social tensions that arise with the inevitable displacement of local populations and the opportunity costs of public sector investments by governments that will be required in order to attract and support the schemes.

The experience of the Asian rice-growing countries during the dramatic food price spike in the early 1970s might be instructive. At that time, it suddenly looked attractive from a business perspective for companies to engage in their own rice-growing operations. In the Philippines, this was further stimulated by the Government's decision to have all companies with more than 500 employees produce rice for their employees. Hundreds of rice schemes were launched, but a decade later very few of them survived. As rice prices settled nearer to historical levels, and as many companies experienced difficulties in growing rice commercially on a big scale, it became obvious that corporate rice production was less attractive than earlier thought. To the surprise of the corporate sector, the smallholder food production sector had proved to be competitive. Large-scale production of rice and other basic food commodities has never become a significant segment of the overall food production system in Asian countries[4]. Could this also be the fate of the current fixation on large-scale food production systems in Africa?

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[4] *This situation does not necessarily apply to large-scale commercial perennial plantation crops, such as tea and oil palm. There has been much greater historical success by multinational corporations in sustained*

There is a type of commercial food crop farming that has been reasonably successful in the African context. That is the medium-scale family-operated commercial farm, typical of South Africa, Zambia, and Zimbabwe prior to land reform. These, however, are family farms that operate as a livelihood as well as a business. They are farming operations with a long term investment horizon. Stimulating the evolution of medium-scale commercial family farming operations, where land availability and other factors are suitable, would thus seem to have clear advantages for countries with these conditions in abundance, such as Mozambique and Zambia, among others.

Growth Corridor approaches are now being implemented in a number of countries, where it is presumed that the conditions exist for larger-scale farms to be developed in association with the small-farm sector. Such experiments are being proposed or implemented in southern Tanzania's maize-mixed farming systems domain, in northern Mozambique, and in northern Ghana's cereal-root and tuber crops farming systems. Development partners such as USAID and AGRA are heavily engaged in supporting these developments. Their performance will be watched carefully by many other countries in the coming years as to whether such models are a suitable approach to stimulating dynamic agricultural growth in these areas.

The attraction of this model of agriculture is based on the confidence that there will be a trickle down benefit to the much larger pool of smallholder agriculturists. But this is dubious if the smallholders in the neighbourhood themselves obtain no respite from the basic limitations of land, labour, knowledge ad capital.

4.2 Natural Resource Management Challenges

4.2.1 Land Degradation

A recent time series analysis of remote sensing images between 1981 and 2003 revealed that biomass productivity has been declining on a huge scale in Africa (**Figure 4-2;** Bai et al 2008). Large swaths of southern Africa are affected, particularly in the Maize-Mixed Farming Systems (no 9 on the map) in Zambia, Angola, DRC, Mozambique and Tanzania. There was also intense degradation in the Forest-Based Systems in the countries of the Congo Basin. Much of this loss of biomass productivity is due to forest clearing for agriculture, in addition to reductions in the productivity of land previously cleared for agriculture.

investment in plantations of these export commodities, particularly in Asia, because processing facilities must be available in the local area. Rubber plantations used to be a major investment area for multinationals also, but more recently there has been disinvestment in rubber in favor of investment in buying the raw material from smallholders and processing it centrally into rubber products. Thus, rubber has become another commodity in Asia where the smallholder producer has moved to dominate the production system.

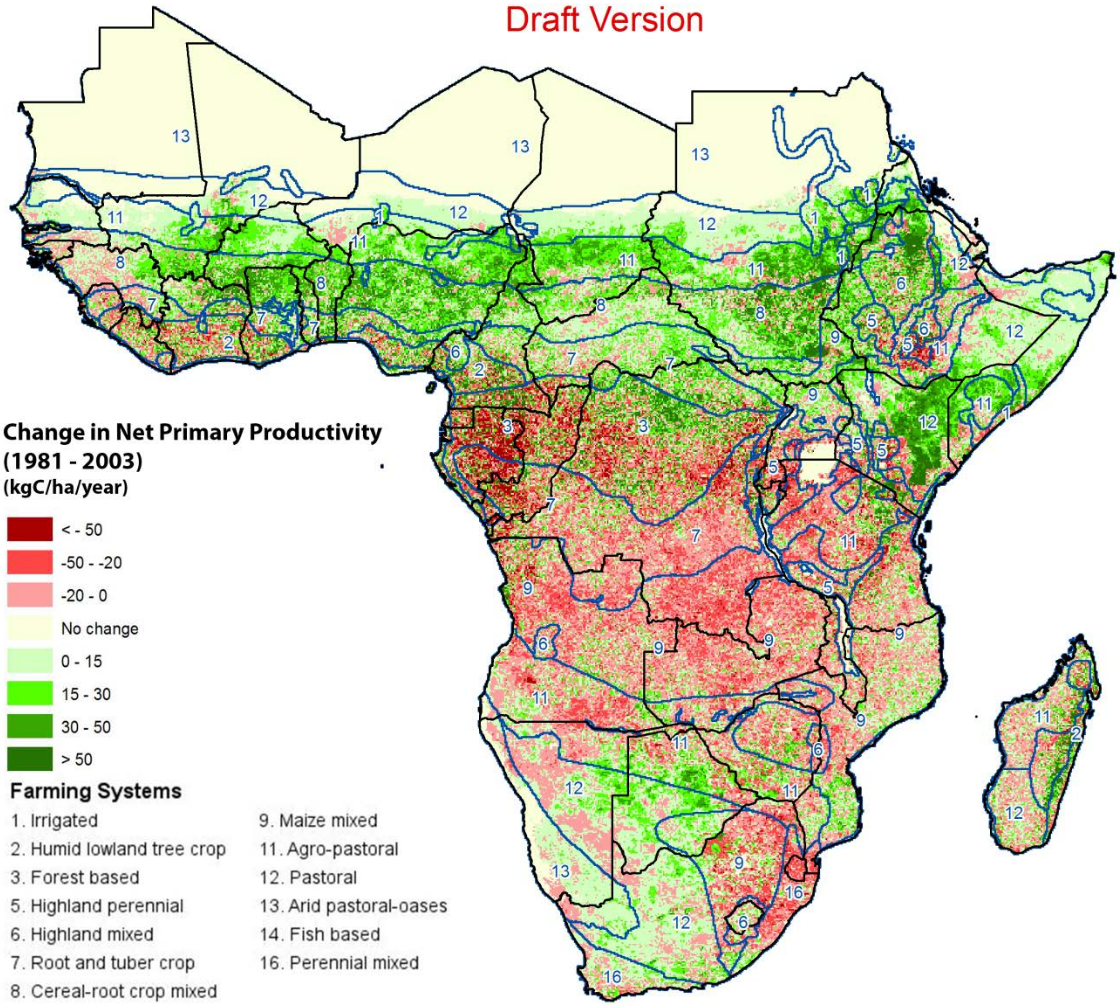

Figure 4-2 Map of the trend in biomass productivity by farming systems in Africa.

Source: See Acknowledgements

The amount of land subject to degradation is shown by farming system in **Figure 4-2.** Earlier estimates indicated that approximately 65% of agricultural land in SSA is subject to degradation (UNEP/ISRIC, 1991; GEF, 2003). These trends are worrisome, considering the imperative to increase agricultural yields in the future. However, the degradation trends are not ubiquitous. Biomass productivity in some parts of West Africa had an increasing trend during the two-decade period, particularly in the Agropastoral and Cereal-Root and Tuber Crops Farming Systems. This may have been due to the emergence of these zones from the devastating drought period of the 1970s and 80s. But there has also been a widespread farmer-managed regreening in parts of the Sahel (Reij et al 2009) and in the Ethiopian drylands (Highland Mixed Farming Systems) during this period, managed by farmers as low cost land improvement for multiple benefits. The costs of taking definitive action to reverse land degradation are often only a small fraction of the costs of inaction on farmers and society. The costs of farmer regreening in Niger were recently estimated at 10 percent of the costs of inaction by IFPRI (2011).

4.2.2 Soil Fertility Replenishment.

Reversing the trend of soil fertility depletion, which governs the biomass index and agricultural productivity, in all African farming systems, has become a major development policy issue on the continent. Resting or fallowing exhausted cropland for several years had always been the means by which African farmers restored the fertility of their soils

(Allan 1965). But as rural populations have grown, and farm sizes decreased, fallowing is phased out in most farming systems. The vast majority of farmers are now forced to crop their fields continuously. Farm yard manure supplies are also declining in many areas, because livestock numbers cannot be sustained because the community grazing lands disappeared. Thus, recent surveys have highlighted that yield decline due to soil impoverishment has become a primary concern for smallholder farmers across a range of countries (Bunch 2010).

Farmers are aware of the need to improve soil fertility, and they allocate the various sources of nutrients available to them among their crops and soils according to their differing needs and expected returns. As population density rises and land becomes scarcer, they find it more worthwhile to invest labour in sustaining and improving their soils, and to purchase fertilizers. Crop-livestock interactions are of great significance for maintaining soil nutrients, even in farming systems with the highest population densities (see for example, section 3.1 on the importance of cattle in Highland Perennial Systems). Culturing fertilizer trees in crop fields is also becoming increasingly popular as a component of integrated soil fertility management (Garrity et al 2010). However, the extent to which households invest labour and cash on soil fertility depends on their opportunity costs in making investments to recycle or generate more organic nutrient sources on the farm, or to purchase inorganic fertilizers from the market. Unfortunately, the farm gate cost of fertilizers relative to crop prices is low in Africa, particularly for food crops. There is also the capital risk of applying fertilizers. As a result, more than 3 out of 4 farmers do not use fertilisers.

4.2.3 Public intervention in soil fertility management.

Public intervention should be targeted at soil degradation where farmers' own private initiatives, and the markets, are failing to reverse a decline in potential productivity. There are many parts to this puzzle. These include improving poorly developed input markets, combined with better road and distribution infrastructure; active encouragement of agro-dealer networks and enhancing farmer associations' ability to purchase inputs in bulk at lower prices; accelerated provision of agricultural credit for smallholders; streamlining fertilizer importation processes; making fertilizers available in smaller-sized bags; and in some cases fertilizer subsidies (see**Box** 5). But the right mix of interventions depends very much on the local context, particularly between high potential areas and remote dryland areas. A mixed strategy to assist farmers to improve soil fertility would combine organic and inorganic nutrient sources, depending on their access to labour, cash, livestock, trees and credit. Inevitably, such a strategy is more intensive and tailored to local conditions, and requires sensitivity in understanding how farmers' adapt their systems over time.

Box 5 Malawi's Journey from Fertilizer Subsidies to Sustainability

During the 2004–2005 maize-growing season, drought had a devastating effect on maize yields in Malawi. The national average yield dropped 40%. By November 2005, five million Malawians or 38% of the population needed food aid (Famine Early Warning Systems Network 2007). In the face of this crisis, the Government launched an input subsidy program that has generated large surpluses and improved rural welfare. This success caused a surge of renewed interest among African governments in fertilizer subsidies as a vehicle for enhancing food security. However, in Malawi itself, the recurrent costs of the program contributed to the recent bankruptcy of the country, which was associated with massive economic difficulties, and the fertilizer subsidy program is now being scaled back. But an alternative strategy for the long term is now taking root. . The Malawi Agroforestry Food Security Program has been assisting farmers to deploy biofertiliser trees on about 200,000 farms across the country. They have doubled farm yields and complement the use of inorganic nitrogen fertilizers. Ways are currently being developed to link the fertilizer subsidies with these EverGreen Agriculture investments to provide for long-term sustainability in nutrient supply, and to build up soil health, inducing a *'subsidy to sustainability'* pathway for integrated soil fertility management (Garrity et al 2010).

4.2.4 Trees and Forests.

Currently, forests cover approximately 660 million ha in Africa (almost 27 percent of the land area). The current annual deforestation rate is 0.16 percent and the decline in forest area is expected to continue. **Figure 4-2** highlighted the scale of forest clearing, particularly in the Congo Basin and Southern Africa. Farming systems that are most closely linked with deforestation are the Forest Based System, the Tree Crop System, the Root Crop System, and the Cereal Root Crop Mixed System. Currently, the Maize Mixed, the Highland Perennial and the Highland Temperate Mixed Systems are experiencing particularly acute fuel wood shortages.

As forests disappear, a countervailing development factor is the maintenance or regeneration of trees on agricultural lands. This is particularly significant in Africa, where farmers historically sustained medium to high densities of trees in their cropping systems. **Figure 4-3** shows the percentage of tree cover on farmlands (Zomer 2009). Trees are retained or established for many purposes, but particularly to provide a source of livestock fodder as community grazing lands are depleted, a source of fuel wood and timber for home consumption and sale, a source biofertilisers to sustain soil fertility (particularly leguminous trees such as *Faidherbia albida)*, as well as fruits, leaf vegetables, medicinals and other products, and local environmental services (Garrity et al 2010). The recognition of these multiple co-benefits has stimulated increasing interest across the continent in the upscaling of these EverGreen Agriculture systems (ICRAF, 2012). They are particularly important in the agropastoral systems of the Sahel where young agroforestry parklands have been recently mapped on millions of hectares (Reij 2009).

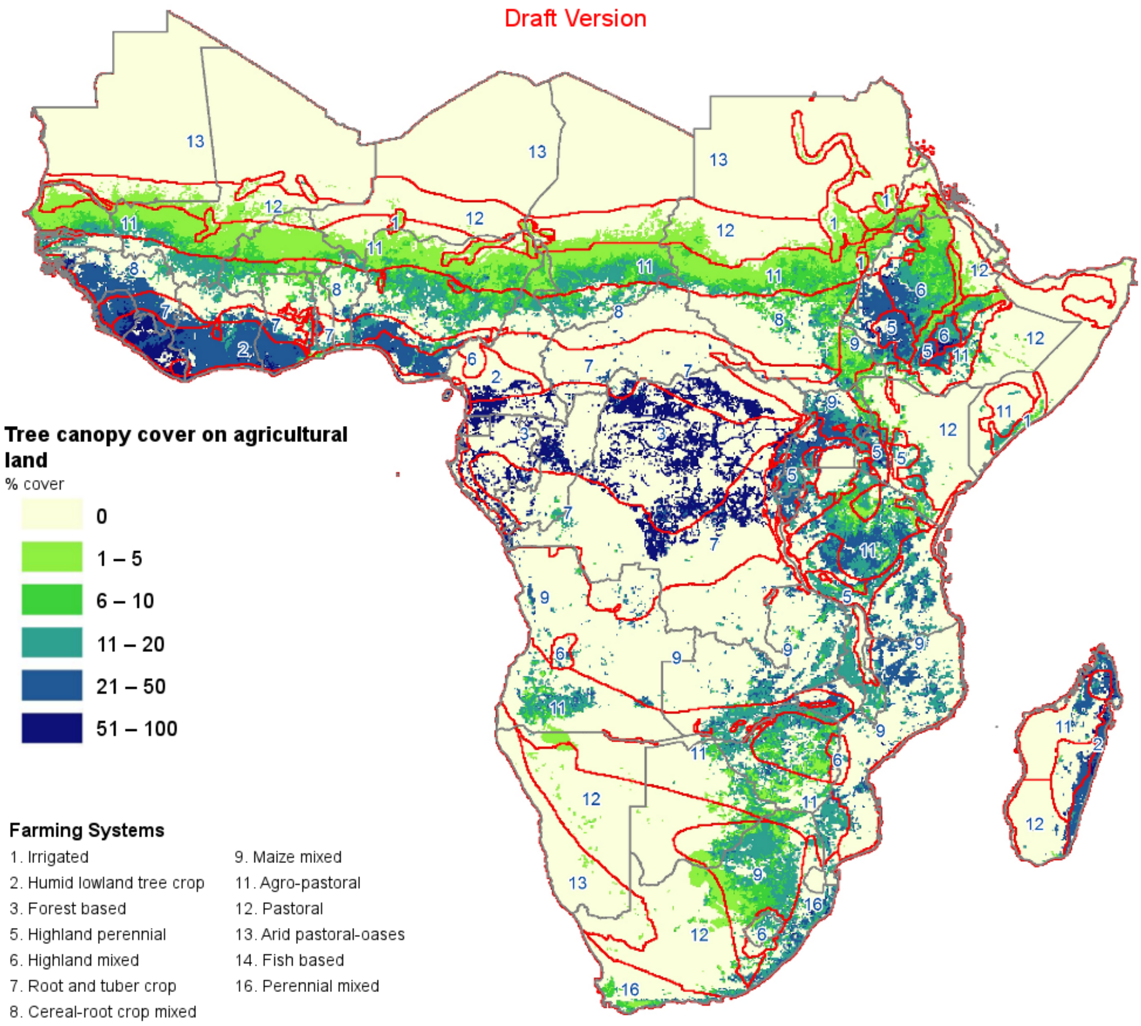

Figure 4-3 Map of tree cover in Africa by farming system.

Source: See Acknowledgements

4.2.5 Water Management.

Irrigation holds great potential for agricultural growth, food security and poverty alleviation in Sub-Saharan Africa (SSA), but its contribution to date has been constrained by lack of investment and the poor performance of existing public sector managed large-scale irrigation schemes. SSA's agricultural water resources are underutilized with only 7.2 million ha of land equipped for irrigation in 2006, representing just 3.2% of the total cultivated area of 225 million ha, and less than a fifth of the estimated physical potential of about 39 million ha. Pavelic et al. (2012) and MacDonald et al. (2012) have shown evidence which indicates that groundwater is also a widely distributed store of freshwater in Africa.

Over the 45-year period between 1961 and 2006, about 3.7 million hectares of new irrigation was developed, an average growth rate of 1.6% per annum. With few exceptions, however, large-scale public investments in irrigation have often failed, despite millions in large public schemes for surface irrigation. The usual result has been a scheme developed at costs much higher than originally estimated, then poorly operated, and yielding a miserable return. If there is one reason these schemes fail, it is that they try to change too much too quickly in complex systems, and they almost inevitably run into a series of unforeseen obstacles (Adams 1991; Movik et al 2005).

There are, however, other options to improve the capture and utilization of water in agricultural systems that deserve much more attention, particularly smaller-scale activities in field water management. Many smallholder farmers engage in irrigation without government support, using their own resources to procure irrigation equipment (buckets, pumps, drips, pipes and sprinklers) either individually or in small groups. They access water available from shallow groundwater, rivers, lakes, reservoirs, farm ponds, and abandoned or under-performing public irrigation schemes. This smallholder farmer-driven spontaneous irrigation has proved to be successful, affordable, and adaptable and is it spreading rapidly. It provides significant direct and indirect benefits to poor farmers.

In addition, rainwater harvesting technology can be applied at the farm or community level across wide areas, particularly in dryland areas with little or no groundwater or surface water potential. This includes the deployment of simple field-scale techniques for capture and storage of rainwater. Conservation agriculture with trees is a noteworthy system to enhance soil water availability for crops (see **section** 3.3 above on Cereal Root and Tuber Crops farming systems).

The key water management lesson of the past half-century is that the development of irrigation solutions for Africa's farming systems are much more diverse than has previously been emphasized, and that tailored solutions to local conditions are the pathway to accelerating the spread of irrigation benefits to millions more smallholder households across the continent.

4.3 Markets and Trade

Alongside the growth in consumption requirements, demand from the international market was, for much the last century, the clearest stimulus to agriculture. But the share of produce going for export has declined over time. The volume of most of the traditional exports (cocoa, coffee, cotton, sugar, tea, tobacco, etc.) has increased absolutely, but usually more slowly than the growth of world agricultural trade. There have been some instances of lively growth of exports, for examples cotton from francophone West Africa, horticulture and floriculture from Kenya, and fruit and wine from South Africa (Toulmin and Guèye, 2005).

For much of the 1980s and 1990s, a uniform view dominated donor thinking about agriculture in Africa. Washington Consensus policies, promoted aggressively by the international financial institutions, focused on "getting the state out" and "getting prices right". These ideas translated into policies of market liberalisation, including parastatal abolition or commercialisation, and removal of input subsidies. Many countries resisted these reform packages, by phasing their implementation, or indulging in bureaucratic foot-dragging. But, with few exceptions, agricultural reforms based on "market fix" thinking were implemented across Africa (Ponte 2002).

The consequences for African farming systems and rural livelihoods have been highly variable. However, over two extended periods in the twentieth century, one from the start of the century until 1929, the other from the late 1940s until the early 1970s, African agriculture grew well ahead of population growth. In both periods strong demand for exports of tropical products was a driver, and both ended when primary commodity prices fell. Since the early 1970s episodes of notable growth have been less general, being specific to particular crops and regions, and were sometimes short-lived. A few examples are rice in the inland delta of the Niger (Diarra *et al.* 1999), open pollinated varieties of maize in the middle belt of Nigeria (Smith *et al.* 1993), maize and cotton in Zimbabwe (Eicher 1995; Poulton *et al.* 2004a), horticultural exports from Kenya (Minot and Ngigi 2003), and peri-urban production of dairy, fruit and vegetables for the city of Kano (Mortimore1993). Thus, in some places, certain (mainly export) crops have enjoyed production and income gains.

In Kenya, horticulture has been an economic success. In West Africa, cocoa smallholders saw significant growth for many years, cotton has grown strongly in parts of the Sahel, and livestock exports to the Middle East have been expanding. For those who are well connected to effective markets, and have products to sell for good prices, liberalization has had positive impacts. But commodity price shifts and cycles, and growing competition from elsewhere have presented serious problems. The challenge of producing cotton competitively has proven enormously difficult for Sahelian producers, in a market where US competitors have received vast subsidies (Watkins and Sul 2002).

In Africa's rural hinterlands, where most poor farmers live, the story has been even less positive. The deleterious terms of trade for export commodities from the more remote highlands in the Albertine Rift countries in eastern Africa, as compared to the more accessible areas in Kenya, was highlighted in the Highlands Perennial analysis above. In the maize-based farming systems in Zambia, some farmers have diversified into cash crops (particularly cotton) in some provinces, but in others they have reverted from maize production to subsistence farming, and are worse off after agricultural liberalisation than before.

The consequence has been increased livelihood vulnerability. Thus, for a variety of reasons, the gains from liberalisation in Africa have been patchy, limited or absent. Poorer farmers have lost the support once offered by (admittedly inefficient and often corrupt) parastatal marketing boards and government research and extension systems, but have rarely gained new support, markets or production opportunities. The consequence has been increased impoverishment for many, and growing inequalities between those who have gained and those who have been marginalised.

Even the World Bank has been rethinking whether liberalisation is really the route to pro-poor growth in the agricultural sector. Some continue to argue that the medicine is correct, but the patient is at fault: The reforms have not been sequenced well, they have not been implemented properly, or other factors have got in the way (Jayne *et al.* 2002). But an argument for other alternatives is emerging (Dorward *et al* 2004*)* embodying a mix of strategies: getting prices right does matter, but so does getting institutions right, and this must be preceded by putting certain basic conditions in place (including infrastructure and land reform). The primary diagnosis here is institutional.

Markets cannot be expected to work if coordination is weak and institutions are missing, because these increase transaction costs and encourage market failure (Dorward *et al* 2004). Addressing coordination and market failures requires support for regulated monopolies, franchises, and trader and farmer associations, combined with price guarantees, price support and subsidies. This approach provides an important progression from the extreme neoliberalism of the Washington Consensus, defining a route to pro-poor agricultural growth that takes account of the complexities of local implementation and the need to invest in institutional innovation.

Agribusiness is starting to dominate the profitable agricultural sectors, squeezing out others in the process (Amanor, 2005). As a consequence, a dualistic scenario is emerging, where wealthy entrepreneurs, linked to foreign capital and connections to political elites, are making money from agriculture, but others are languishing behind. Studies have noted how the trickle-down benefits from large-scale commercial agriculture to smallholder farming are often limited (IFAD 2001; Lipton 2004). All this suggests the need to focus development efforts not just on technical, economic and institutional policy measures, but to pay more attention to more fundamental political processes of agrarian reform.

Leaving aside the commercial viability of export oriented agriculture under today's global market conditions, the social and political consequences of increasing inequality within agriculture are of even greater concern. Tensions are rising in many countries between the smallholder majority and a new commercial elite – often deeply intertwined with a new political elite, and the resolution of these tensions may not always be nonviolent or democratic (Amanor, 2005; Olukoshi, 2005).

4.3.1 African Domestic Urban Market Expansion.

The rate of urbanisation in Africa is proceeding with exceptional rapidity**.** This process is often seen as a negative result of the push factors from over-stressed farming systems. But our analyses and those of others is showing that there is also a blessing inherent in the rapid growth of Africa's cities: The demand for agricultural products of a wide diversity is now growing very rapidly, providing market opportunities for greater quantities of farm products. Even a decade ago, Diao *et al.* (2003) estimated that the potential demand for agricultural products in Africa far exceeded supply. This is a major stimulator for both the intensification and diversification of farming systems.

Throughout West and East Africa there are thriving belts of agriculture surrounding cities, supplying all manner of produce including the vegetables, fruit, dairy and other livestock produce that command higher than average returns (Tiffen 2003). Urban demand in some countries is also expanding production opportunities in others. The demand for meat and fuel wood energy in Nigeria has been stimulating increased livestock and on-farm tree production in the hinterland countries of Niger and others. But it has been noted that taking advantage of this demand is still highly constrained by inappropriate barriers, poor transport and inadequate knowledge of demand projections.

These examples confirm that access to markets and the associated demand for agricultural surpluses is a strong driver of growth (**Figure 4-4**). Given effective demand, the most likely outcome is agricultural growth that sees greater marketed surplus and higher incomes for farmers, with multiplier effects within the local rural economy. On the other hand, farmers will not produce a surplus unless there are markets and attractive prices, but this is surprisingly often overlooked by policymakers (Wiggins 2005).

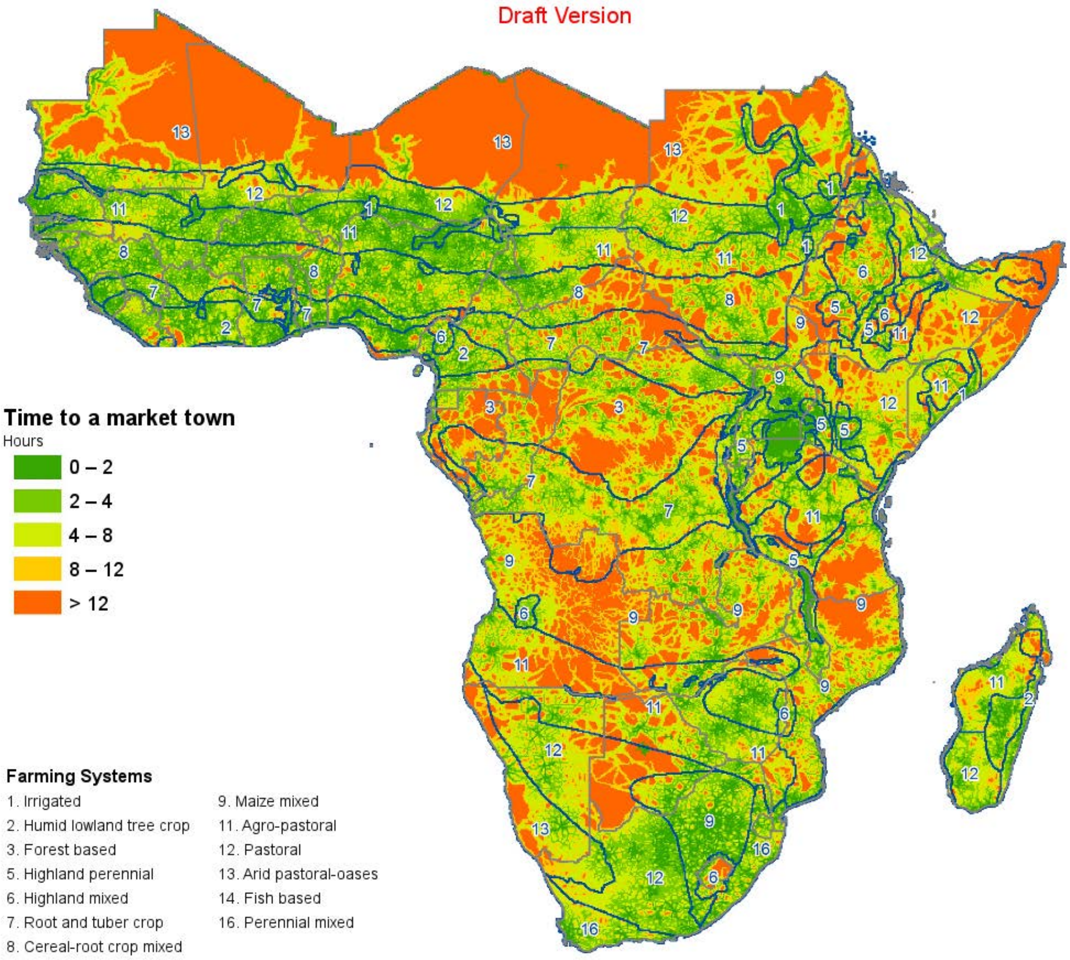

Figure 4-4 Time to reach a market town of greater than 20,000 population.

Source: See Acknowledgements

The overview of five farming systems highlighted above (**section 3**) reveals enormous variation in the underlying potential for particular areas to participate in market-driven opportunities. If the variation among the farming subsystems is mapped by two factors, the land available per household, and the accessibility of agricultural services (particularly markets), virtually all of them suffer from severe inadequacy in either one or both factors **(**

Table 4-1**).**

Table 4-1 Farming systems by land availability and access to agricultural services

Agricultural services (marketing, credit, insurance)	Very good				
	Fair	**Highland perennial:** Central Kenya			
	Poor	**Highland perennial**: Mt Kilimanjaro			
	Very poor	**Highland perennial:** Albertine Rift **Maize mixed:** Malawi **Agropastoral:** Burkina Faso, SC Niger **Highland mixed:** Ethiopia	**Maize mixed:** Zambia **Cereal root and tuber crops:** West Africa **Agropastoral:** Mali	**Maize mixed:** Mozambique, DRC, Angola	
		Very small	Small	Large	Very large
		Land per smallholder household			

By and large, changes within farming systems tend to be evolutionary, and they build upon the structure of farming by households working smallholdings on land often held under communal systems of tenure, rather than being revolutionary. In response to forces of population pressure and market demand, farmers change their cropping patterns, redeploy household labour and intensify work, and make small capital investments in inputs, draught animals, and tools. New techniques are generally adopted by making small changes to existing systems. Given time, the accumulation of successive changes can transform farming, landscapes and society: but such transformations are generally seen in the medium to long term. In this respect, the African experience may not be so very different from that seen in much of Asia, where the apparent quantum leaps of the Green Revolution were actually, on closer inspection, the cumulative effect of a series of quite small improvements for any given crop or locality.

4.4 Science and Technology

Practically without exception, yield gaps are large and persistent all over Africa (see **Figure 4-5**). Under future 'business-as-usual' scenarios, major production increases are expected to come from expanded production on heavy lowland soils, humid and moist subhumid tropics, and on irrigated land in several farming systems - although most production in Sub-Saharan Africa will continue to come from rain fed farming.

Public research funding has declined in most countries with the exception of some countries with CAADP Investment Plans or a strong tradition of agricultural research, such as Ethiopia and Kenya. As yet there is limited private sector research for the major commodities. Past research has focused on the improvement of germplasm and crop management for food crops, and will need to continue to underpin sustainable intensification. However, not all commodities have been treated equally: in recent decades food crops have fared better than most cash crops, and among the food crops maize, rice and cassava have received more attention than coarse grains (e.g., sorghum and millet). The leguminous pulses, including pigeon pea and soybean, oilseeds, vegetables and trees have been greatly neglected. Given the production challenges, it is important to continue research on the major food crops while increasing investment on minor cereals, root crops, and pulses. Related to pulses, two important areas of future research will be the efficacy of rhizobia (see below) and cropping system patterns, given the inevitable increase in cropping intensity even in rain fed areas.

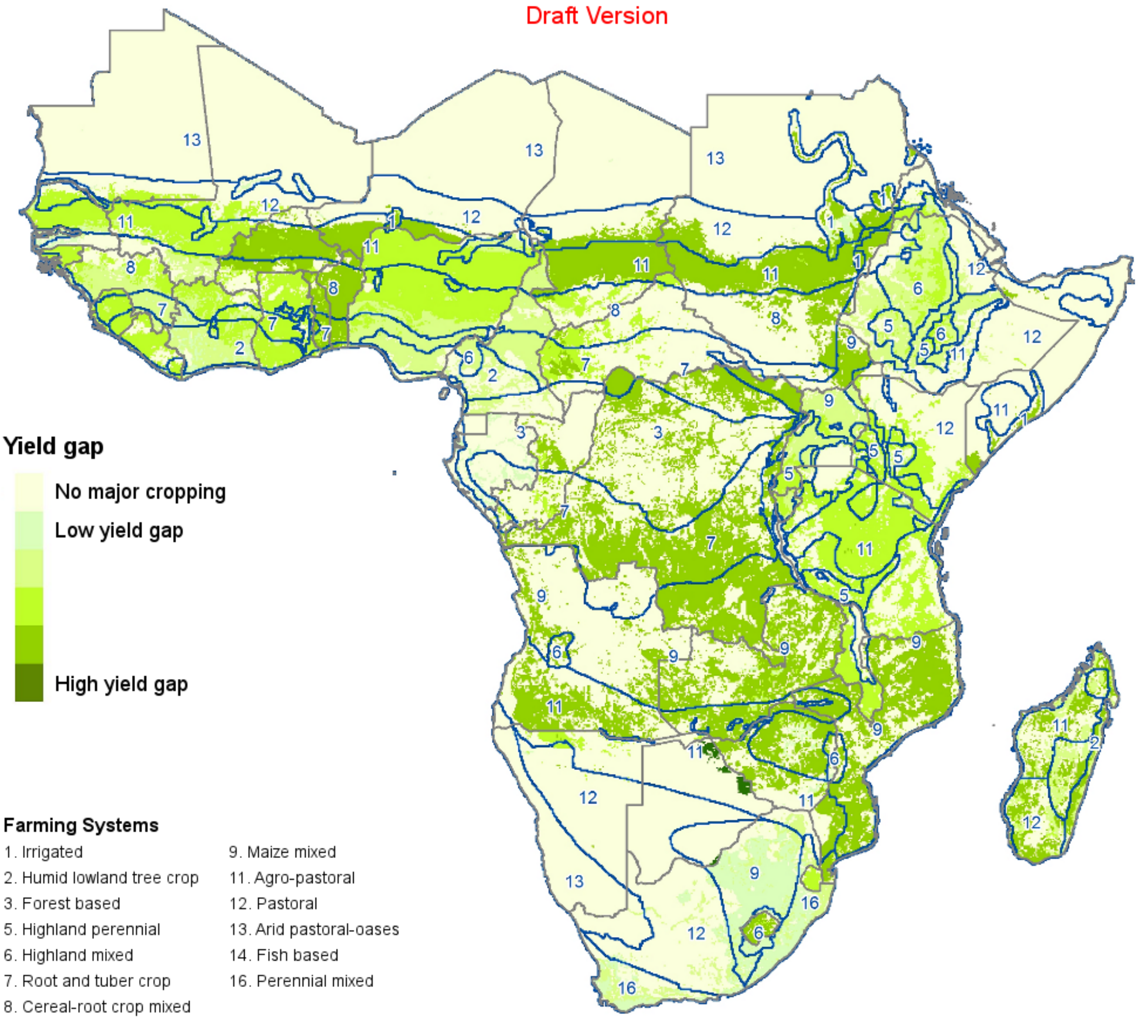

Figure 4-5 Map of yield gaps in Africa by farming system.

Source: See Acknowledgements

The key to transformation of rain fed cropping systems might lie in the managed application of small amounts of water and nutrients. Some success has been achieved with micro-dosing, the origin of which can be traced back to an ACIAR project in Kenya during the 1980s and subsequently investigated more widely by ICRISAT in southern Africa and the Sahel. Another option, the integration of trees and annual crops, is being developed through an AIFSC-ICRAF Evergreen agriculture project, including 'fertilizer trees'. A further critical research area is understanding soil dynamics and soil health under conservation agriculture.

Tsetse infestation is a major factor influencing the distribution of livestock among farming systems. The tsetse challenge tends to be concentrated in the moist subhumid and humid lowlands, and in drier areas near game reserves. In spite of this, increasing numbers of cattle are raised in areas that were originally tsetse infested in the moist subhumid and dry subhumid zones, e.g. in the Root Crop and Cereal-Root Crop Mixed Systems. This trend is likely to continue. Nevertheless, cattle numbers per household tend to be higher in the drier farming systems (*viz* Agropastoral and Pastoral) than in the moist systems. From 1970 to the present time, regional cattle, goat and sheep numbers grew moderately, but poultry and pig populations have grown faster. Between 2010 and 2030, livestock and poultry numbers production are projected to grow at a moderate rate, due to expansion of urban consumer demand for meat, milk and eggs.

One research challenge is understanding delivery chains for vaccines to villages for livestock and poultry, e.g., Newcastle Disease. One theory notes the potential of integrating supply chains, for example low margin vaccines, with higher margin fertilizers or other inputs.

There is a general recognition that socioeconomic issues are critical constraints to sustainable intensification in Africa, relatively little research is being conducted on socioeconomic issues, e.g., policy making, decision science, knowledge sharing, micro-insurance, use of information and communications technologies for knowledge sharing or adoption processes, such as the ACIAR/AIFSC project on adoption constraints in SIMLESA program sites. Innovation systems development requires both research and capacity building.

Perhaps the most important research challenge is organization and delivery of mission-directed systems research. A related challenge is the effective integration of socioeconomic and biophysical research. An example of an attempt along these lines is the SIMELSA program which is exploring the integration of systems agronomy focused on conservation agriculture, improved germplasm and improvements in value chain performance. A majority of poor smallholders operate mixed crop-livestock farming systems and so research on crop-livestock must interface among fodder, cash flow and risk management. It must grapple with the challenge of biomass management and trade-offs between the multiple purposes of energy, fuel, construction, soil protection and livestock fodder.

4.5 Human capital, knowledge sharing and gender

Not only have education levels of rural people increased substantially, but the sea-change in communications technology has brought information and knowledge much closer to small farm households. **Figure 4-6** illustrates the revolution in mobile phone numbers in Kenya, which has had many positive repercussions on rural marketing and mobile banking. A similar expansion in mobile phones has occurred in most other countries of the region. They have reduced the gender inequity in access to agricultural information, including market prices and 'mobile banking'.

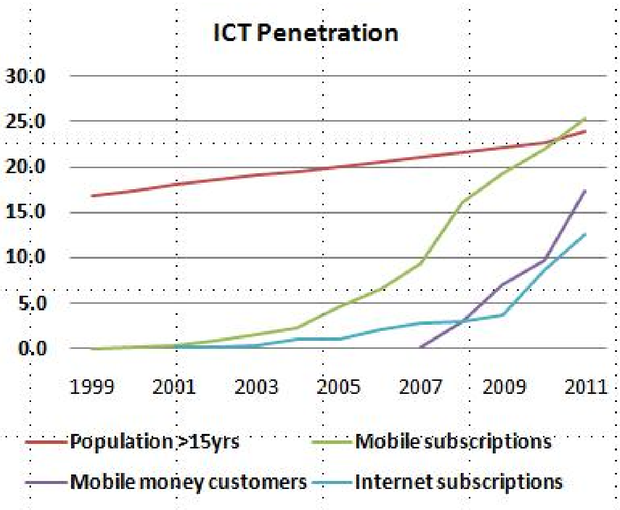

Figure 4-6 A Kenyan revolution: more phones than adults

Source: World Bank calculations based on Communication Commission of Kenya

Modern knowledge sharing technologies will be a powerful tool for bridging the research and scaling-out divide; and for energizing scaling-out itself. The functionality of mobile phones is likely to grow dramatically in the coming decades for many forms of information provision e.g., disease identification, and decision support tools. Beyond the mobile phone, there are also advances in a number of new ICTs and new variants on old communications methods, e.g., local community radio. These tools will reinforce and increase the effectiveness of innovation platforms to accelerate the diffusion of knowledge more effectively than in the past.

There are a set of issues related to gender inequities which merit research. The most basic of these relate to the control and management of agricultural resources, especially land, and also access to credit though banks (micro-finance opportunities notwithstanding).

5 Conclusions: Strategic priorities for investment in food security

5.1 The policymaking context

Policymaking for the future of African agriculture can benefit from an understanding of the history of previous policy initiatives (Scoones et al 2006). Agricultural policy at the time of independence in the 1960s was driven by a modernization perspective, with technology and state-led planning in the ascendance. This was generally combined with a nationalist, often socialist, ideology and an emphasis on nation-building and food production self-sufficiency. The Green Revolution in Asia began to show dramatic impacts from the early 1970s (Hazell and Ramaswamy 1991), and has been widely seen as a model for Africa ever since: high-yielding varieties, fertilizers and irrigation, delivered through credit schemes, supported by cooperatives. But successes remained isolated and the "green revolution" failed to take off in Africa.

The 1970s saw a shift towards integrated rural development programmes (IRDPs) which linked agricultural development to credit facilities, extension support, even education and health services. IRDPs created islands of success, but were dependent on high levels of government (and loan) support. When these programmes wound down or were incorporated into local government or line ministries, the impacts quickly faded.

It was during the late 1970s and early 1980s that the farming systems approach initially received attention. It fostered attempts to move beyond the research station bias of green revolution-style technical fixes, and engage with the real, complex problems of farming at the grassroots. More adaptive research was emphasized, highlighting the full range of interacting factors that affect household decision making and impinge on agricultural production. It came to be appreciated that agricultural development must go well beyond technology generation and transfer, into marketing, rural finance, and natural resource management. The critical social dimensions became more evident as well: that men often have different priorities than women, that the rich have different interests than the poor. More realistic recommendation domains emerged, and research and extension became somewhat more finely-targeted and nuanced (Collinson 2000).

During the structural adjustment era of the 1980s and 1990s, much of the investment in building research and extension capacity unravelled. Governments experienced severe budget constraints, and were blamed for being too interventionist. They retrenched researchers and extension workers, closed down farming systems programs, and abandoned on-farm trials. The private sector was expected to fill the gap (World Bank 1995). But this didn't happen to anywhere near the degree that was anticipated for success.

The post-reform era of the past decade has continued to be hampered by lack of government capacity in basic agricultural research and support (Chema *et al.* 2003; Friis-Hansen 2000). Agricultural extension systems were particularly weakened in relation to the expanding needs. Meanwhile, many countries have seen the emergence of a two-track agricultural sector: a small one profiting from new commercial opportunities, and a big one characterized by stagnation and poverty. Today, the limitations of the liberalization reform experiments are clear, and there is renewed interest in poverty reduction through agriculture as the core challenge for development.

At the macro level a new policy architecture has emerged. The Millennium Development Goals (MDGs) have provided a better framework for achieving results. Ambitious targets have been set, supported by the African Union's CAADP, national strategies, and associated direct budget support mechanisms. But the cutbacks associated with structural adjustment reforms have so undermined the institutional capacity to design and implement effective poverty reduction strategies that there is real concern as to whether the new policy approaches can succeed.

Policymakers face a dilemma. Effective demand for output is critical to stimulate production, but this is not something that the state can affect directly where the provision of (private) goods is left to the market. But governments can encourage and facilitate institutional innovation in agricultural supply chains to overcome market failures (Dorward et al 2005). Thus, a better understanding of markets and the levers for competing in them can help guide key institutional innovations, and the direction of research.

5.2 Options for policy makers from a farming systems perspective

This paper provided an overview of some of the principal farming systems of Africa, and their interplay with major trends and drivers. It has highlighted a number of key points for consideration by policymakers.

Rural populations have now reached critical levels in many farming systems, as evidenced by farm sizes that have declined to levels that cannot sustain the minimum production needs and satisfy the livelihood needs of farm households. At one level, the situation points to the imperative for more pro-active policies in moderating overly-rapid population growth in culturally-sensitive ways. Fortunately, there is also considerable unmet demand for family planning services, and a rich experience of success in this area from Asian countries with similar a poverty profile. It is clear that marked progress in reducing rural household fertility rates can be achieved and would contribute enormously to achieving food security goals at both the household level and national levels. At a second level, in the short run, a determined focus is needed to better educate the majority of rural youth who have no prospect to farm themselves, and facilitate off-farm employment generation for them. The differentiation across farming systems is illustrated in the following examples:

- Highland perennial systems: Strong rural-urban labour market integration occurring in some subsystems. This can be accelerated through education, business development, and education
- Highland mixed systems have more limited but significant potential for such development.
- Agropastoral systems have strong labour migration, which can be rationalized with emphasis on improving labour market information and education.

Increasing crop productivity on the farm is critical. One means of doing so is tackling the decline in soil fertility that is so evident in many farming systems. There are a number of paths that governments can pursue to support land regeneration. Stimulating greater fertilizer use is high on the agenda, but the right mix of interventions again depends on the local context, particularly between high potential areas and more remote dryland areas. A mixed strategy is needed based on integrated soil fertility management tailored to local conditions; one that draws on understanding how farmers' adapt their systems over time. Naturally, the strategies and policy options differ across farming systems, as demonstrated in the following examples:

- Highland perennial systems: Further strengthen integrated soil fertility management through dairy development with manure recycling.
- Maize-mixed systems: In high-population subsystems target fertilizer subsidies transitioning to tree biofertilisers; in low population density subsystems expand area farmed through more efficient tillage and conservation agriculture on smallholdings.
- Agropastoral: Continue regreening with massive upscaling of farmer-managed natural regeneration along with fertilizer microdosing and more efficient fertilizer input markets.

The key water management lesson is that the development of solutions for Africa's farming systems goes far beyond large irrigation schemes. Helping farm households to exploit rainwater, groundwater and local surface water offer many opportunities that are much more diverse than has previously been emphasized. Again, tailoring solutions to local farming conditions is a pathway to accelerating the spread of water benefits to millions more smallholder households across the continent., as illustrated in the following policy options:

- Agropastoral and highland mixed systems: Upscale a range of small-scale in-field rainwater harvesting practices along with water resource assessments.
- Cereal root and tuber crops systems and others in subhumid environments: Develop micro- and mini-irrigation potential in lower landscape positions.
- Irrigated systems: Water pricing critically important.

The key growth potential in agricultural trade and markets lies at home, in the expanding domestic and regional markets within Africa, where demand in some areas already far exceeds supply. Thus, enhancing these markets, improving infrastructure, removing barriers and reducing transactions costs, is the greatest opportunity to stimulate both the intensification and diversification of farming systems. This will reduce dependency on food imports, and will pave the way for Africa to eventually compete as a food exporter on the world market as well. However, the policy options difer by farming system, as follows:

- Market development is important in all systems, but a priority in systems with strong agricultural potential but poor market access (e.g. Cereal root and tuber systems).
- Maize mixed systems and Cereal root and tuber systems: Strengthen market development for existing patterns of production, which is easier than developing new value chains for diversification to new crop and livestock alternatives.
- Agropastoral and pastoral systems: Opportunities for focused development for livestock value chains.

This paper has emphasized three scales of knowledge that may help decision makers better cope with the imponderables and the complexity. First, there are the larger trends and drivers that are in motion at the continental level, providing a backdrop at the macro level. Second, there is the level of the farming system and subsystem, where the drivers play out in unique ways in the local context. And third, there is the household itself, and how it responds to internal and external forces, including policy interventions. We argue that a perspective which is deeply cognizant of, and knowledgeable about, all three of these scales and their interactions, is fundamental to making and implementing successful agricultural policy – and we place particular emphasis on knowledge related to farm household response.

What are some key general directions that emerge from a more systemic analysis of African farming systems, in light of current possibilities and the painful experiences of the past 40 years? Based on the above analysis of farming systems, we can confidently say that generic policy assessments related to resource management or production are usually inappropriate and are often downright misleading. We find that policy must be tightly grounded in context-specific analysis of particular farming systems. This, however, requires serious investments in building the analytical capabilities of analysis and interpretation. In practical terms, the capabilities should be established at local level, ideally related to particular farming systems, as well as at national level. Arguably, such farming systems R&D teams would have a role in performance monitoring. Pursuing these capacity-building investments must be a community of effort, with support from both within Africa and from donor countries.

Further, substantial investments in local-level multi-stakeholder innovation systems is required, that pursue creative solutions to farming system problems by engaging the private, NGO and public sectors in the local testing and evaluation of technologies and market institutions. Methodological development for the establishment, maintenance and monitoring of such work is needed, including enhancing the capacity of researchers and district officials to better facilitate these innovation systems. Perhaps the most important research challenge is organizing and delivering mission-directed systems research that better frames and guides policy decisions in more concrete and nuanced ways. Patterns of livelihood diversification and farming systems evolution are path-dependent. This reality reinforces the explanatory power of a farming systems classification and its effective utilization.

Fresh external interventions may be effective, and enabling, if they are framed within a deep understanding the interacting drivers and how they play out at the local level in different farming systems. The international and national agricultural establishment would be advised to think more creatively about the development process, in African agriculture, and consider more deeply what models of innovation and policy formulation are actually appropriate to the diversity of farming systems in Africa.

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