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Foresight and African agriculture: innovations and policy opportunities

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Executive summary

This report describes the lessons learnt from cases of sustainable intensification of agriculture in the African Union. These cases show that under supportive conditions, agriculture in Africa can produce higher yields, generate adequate income for farmers, regenerate the natural capital and environmental services, and contribute to human development.

Supportive conditions include active and effective research, sustained community participation, state support and progressive policies, adequate investment and multi-stakeholder partnerships across scales and between sectors. Where these conditions are met, agriculture-led growth generates substantial improvements to human well-being and helps meet a number of human development goals, including gender empowerment, poverty alleviation and food security.

The cases summarised within this report were commissioned by the UK Government's Foresight Programme. This produced a report on *Global Food and Farming Futures* in 2011, which aimed to provide an overview of the key challenges and developments in global food and farming. As part of this project, Foresight commissioned a review of sustainable intensification of agriculture in Africa. 40 cases were selected covering projects that were implemented during the 1990s and 2000s.

These cases were selected to illustrate the processes and outcomes of initiatives over a wide enough area and across a sufficient number of farm systems in order to draw indicative lessons about how to develop productive and sustainable agricultural systems and how to scale-up successes over time. The case studies cover initiatives on variety development, sustainable land and water management, conservation agriculture, integrated pest management, livestock development, aquaculture and novel regional, national and international partnerships. Together, these interventions have resulted in improvements over some 12 million hectares, benefitting more than 10 million African farm families.

In summarizing these lessons, this report contributes to the knowledge required to address agriculture and rural development across the African Union. These challenges include widespread land degradation, the various impacts of climate change, endemic poverty and problematic access to water and other inputs for farming. The scale and impact of these problems is likely to worsen over time, as a result of increasing pressure from competing land uses, and a legacy of inadequate policy support, low investment, inadequate infrastructure, conflict and inadequate or inappropriate aid and other support measures. These challenges can be addressed by investment in approaches exemplified in the Foresight case studies.

The cases described in this report highlight the linked nature of social and ecological change; where initiatives have stewarded land, water and biodiversity, results have been substantial and sustained over time. These initiatives include measures such as development of new crop varieties, integrated pest management, soil conservation, agroforestry, conservation agriculture, and the intensive management of small patches of land. These measures depended on the sharing of knowledge between farmers, across communities and between local communities and research and extension organizations.

Their implementation also depended on the building of social capital – networks of trust and mutual cooperation within and beyond local communities. Through these networks, small groups are able to support each other by sharing costs, distributing benefits and spreading knowledge (for example through Farmer Field Schools or peer-to-peer learning). The benefits from sustainable resource management have been shown to improve individual and community well-being both directly and indirectly. All the Foresight case studies mention positive environmental, social and economic externalities. These include, among others, improved nutrition, the empowerment of women and child-headed households, improved literacy and the development of new products and small-businesses by groups of small farmers.

The Foresight cases demonstrate the fundamental importance of partnerships between farmers and private, public and third sector organizations engaged in research and development, extension, training, finance, product-development and markets. The cases show that it is possible for actors at different scales and across different sectors to work together to meet shared, mutually-beneficial goals. Smallholders can organize effectively to capitalize on new knowledge and new markets when given adequate support and in the context of authentically participatory development. The support of policy makers and the public sector is essential for enabling and sustaining these partnerships.

This support need not come, as it often has in the past, only from centralized structures. Instead, the Foresight cases show that support is needed which enhances the existing capacities of farmers and their communities, creates a favorable environment for innovation and knowledge-exchange and where the interests of private sector actors are aligned with those of farm households and communities.

Section I: Introduction

I.1 Introduction

This report summarizes the key findings of a recent review of agricultural innovations in the African Union (AU). The review indicates that a remarkable transformation is underway across the countries of the AU, where innovations in sustainable intensification are driving increases in yields alongside improved environmental and social well-being. These cases show that significant social, ecological and economic benefits are to be gained from efforts to implement sustainable intensification.

African agriculture is widely thought to have performed poorly over recent decades, especially when compared with the production increases observed in Asia and Latin America during and immediately after the Green Revolution. Yet though the agricultural sector has been thought of as stagnant, net production data shows that there has been significant production growth across all regions of Africa (Pretty *et al.* 2011).

However, despite these recent increases, population growth has meant that per capita availability of domestically grown food has remained largely unchanged over the last 50 years and has even fallen substantially in North, West and Middle Africa (Pretty *et al.* 2011). Within Sub-Saharan Africa (SSA), an estimated 239 people suffer from hunger (FAO, 2012). Estimates by the International Food Policy Research Institute (IFPRI) show that only one country in SSA– Ghana – shows improvements to hunger scores since 1990. Further, with the exception of North Korea, all countries in which the hunger situation worsened between 1990 and 2012 are in Sub-Saharan Africa (IFPRI, 2012). Economic growth and development also imply that demand for food will rise, and consumption patterns will change – though there are uncertainties over the precise nature and extent of these changes (Foresight, 2011).

The emergent challenge is to increase productivity whilst maintaining or improving the flow of ecosystem services, thus contributing sustainably to economic growth and the alleviation of poverty. Though existing knowledge and capacity will need to be deepened in order to meet this challenge, it has been estimated the application of existing knowledge and interventions “could increase average yields two- to threefold in many parts of Africa” (Foresight 2011, p. 16) and be of benefit to smallholders, increasing yields and reducing hunger and poverty (*Ibid.*) Thus, we already have the knowledge required in order to make significant improvements even within existing constraints. This report highlights how the application of this knowledge, through participatory programmes involving groups of diverse stakeholders, is already reaping benefits for African agriculture.

I.2 The UK Government Foresight Programme

The UK Government’s Foresight programme informs UK government policy through systematic, peer-reviewed research on complex issues that pose important challenges in the 21st century. The Foresight Project on *Global Food and Farming Futures* provided an overview of the issues facing global agriculture and food systems. The aim was to “explore the pressures on the global food system between now and 2050 and identify the decisions that policy makers need to take today, and in the years ahead, to ensure that a

global population rising to nine billion or more can be fed sustainably and equitably” (Foresight, 2011, p. 9). The project takes a broad view of the global farming and food system, from smallholders engaged in subsistence cultivation to multinational retailers and from consumers to governance structures.

As part of the Project, Foresight commissioned 40 case studies describing how a wide variety of practices and policies are aiding the sustainable intensification of agriculture across the African Union. This project:

- gathered evidence on the processes, outcomes and options for upscaling of initiatives;
- described the socioeconomic and cultural contexts which encourage agricultural productivity whilst improving natural capital and the flow of ecosystem services and
- analysed the incentives and legal and institutional frameworks required to enable a wider transition to sustainable agricultural practice.

These initiatives were adopted during the 1990s and 2000s, and appear to be delivering sustainable intensification – that is, they are building natural, social and human capital while improving agricultural productivity and farmers’ income. This body of evidence does not represent a random sample, nor was it a comprehensive selection of all the promising initiatives in Africa. Instead, the intention was to investigate the processes and outcomes of initiatives over a wide enough area and across sufficient farm systems in order to draw indicative lessons about how to develop productive and sustainable agricultural systems and how to scale-up successes over time.

The selected case studies show that significant benefits have accrued from relatively low levels of investment, and that small projects and programmes can deliver widespread benefits. The 40 cases delivered yield and production benefits to some 10.3 million African farm families on 12.75 million hectares of cropland (Foresight, 2011; Pretty *et al.*, 2011).

It is expected that these lessons will inform the ongoing work of national, regional and pan-African policy platforms working towards agriculture-led growth and development. In particular, it is expected that the findings summarized within this report will be of specific relevance to the work of the New Partnership for Africa’s Development (NEPAD) and the Comprehensive Africa Agriculture Development Programme (CAADP).

I.3 NEPAD and the Comprehensive Africa Agriculture Development Programme (CAADP)

The New Partnership for Africa's Development (NEPAD) is a pan-African programme initiated in 2001. It aims to spearhead efforts for positive political and socioeconomic change in Africa by enhancing "Africa's growth, development and participation in the global economy". NEPAD recognizes that there exists a "historic opportunity... to end the scourge of underdevelopment that afflicts Africa" and that "the resources, including capital, technology and human skills, that are required to launch a global war on poverty and underdevelopment exist in abundance and are within our reach" (NEPAD 2001a, p. 1). NEPAD lists agriculture as a key priority area for development.

NEPAD's founding objectives and strategy with regard to agriculture are listed in Box 1. The actions important for agricultural development include improved practices (e.g. better water management), an improved social and financial environment for production (e.g. securing land tenure and enhanced credit facilities) and increased investment in infrastructure and financing. The Foresight case studies provide a range of examples of the potential of these measures in various environments and the potential for their spread. In doing so, they show how investment could be targeted in order to increase productivity sustainably.

The Comprehensive Africa Agriculture Development Programme (CAADP) is the agricultural programme for NEPAD. The CAADP was formally established in 2003 with the aim of increasing agricultural productivity by at least 6% a year by 2015, and increasing agricultural investment by 10% of national budgets per year in order to "eliminate hunger and reduce poverty through agriculture" (CAADP 2011). CAADP offers a broad frame of priorities from which more precise strategies and programmes can be derived for different African sub-regions. Its work is organized along four pillars:

1. *Sustainable Land and Water Management* aims to extend the area under sustainable land management and reliable water control systems
2. *Market Access* aims to accelerate growth in the agricultural sector by raising the capacities of private entrepreneurs (including commercial and small-holder farmers) to meet the increasingly complex quality and logistic requirements of markets, focusing on selected agricultural commodities that offer the potential to raise rural (on- and off-farm) incomes.
3. *Food Supply and Hunger* aims to improve domestic production and marketing, facilitate regional trade in food staples, and build household productivity and assets
4. *Agricultural Research* aims to improve agricultural research in order to disseminate appropriate new technologies and boosting the support available to farmers to adopt new options.
5. The CAADP has aimed to support agricultural development by identifying success stories and opportunities for growth and spread. An early news report on CAADP (Harsch 2004) describes how "Where... success stories exist... the challenge facing African leaders will be to find ways to strengthen them and duplicate their experiences in other localities and countries... (CAADP) is not a blueprint, and... it's vision must be adapted to the specific problems of particular regions and countries." These success stories provide indicative lessons to guide the

considerable investment required for agriculture-led growth and development; estimated to total some \$251 billion, under the following headings (Table 1).

Box 1: NEPAD Objectives and Actions for Agriculture (NEPAD 2001b)

NEPAD Objectives for Agriculture

- improve the productivity of agriculture, with particular attention to small-scale and women farmers;
- ensure food security for all people and increase the access of the poor to adequate food and nutrition
- promote measures against natural resource degradation and encourage production methods that are environmentally sustainable;
- integrate the rural poor into the market economy and provide them with better access to export markets;
- develop Africa into a net exporter of agricultural products;
- become a strategic player in the development of agricultural science and technology.

NEPAD Actions for Agricultural Development

At the African Level

- Increase the security of water supply for agriculture by establishing small-scale irrigation facilities, improving local water management, and increasing the exchange of information and technical know-how with the international community;
- Improve land tenure security under traditional and modern forms of tenure, and promote the necessary land reform;
- Foster regional, sub-regional, national and household food security through the development and management of increased production, transport, storage and marketing of food crops, livestock and fisheries. Particular attention must also be given to the needs of the poor, as well as the establishment of early warning systems to monitor droughts and crop production;
- Enhance agricultural credit and financing schemes, and improve access to credit by small-scale and women farmers;
- Reduce the heavy urban bias of public spending in Africa by transferring resources from urban to rural activities.

At the international level:

- Develop new partnership schemes to address donor fatigue for individual, high-profile agricultural projects;
- Developing countries should assist Africa in carrying out and developing its research and development capabilities in agriculture;
- Promote access to international markets by improving the quality of African produce and agricultural products, particularly processed products, to meet the standards required by those markets;
- Support African networking with external partners in the areas of agricultural technology and know-how, extension services and rural infrastructure;
- Support investment in research in the areas of high-yield crops and durable preservation and storage methods;
- Provide support for building national and regional capacity for multilateral trade negotiations, including food sanitation and other agricultural trade regulations.

Table 1: CAADP projections for required investments in agriculture, 2002-2015 (Harsch 2004).

Activity	Investment (US \$ billion)
Land and water operations	37
Operations and maintenance	32
Investment in rural infrastructure	89
Operations and maintenance	37
Trade-related capacities	3
National food security	6
Regional food security	1
Research and technology	5
Humanitarian safety nets	42

Both the NEPAD and the CAADP emphasize the importance of agriculture to socioeconomic development in the African Union. The NEPAD highlights the vital link between agricultural development and wider economic development in its 2001 mission document: “Improvement in agricultural performance is a prerequisite of economic development on the continent” (NEPAD 2001a, p. 33). The CAADP cites agricultural development as a key vehicle for economic growth: “CAADP aims to help African countries to reach a higher path of economic growth through agriculture-led development” (CAADP, 2011).

1.4 Regional programmes

In addition to the NEPAD and CAADP, the lessons contained within this report are expected to inform the ongoing work of regional platforms, including, for example, the agricultural programme of the Economic Community of West African States (ECOWAS). The 15 member states of this consortium have adopted a regional agricultural policy, ECOWAP, which sets out a vision of a “modern and sustainable agriculture based on effective and efficient family farms and the promotion of agricultural enterprises through involvement of the private sector” (ECOWAS Commission, 2008). Another platform, the West Africa Agricultural Productivity Programme, is a 10-year, sub-regional programme of the ECOWAS, and focuses on generating and disseminating agricultural technology in Ghana, Mali, Senegal and most recently, Liberia.

These platforms and programmes emphasise the centrality of agriculture to sustainable growth and development, the attainment of food security and the realisation of poverty alleviation. Their commitments and strategy highlight a shared recognition that agriculture-led growth will require sustainable intensification, attained through participatory initiatives which build social, ecological and human capital.

1.5 The need for investment in agriculture in Africa

Globally, employment in agriculture has been declining in favour of services (ILO, 2011). However, agriculture is still vital for employment generation and economic growth across Africa. The sector accounts for 65% of full-time employment (Pretty *et al.*, 2011), and agriculture underpins the livelihoods of two-thirds of Africa’s poor (*Ibid.*) Furthermore, “in Sub-Saharan Africa, growth in agricultural employment accounted for half of all employment growth between 1999 and 2009” (ILO, 2011).

It has also been shown that agricultural growth remains the most powerful way to reduce poverty. In general, countries which have increased agricultural productivity most rapidly have also experienced the most significant reductions in poverty (DFID and Wiggins, 2004). A 2008 report by the World Bank stated that “growth in agriculture is at least twice as effective at reducing poverty as growth in any other sector of the economy, whilst a 1% growth in agriculture has been shown to generate approximately 1.5% growth in non-agricultural sectors” (World Bank, 2008). The report shows that “a 1% gain in gross domestic product (GDP) originating in agriculture generates a 6% increase in overall expenditure of the poorest 10% of the population, while the equivalent figure for GDP growth originating in non-agricultural sectors is zero growth.”

In Africa, every 10% increase in yields has been estimated to result in a 7% reduction in poverty, an equivalent effect is absent from growth in manufacturing and services (Pretty *et al.*, 2011). These benefits are realized through a variety of avenues, including increasing employment and income, better nutrition and poverty reduction (Headey *et al.*, 2010), improving the incomes of smallholder farmers who are net buyers of food and leading to an increase in non-farm economic activity in rural areas. Aside from poverty-alleviation, it has also been shown that it is only in regions where agricultural growth has increased that hunger has been reduced.

The scope for investment is high. In 2008, the World Bank noted that public spending on agriculture is lowest in the very countries where the share of agriculture in GDP is highest. Substantial gains can be made from targeting investments towards smallholders. Neglect of smallholders has been cited as a key reason for the poor general performance of African agriculture (APPG, 2011). Smallholders in Africa are exiting agriculture in Africa faster than in other developing regions, such as Asia (Headey *et al.*, 2010) possibly as a result of ‘push’ factors (the neglect of the agricultural sector) rather than ‘pull’ factors (such as the pull of productive non-farm employment) (Hazell, 2011). Mitigating this trend through renewed investment in small scale farming provides a relatively cost-effective alternative to other forms of public assistance such as food aid or income transfers. For instance, while food aid costs over US\$250 per tonne of cereal delivered to rural areas, producing the same amount on a small scale farm typically costs US\$100 or less (Hazell, 2011). Improvements on labour-intensive, smallholder farms have been shown to yield relatively greater improvements to local job-creation, increases in income and reductions in poverty and hunger than improvements on large farms using labour-saving, capital-intensive technologies and where farmers subsequently spend their additional income on goods produced outside their communities (DFID and Wiggins, 2004). These differences are increasingly subject to change as a result of global changes to agriculture including increases in the capital investment required for agricultural modernization and changed market conditions (DFID and Wiggins, 2004).

Poor performance in agriculture is also locked in a two-way relationship with conflict. Conflict and violence have reduced agricultural production in Africa (Allouche 2010, *in* Pretty *et al.*, 2011). Food production in 13 war-affected countries of sub-Saharan Africa between 1970 and 1994 was 12% lower in war years compared with peace-adjusted values. Over the period 1970–1997, conflict-related losses of agricultural outputs amounted to some \$121 billion (\$4 billion per year) (FAO, 2000 *in* Pretty *et al.* 2011). However, investment in agriculture and food security could also reduce conflict. de Soysa and Gleditsch (1999) point out that “the perpetration of violence in impoverished areas is intimately related to the problem of ensuring food. In states which have collapsed or are teetering on the edge, such conflicts resemble the form of collective violence common in pre-industrial times – rational responses to subsistence crises” (p. 21).

Policy support is critical to the effectiveness of investments in agricultural development. For example, where agricultural development is oriented towards market-based production, policy intervention is required in order to “protect the subsistence bases of the poorest households” (DFID and Wiggins 2004, p. 15). Supportive policies are those that are well-targeted to their context (Headey *et al.*, 2010) in order to improve welfare, reduce poverty and contribute to meeting the other Millennium Development Goals.

Section 2: Key issues

This chapter summarises the key challenges for African agriculture and food security. This overview reveals the need for a renewed emphasis on alleviating hunger and poverty through agriculture-led development. Investment in African agriculture will be needed in order to address these significant and complex challenges.

The right to food remains a significant challenge globally, but especially across the African continent. The targets set by the World Food Summit in 1996 for the reduction of hunger have not yet been met, and instead progress in reducing hunger in the developing world has slowed, with negative progress being reported in some areas. Many countries across the continent are unlikely to achieve the Millennium Development Goal of halving the proportion of undernourished people by 2015 (Foresight, 2011). This has resulted in increases in the number of undernourished people despite global food production having grown faster than world population in recent times (Clover, 2003).

Globally, around 1 billion people suffer from hunger and an additional billion who suffer from under-nutrition, or a deficiency of the nutrients required for optimal health (Foresight, 2011). 239 million individuals in Sub-Saharan Africa are hungry (FAO, 2012), and over 40% of the population in the region lives on under \$1.25 a day. In this region, over 750 million people who live in dire poverty rely on subsistence agriculture for food and income (Committee on Twenty-First Century Systems Agriculture and National Research Council, 2010). Progress towards ending hunger and malnutrition in the region have been relatively slow. Sub-Saharan Africa registered only a 3% gain in calorie intake between 1969 and 2005, compared with East Asia, where consumption levels increased by 41% during the period (Foresight, 2011).

Of 29 countries where hunger was classified as 'extremely alarming' in 2010, four were in sub-Saharan Africa – Burundi, Chad, the Democratic Republic of Congo and Eritrea. Overall, around 33% people in the region are under-nourished, compared with only 6% in North Africa (IFPRI, 2010). Compared with the North and the West, the countries of East, Central and Southern Africa bear a relatively greater burden of poverty, hunger and disease due to decades of stagnant agricultural and economic growth coupled with the impact of severe spikes in food prices. Smallholders are particularly vulnerable, as they are either too poor to have food surpluses or have to sell their output at harvest only to purchase them later in the season at much higher prices. These farmers continue to face low food stocks, high food prices, and the declining ability to purchase food.

In South Africa, one-fifth of the population lives on less than \$1.25 a day, even though the country has the largest economy in Africa (Beddington *et al.*, 2012). Food security in Eastern Africa is of particular concern, with more than half the populations of the Democratic Republic of Congo and Mozambique by undernutrition, while Angola, Cameroon, Ethiopia, Kenya, Tanzania, and Zambia show prevalence rates of between 40- 50%. Though Kenya is one of the most highly developed economies in Eastern Africa, one-third of Kenyans remain undernourished, even though four of every five Kenyans depend primarily on agriculture (Beddington *et al.*, 2012). The rate of hunger and malnourishment in Nigeria is relatively low, but its large population means that the country accounts for 22% of the food-insecure in West and Central Africa (Interacademy Council, 2004).

The land-locked countries of Zimbabwe, Zambia and Lesotho are experiencing the slowest overall growth rates in agricultural production (Ndulu *et al.*, 2007) accompanied by high population growth rates, coupled with the challenges presented by poor governance and macroeconomic instability. Within these countries, structural impediments continue to hinder agricultural growth. These include poor infrastructure such as roads, water and energy supply; relatively high transaction costs compared with other regions in Africa and the rest of the world and poorly developed financial markets in general and rural finance. Within these regions, there is an urgent need to improve the climate for investment in agriculture-led growth through innovation and the development of institutional and human capacity. Key factors needed to revitalize agriculture are similar to those needed for economy-wide growth, but in addition, policies need to specifically target agriculture, in order to redress a longstanding neglect of the sector in macroeconomics and trade which has resulted in the sector being starved of resources. This neglect has prevented agriculture from contributing to growth and reducing poverty and hunger as it has so powerfully done in East and South Asia.

Though there is some evidence that policies are changing to give more attention to agriculture-led growth, more effort is needed. Poverty reduction and agricultural development programmes need to target smallholder farmers. Agricultural policies will need to specifically target hunger, malnutrition and poverty. Where food production is prioritized within agricultural policy, it has a threefold role in ending hunger, by improving physical access to food, raising farm income and generating employment and engendering social change by, for example, empowering women and other historically marginalized groups (Foresight, 2011). Projections indicate that without significant effort, over 500 million will be food insecure in the region by 2020 (USDA, 2010).

Smallholders are a particularly important target group for renewed agricultural policies around the world, even though farming systems and their needs are diverse. Across the region, some 33 million smallholders account for about 80% of agricultural production, cultivating farms of on average 1.6 ha in size (Wiggins, 2009). For example, Foresight (2011) states that, "It is counter-productive to be absolute or overly ideological about agricultural strategy, especially in Africa. Farming contexts are heterogeneous, and different types of investment and focus are needed. Nevertheless, 'half of the world's undernourished people, three-quarters of Africa's malnourished children, and the majority of people living in absolute poverty can be found on small farms" (p. 120).

Alongside chronic malnutrition and scarcity, acute hunger is also a common feature in parts of Africa, causing mass starvation and deaths. A number of notable famines have occurred in Africa, mostly in Sub-Saharan Africa. Examples include in Ethiopia: in Tigray (1958); Wole (1973); and elsewhere (1984-1985, 1998-2000), in Nigeria: Biafra (1967-1970), Somalia (1991-1992), Sudan (Darfur 2003). While famines are often directly linked to droughts, there is evidence that abuse of human rights, absence of proper planning on the part of policy makers, and inadequate access to resources have been as responsible for most of this suffering as harsh environmental conditions.

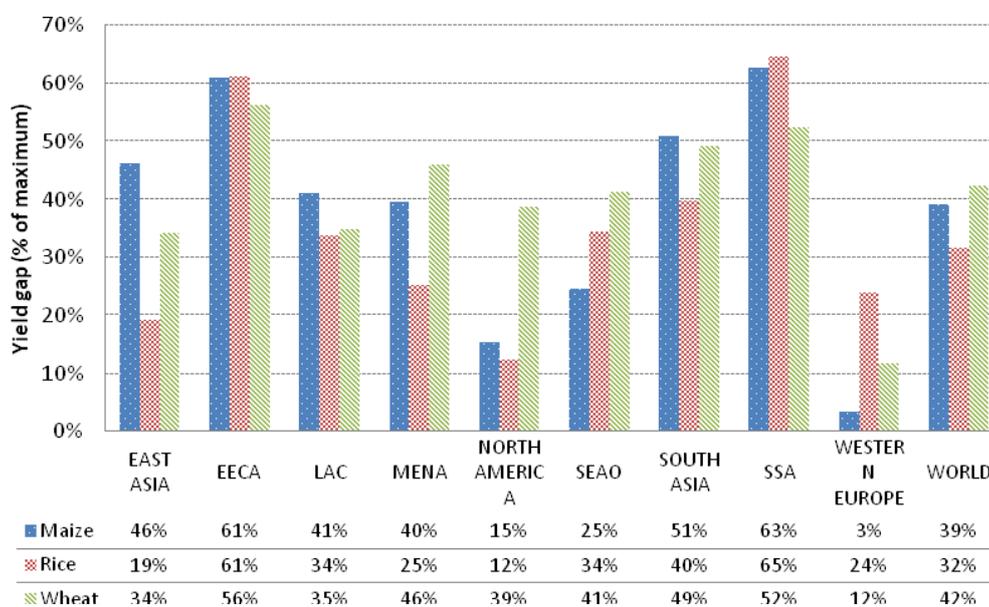
There are subtle linkages between hunger and a number of negative social challenges, notably lower literacy rates and access to education for women and human disease. 15% of the global disease burden is attributed to undernourishment (IAASTD 2009).

2.1 The production challenge for African agriculture

A long decline and slow recovery in agricultural production has helped to frame a prevailing view that African agriculture has remained stagnant and lagged behind the rest of the world (Pretty *et al.* 2011). However, as described earlier, net production data shows that there has been substantial production growth across all regions of Africa. Output has trebled, and is growing faster than world output (Pretty *et al.* 2011). Nevertheless, there is much room for improvement. There are still wide gaps between actual and potential crop yields. Licker *et al.* (2010), for example, show that for maize, rice and wheat, yield gaps in Sub-Saharan Africa are above 50% (Figure 1). Yield gaps can be closed if a number of on-farm and off-farm constraints are addressed (Sileshi *et al.* 2009; Andersen and Watson 2011), including increased investment in agricultural research, improved market conditions and the provision of rural services.

Figure 1. Yield gaps for key crops across different regions of world

(EECA = East Europe and Central Asia; LAC = Latin America and Caribbean Countries; MENA = Middle East and North Africa; SEAO=Southeast Asia and Oceania; SSA = Sub-Saharan Africa) Source: Licker *et al.* 2010.



Africa is the only continent where per capita food production has been on the decline in recent decades. While there have been increases in per capita food production in other regions (e.g. Asia and Latin America by 30% and 20% respectively), there has been at least 3% annual decline in per capita food production in sub-Saharan Africa (SSA) since 1990. It has been estimated that between 1970 and 2000, per capita food production in the region fell by about 20% (Stock, 2004).

This region has the lowest average crop productivity in the world (FAO 2011). Yields from rainfed cultivation are low because of low rainwater use efficiency, poor soils, lack of farm inputs (improved seeds, fertilizers, and technology), and poor pest management (Gregersen *et al.* 2007).

As a result of a number of challenges to food production and a number of constraints on availability and access, per capita availability of food has been stagnant or declining over the past 50 years. Population growth is a key driver of this trend; the continent – and has

highest population growth rates worldwide and population is expected to more than double by 2050 (Foresight, 2011; Royal Society, 2012). Within sub-Saharan Africa, the population is expected to grow by 2.4% between 2010 and 2011, compared with a worldwide average of 1.1% (UNFPA, 2011). Growing population density has also contributed to land degradation, due to limited intensification.

However, population alone is not enough to place stress on food security; rising demand from a growing population acts in concert with demographic and socioeconomic changes such as urbanization, changing food preferences, changing livelihood structures, industrialization and changing relationships with the global economy. Though there are uncertainties on the precise nature and extent of these changes in the countries of the AU, it is clear that these factors place a number of social, economic and ecological demands on agriculture and the food system which must be accounted for in order to achieve sustainable growth.

A combination of increased demand for food, negative increases in food production, increases in energy and transaction costs, together with other factors have led to increases in food prices. These prices have significantly risen, since 2005, by over 60% of the 1998-2000 levels, and all predications are that they will settle at significantly higher levels than in the last decades (FAO, 2008). These higher food prices, combined with high energy costs in the short run have serious adverse effects on balance of payments for the net food and oil importing countries of Africa, and their poor citizens who are net buyers of food, as they spend over 70% of incomes on food purchases (compared with 7.8% of American incomes spent on food) (FAO 2011b). Against this context, the continent has transitioned to being a net importer of agricultural commodities, and also receives the most food aid globally, with some 30 million people requiring emergency aid in any one year.

A number of key biophysical, socioeconomic and political factors are responsible for the challenges facing African agriculture. We review these below, before turning to an analysis of potential alternatives which might inform a transition to sustainable intensification.

2.2 Biophysical factors

Biophysical constraints to high yields include degraded soils, pests, crop disease and weeds. Ecological conditions in parts of the African continent are conducive to rapid pest growth, disease-causing and vectoring organisms and weeds whose recommended control methods are either unaffordable to the resource-constrained smallholder farmers, incompatible with their cropping systems, or are neither effective nor environmentally sustainable.

Land degradation

Land degradation is widespread across the continent; though estimates vary from 30 percent of total agricultural land, permanent pasture, and forest and woodland areas to 75% of arable land. About three-fourths of these degraded lands lie in dry regions (Oldeman et al., 1990; Oldeman, 1992). A recent study by Bai *et al.* (2008) showed that between 1981 and 2003, African land south of the equator experienced the most severe land degradation in the world, accounting for 13% of degraded lands globally during the same period.

Water and wind erosion are exacerbated by overgrazing, improper agricultural practices and a history of continuous cropping with minimal or no investment in soil improvement. Nutrient depletion, especially on smallholder farms, is a key concern; at least four times more nutrients are removed via African harvests than are added via manure or inorganic fertilizer (FAO 2011c). Sub-Saharan Africa currently has the lowest rate of inorganic fertilizer use in the world (Bruinsma, 2003).

Across the semi-arid regions of Burkina Faso, Niger, and Senegal serious land degradation results from nutrient depletion, inadequate organic matter, and wind erosion, with nutrient mining occurring over significant areas of cropland under transition from long and medium fallow to short fallow or permanent cropping systems. The adoption of mechanization with inappropriate plowing techniques and the removal of tree cover has led to soil degradation in many areas of Africa, particularly the transition zones of West Africa and the savannahs of southern Africa. Within Eastern and Southern Africa, nutrient depletion and mining are critical concerns; annual depletion of nitrogen, phosphorus and potassium are high, especially in areas without fertilization or nitrogen fixation (Sheldrick *et al.*, 2002). Degradation is likely to be intensified by climate change, rising population and the pressures of stemming from competing landuses.

Land degradation severely constrains agricultural productivity and threatens food security and land-based livelihoods, with especially serious consequences for the livelihoods of rural dwellers in the more marginal agricultural areas. It has been estimated that degradation caused by past soil erosion alone is responsible for reductions of between 2-40% in African crop yields (Lal, 1995).

In Sub-Saharan Africa, it is acknowledged that land degradation has contributed to decreases in food production and the region loses an estimated \$4.5 billion each year due to severe nutrient depletion (Gregersen *et al.*, 2007; Molden, 2007; Morris *et al.*, 2007). If accelerated erosion continues unabated, yield reductions by the year 2020 may be 16.5% for the continent and 14.5% for Sub-Saharan Africa (Scherr and Yadav, 1996). The threat of degradation may also be reflected in the need to use a higher level of inputs in order to maintain yields, which is not an option for the majority of African smallholders.

Given the scale and impacts of degradation, renewed investment in participatory soil and water management are urgently required and to restore productivity where possible and to prevent food-related crises in densely populated areas such as humid lowlands of West Africa, where large-scale urbanization is expected, the highland areas in Rwanda, Burundi, and Kenya, where there are no obvious sources of further productivity increase. There are likely to be major conflicts along the subhumid and semi-arid border zones, due to migrations induced by droughts and dryland degradation.

In order to elicit effective and long-lasting impacts on erosion-control, participatory soil and water management needs to occur within a context of secure land tenure, and equitable systems of collective ownership building on customary rights; these enable farmers to make the necessary investments in soil management (Foresight, 2011).

The availability of water for farming

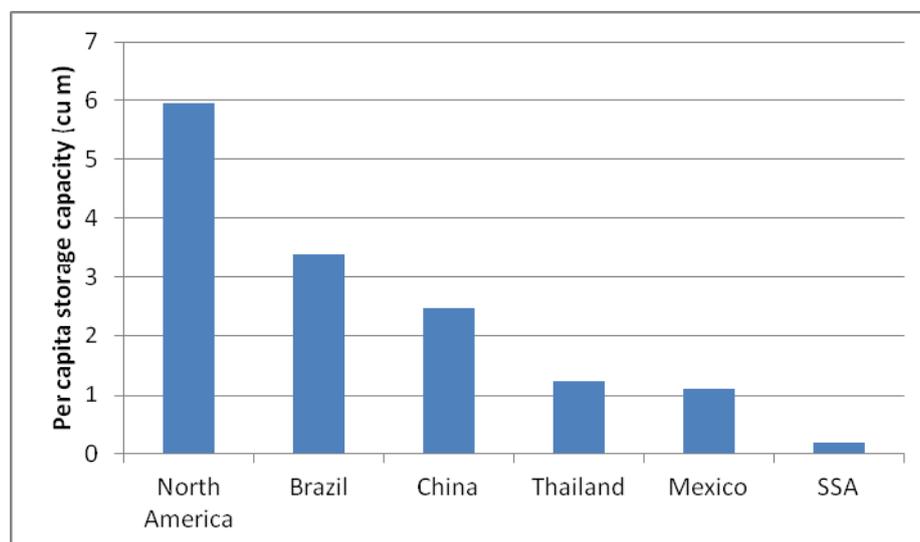
Globally, water security is an increasingly pressing concern, partly because of sudden increases in the demand for water following population growth surges and the need to intensify food production systems to meet the demand. The availability of adequate water is a key limiting factor to agricultural development. In Africa, irrigation potential is

relatively constrained, a factor which is partly responsible for the stasis in agricultural development (FAO, 2011d). In sub-Saharan Africa for example, less than 3.7% of agricultural land is irrigated (*Ibid.*) Where it has occurred, irrigation development has generally been patchy and performed poorly (*Ibid.*).

The availability of water for farming is mediated by a range of biophysical and socioeconomic factors including climate change, the demands of industrializing and urbanizing populations and changes to cropping preferences. With regard to climate change, it is estimated that by 2020, between 75 and 250 million people could be exposed to increased water stress and in some countries, yields from rainfed agriculture could drop by some 50% (FAO, 2011d). The effects of competing demands are likely to be particularly severe, in North Africa, where there is likely to be increased competition for water between agriculture and municipal and industrial sectors. Sustainable and equitable water allocation here is an urgent policy priority.

Against this context of increasing water scarcity, it is also clear that agricultural intensification will require the development of some irrigation potential. The sustainable development of irrigation potential implies achieving higher water-use efficiency through improved water collection, storage, distribution and application and reducing salinisation, waterlogging and wastewater problems (FAO, 2011c). Investment in both large and small-scale irrigation has been low across Africa (Foresight, 2011). Sub-Saharan Africa also currently has the lowest constructed water storage reservoir capacity in the world, with an estimated per capita annual water storage capacity of only 200 m³, a level relatively much lower than in other countries (Figure 2).

Figure 2: Per capita water storage capacity in selected countries. Source: Grey and Sadoff 2006



Increasing irrigation potential requires thorough planning and sensitivity to the potential negative impacts on water users and ecosystems throughout the catchment. River basins may become stressed or 'close' as a result of over-allocation for agriculture. Impounding and withdrawing water for agriculture may affect downstream users all the way up to the coast. For example, coastal fisheries in Mozambique and eastern South Africa are suffering as basins dry out due to water abstraction for cooling and irrigation (FAO, 2011d).

Climate change

Climate change is expected to have far-reaching effects on sustainable development in Africa, including the ability to attain the millennium development goals (MDGs). It has been estimated that even a 2° C rise in Africa will have more negative consequences than originally thought as a result of the continent's relatively greater sensitivity to more frequent extreme weather events (FAO, 2011d).

The magnitude and speed of climate change over major crop areas in Africa has been predicted by calculating the percentage overlap between historical (1960–2002) crop growing season temperatures and the projected 2025, 2050, and 2075 values over reported crop area (Burke *et al.*, 2003). Results indicate that growing season temperatures at any given maize-growing region in Africa will overlap on average 58% with its historical observations by 2025, 14% by 2050, and 3% by 2075. This suggests that within two decades, average temperatures during the growing season average will be higher than any year in historical experience for four years out of 10 for the majority of African cereal crop area, growing to nearly nine out of 10 by 2050 and almost 10 out of 10 by 2075. Similar results have been reported for precipitation, with rainfall expected to become progressively more unpredictable, and the incidence of drought and flood increasing. The FAO (2011d) cites estimates which suggest that some 75 million ha of land currently suitable for rainfed cultivation will be lost to viable rainfed cultivation by 2080.

These threats and shocks will directly impact farms and agricultural communities, exacerbate existing land degradation and increase pest and weed pressures. Combined, these pressures will strain production and contribute to food and nutritional insecurity, especially for the resource-poor in SSA.

Greater attention needs to be paid to the potential contribution of agriculture to GHG emissions. As African agriculture develops, support should be given to techniques, processes and models which do not contribute to emissions. Evidence shows that in recent times, the proportionate share of African countries' contributions to emissions from landuse change and agriculture has been increasing (Foresight, 2011). A notable example is the current and projected rise in emissions as a result of increased use of inorganic fertilizer. SSA currently has the lowest rate of fertilizer use in the world; reversing this situation without a concomitant increase in emissions is a key challenge for sustainable intensification.

2.3 Competing land uses

Though there is continuing controversy over the extent of potentially cultivable land in Africa, it is clear that African farmers are faced with a shrinking per capita land base (Beddington *et al.*, 2012). Arable land per capita in SSA has declined from 0.5 ha/capita in 1970 to 0.25 ha/capita in 2005, an average annual decline of 70 m² per capita compared to a decline of respectively 46 m² per capita and 38 m² per capita in South Asia and Latin America and Caribbean (LAC) (Nkonya *et al.*, 2012). At the same time, though cereal yields have been static in Africa, *more* land has been brought into cultivation (Foresight, 2011).

Expansion of agricultural land has traditionally been at the expense of biodiverse habitats in forests, savannah and natural grasslands (Foresight, 2011); policy thus needs to better balance the demands of habitat-conservation, agriculture and other competing landuses.

These include the demands made by urbanization, industrialization, forestry (particularly timber extraction), the production of non-food crops, protected areas. In addition, there is substantial concern about the potential impact of “past and future land-purchase and leasing agreements involving both sovereign wealth funds and businesses” (Foresight 2011, p. 55).

There is substantial uncertainty about how these different drivers and pressures will evolve and interact. Some of these competing land uses have their ultimate origins outside of Africa, but are expected to pose a challenge to agricultural development and food security within the continent.

Urbanization, defined as the increasing share of a nation's population living in urban areas relative to rural areas, is expected to reduce the number of people engaged in agriculture and food production (Satterthwaite *et al.*, 2010). Africa is expected to follow the same demographic pattern as the rest of the world, with populations shifting to urban living (FAO, 2011d). This shift is also expected to result in significant reduction in arable land as urban centers often expand over their nation's most productive agricultural land. Associated with urbanization is the rapid development of infrastructure, changes in demand for different agricultural products and associated changes in how demands are met and in the farmers, companies, corporations, and local and national economies who benefit (and who lose out), with major challenges for both urban and rural food security. Urban expansion leads to changes in land values and land markets around cities often resulting in land being left vacant, as land owners anticipate the gains they will make from selling land or using it for non-agricultural uses.

Urbanization – and especially the growth of large cities – is proceeding apace across Africa. The absence of any land-use plan or strategic planning framework to guide urban development means that urban areas expand haphazardly. This expansion is determined by where different households, enterprises and public sector activities locate and build, legally or illegally. In most instances, there is little effective control over land-use conversions from agriculture to non-agricultural uses. Regulations that are meant to limit this are either missing or inadequately implemented.

Though urbanization is generally associated with economic growth, many urban dwellers still face hunger. A study of 10 nations in sub-Saharan Africa showed that the proportion of the urban population with energy deficiencies was above 40% in all but one nation and above 60% in three (Ruel and Garrett, 2003). In 12 of 18 low-income countries, food-energy deficiencies in urban areas were the same or higher than rural areas, even though urban-dwellers have higher average incomes (Ahmed *et al.*, 2007).

The cultivation of biofuel crops may represent an opportunity for long-term poverty reduction in Africa and other regions that depend heavily on agricultural commodities. Biofuel cultivation presents a range of benefits, from expanded employment opportunities to the mushrooming of secondary industries and associated benefits. However, a lack of adequate planning could further marginalize the rural poor who rely on land for their livelihoods. Clear land tenure policies are required to guide investment and the proper allocation of land, and the development of the industry must demonstrate an understanding of national and local land tenure systems as well as a comprehensive assessment of existing land-uses (Molony and Smith, 2010). Indeed there is currently an imminent fear in countries such as Tanzania, where powerful forces behind biofuel production offer comparatively large amounts of windfall cash, thus tempting poor

farmers to sell their land at low prices or, where the government allocates land that would have otherwise been put to food production to investors for biofuel production.

2.4 Low investment in research and development

Globally, investment in agricultural development remains an urgent priority. Some 2.5 billion people rely on agriculture for their livelihood in developing countries, and 75% of the world's poor live in rural areas (FAO, 2011d). Against a context of increasing population and a constrained resource-base, a recent analysis recommended that globally, some \$7.1-7.3 billion per year is required for agricultural development, with 40% of this recommended for Africa (Nelson *et al.*, 2009 *in* FAO, 2011d).

African agriculture is marked by relatively low investment in research and development. During the 1960s, many African governments sought transition from agricultural to industrial economies, with the agricultural sector only meant to provide fiscal and labour surpluses. The structural adjustment programmes of the 1980s then dismantled many of the government agencies that provided agricultural services to farmers, including extension. More recently, African governments and donor agencies have embarked on revitalizing agriculture, but there has been no sustained effort and commitments from most governments, with investments in agricultural development averaging only 3% of government resources. Lynd and Woods (2011, p. 20) describe how “global support for agricultural development in Africa has declined from US \$8 billion a year in the 1980s to less than US \$3 billion.”

However, there is evidence that public sector investment in agricultural R&D is emerging from a long period of stagnation. Public sector agricultural R&D averaged over 20% of growth in sub-Saharan Africa during 2001-2008. “In 2008, the region spent \$1.7 billion on agricultural R&D (in 2005 purchasing power parity dollars)—or \$0.8 billion (in 2005 constant US dollars)—and employed more than 12,000 full-time equivalent (FTE) agricultural researchers” (Nienke and Gert-Jan, 2011). However, in general, agricultural R&D funding in Sub-Saharan Africa has been highly volatile (Nienke and Gert-Jan, 2011); stable, sustained backing from national governments and donors is required to counteract this trend. Funders must also explicitly recognise the importance of developing human capital to drive forward R&D by investing in graduate programmes, improving curricula and mentoring younger scientists.

2.5 Policies, institutions and infrastructure

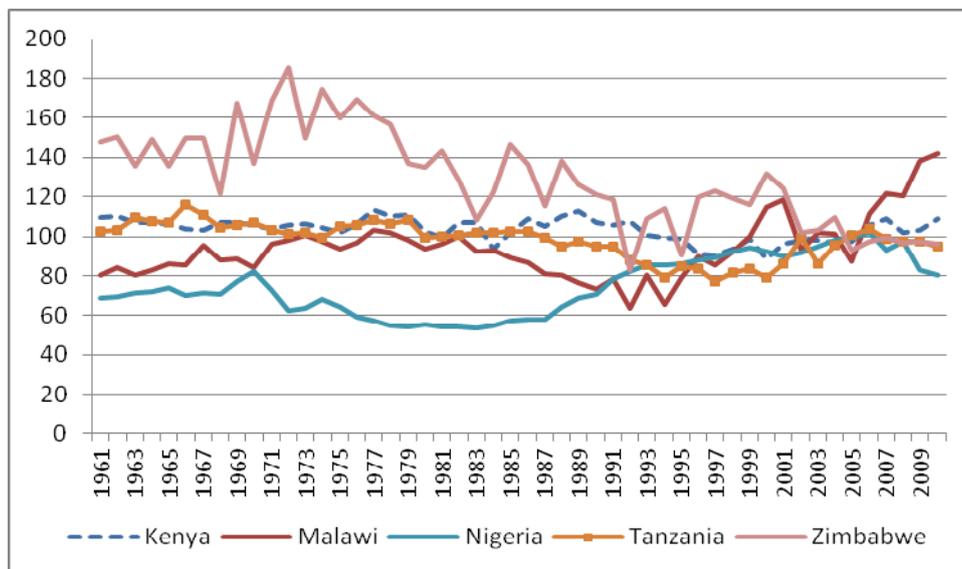
A supportive policy environment, robust institutions and infrastructure make a difference to yields. Thirteen countries in SSA have experienced a positive trend of per capita agricultural production, which can be attributed in part to pro-agricultural policies and a supportive set of institutions and infrastructure. In Nigeria, Kenya and Malawi, for example, gains can be attributed to investment in research and development, fertilizer subsidies and other pro-agricultural policies. Nigeria and Malawi have both used a large share of their agricultural budgets to finance fertilizer subsidies. For example, Malawi and Nigeria respectively use over 70% and 40% of their agricultural budgets to finance fertilizer and seed subsidies (Mogues *et al.*, 2008; Dorward and Chirwa, 2011).

Even though the sustainability of investment in fertilizer subsidies has been questioned (e.g. Minot and Benson, 2010), it has a favourable impact on agricultural productivity as it lowers the fertilizer prices. Nigeria has also invested significantly in agricultural research;

it is among SSA's big 8 countries which spent more than US\$50 million for research and development in 2008 (Beintema and Stads, 2011). Likewise, Kenya is among the 8 countries whose intensity of research and development (R&D) investment exceeds NEPAD's target of investing 1% of the agricultural GDP to agricultural R&D (*Ibid.*) Additionally, Kenya has maintained agricultural marketing environment favourable to strong development of the private agricultural input market. This has led to the favourable agricultural productivity using a much pro-market approaches.

By contrast, the disappointing decline of agricultural productivity in Zimbabwe is largely due to land policies, which weakened the large-scale production in the country. Another example is the almost flat trend growth of per capita agricultural production in Tanzania. Even though Tanzania has recently increased its investment in agricultural R&D, and is among the big 8, its per capita agricultural production has largely remained stagnant (Figure 3). This underscores a need for a long-term investment in agriculture R&D, which should be accompanied by favorable market environment and the provision of rural services.

Figure 3: Net per capita agricultural production (2004-06=100) for selected countries. Source: FAOSTAT



Policies, institutions and infrastructure, and access to the benefits these provide, are hampered by widespread corruption. In SSA especially, corruption is the major challenge to poverty alleviation strategies and food security. The region is perceived to have the highest extent of corruption in the public sector in the world (Transparency International, 2011), and also scores very low on an index of government effectiveness (Figure 4). A recent study showed a positive correlation between improvement in government effectiveness and a government's capacity to implement policies with independence from political pressures and with respect to the rule of law (Kaufmann *et al.* 2009). Improved land management has also been demonstrated where communities are empowered to design and enact their own bylaws as a result of decentralized governance structures. Nkonya *et al* (2011) describe how, with the enactment of bylaws prohibiting bush burning, the Emigginda community in Niger managed to reduce loss of forest and shrubland to burning in comparison with other communities without these prohibitions.

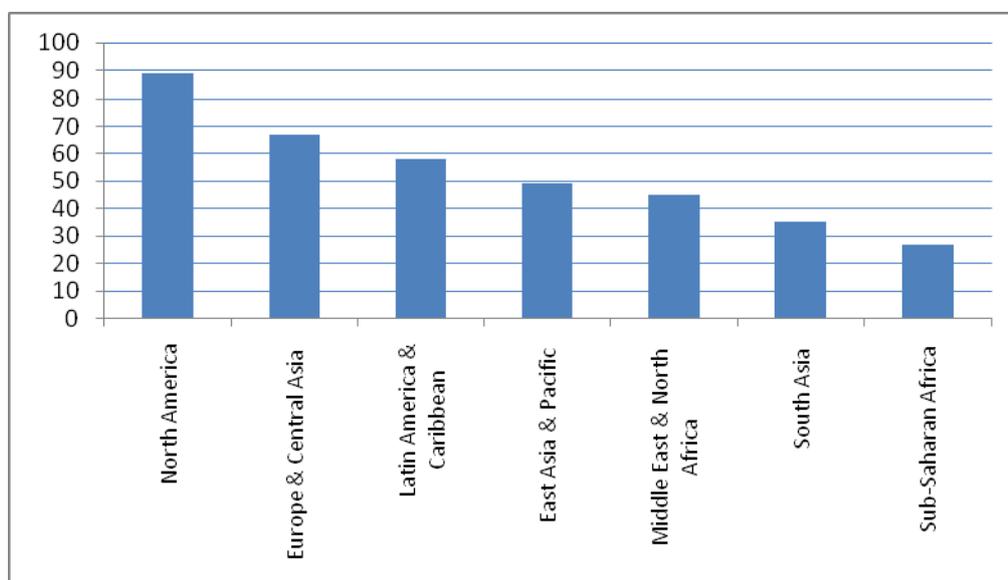
Agricultural development requires the support of specialized infrastructure. In Africa, structural adjustment has dismantled the base of agricultural parastatals, networks of

extension agents and national agricultural research programmes (Foresight, 2011). Significant public investment is needed in order to reverse this legacy.

Poor infrastructure, such as inadequate storage and distribution systems, ensures that transaction costs remain high. Infrastructure in Africa compares unfavourably with other developing countries and transport costs are the highest in SSA compared to other regions of the world. The paved-road density in the region is 0.31km/km² while the paved road density for the developing world is 1.34 km/km (Yepes *et al.*, 2008). Within certain countries in the region, it has been estimated that transport costs can be as high as 77% of the value of exports (Foresight, 2011). Where storage and transport infrastructure are poorly developed, harvests may be lost in storage or as they move through the supply chain, especially if the chain is lengthened as a result of urbanization (*Ibid.*) Foresight (2011) cites estimates of post-harvest losses in parts of Africa, showing that over substantial areas they reach between 10-30%.

Figure 4: Government effectiveness for regions ranked by percentile rank. Source: Worldwide Governance Indicators:

<http://info.worldbank.org/governance/wgi/index.aspx#reports> (Kaufmann *et al.* 2010).



For individual farmers, an inability to connect to markets, and high transaction costs implies a restriction to subsistence cultivation (Omamo, 1998). While SSA has registered significant economic growth in the past decade, the region continues to contend with a legacy of lack of infrastructure development, resulting in the very high transaction costs. Most of roads and railway infrastructure in SSA were built during colonial period and there has only been limited improvement. As a result, most infrastructure especially in rural areas remains poor, deficient in coverage and unreliable. The cost of transportation in the region is as much as four times higher than in other developing countries (Table 2). For example, the UN Millennium Project (2005) reported that the local transport in Africa can be as high as US\$800 per metric tonne compared with US\$300 in Asia.

Supportive market environments protect farmers and consumers from volatility. This has adverse effects and negative implications for the supply response, the macro-economy and public finances, which may be especially important for poorer countries. Market volatility is currently poses a significant problem and insofar as the tendency is for

volatility to increase, this strengthens the case for considering policy measures which could reduce it or ameliorate the effects for poorer nations. Policies to address volatility may take various forms, namely policies to make agricultural markets work better, interventions in markets to limit fluctuations, and policies to reduce the harmful effects of fluctuations.

Table 2: Africa: poor infrastructure and cost of access. Source: Foster and Briceno-Garmendia, 2010

	Africa	Developing countries in other continents
Paved road density (km/km ² of arable land) ^a	0.34	1.34
Population with access to electricity (%) ^a	14	41
Population with access to improved potable water (%) ^a	61	72
Power tariffs (\$/kwh)	0.02-0.46	0.05-0.1
Transportation cost (\$/tonne/km)	0.04-0.14	0.01-0.04
Water tariffs (\$/m ³)	0.86-6.56	0.03-0.6

^aExcludes medium income African countries (South Africa, Kenya, Botswana, Gabon, Namibia, Cape Verde, etc) and is compared to other low income countries. The rest of the statistics refers to entire Africa and other developing countries.

2.6 Labour

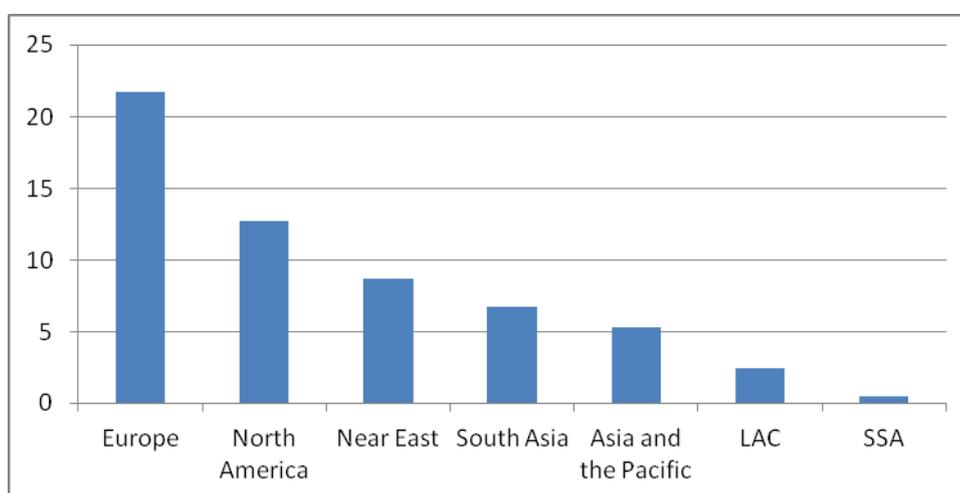
Smallholder agriculture is highly labour-intensive and frequently heavily reliant on women, who contribute up to 70% of the agricultural labour within Africa (Foresight, 2011). Women are often marginalized from skill development opportunities, have few land-tenancy rights, limited access to credit facilities, and are commonly overburdened by other household chores. Improvements are constrained by cultural factors (e.g. historical gender inequality), corruption and conflict. The impact of these constraints is reinforced by poverty.

The HIV/AIDS epidemic is a significant driver of labour shortages across the AU and thus has significant negative effects on yield gaps, agricultural productivity and food security. SSA is the region most affected by the global HIV epidemic. In 2010, about 68% of all the people with HIV/AIDS in the world lived in SSA; additionally, the region accounted for 70% of all new HIV infections in the world (UNAIDS, 2011). Most of the infected are the most productive members of society, between the ages of 15 and 49. By hampering individuals' ability to engage in agricultural production, HIV/AIDS hampers household food security by decreasing household's ability to grow their own food and buy food. It is estimated that more than 20% of the population that provide agricultural labor in SSA countries will die of HIV/AIDS by 2020 (Rosegrant *et al.*, 2005). Because women are often primary caregivers to ill members of the household in addition to their role within the agricultural labour-force, HIV/AIDS can reduce household food production by 60% (Oxfam International & Save the Children, 2002).

Recent trends have shown significant reduction in the rates of HIV/AIDS infection, as a result of concerted national and international efforts to prevent new infections and provide treatment for those affected. Yet the burden of past infections and the scale of new ones remain significant and thus the impact of HIV/AIDS on agricultural productivity continues to present a sizeable challenge.

Lastly, labour productivity is lowered by a pervasive lack of mechanisation. The number of tractors per 1000 hectare in SSA is the lowest in the world (Figure 5), leading to relatively higher labour intensity of farm operations. Even though small farms in SSA may not permit mechanization, lack of machinery translates into low labour productivity and high labour intensity and restricts farmers to subsistence farming (Pingali, 2007). Mechanization in Africa has actually been declining even in countries which were pioneers of mechanization, such as Zimbabwe and Kenya (*Ibid.*) As a result, labor productivity has remained persistently low compared to other regions in the world (De Janvry and Sadoulet, 2010).

Figure 5: Number of tractors per 1000 ha of arable land. Source: FAOSTAT



As indicated earlier, policies which prioritize food production and agriculture-led growth enable farmers to increase household-level food security and have the added advantage of increasing farmer’s income, generating employment and increasing expenditure within the local economy. Though not necessarily restricted to connecting farmers to markets, the notion of farming as a business has been gaining the attention of policy makers and development agencies in Africa. Cases show that where farmers are sufficiently organised to be able to take advantage of commercial opportunities, rural incomes have risen (Foresight, 2011).

2.7 Food availability and access

Apart from the above-described constraints on food production, access and availability present complex challenges. Access to food is constrained by poverty, combined with poor infrastructure and distribution systems which hamper the movement of food to where it is most needed.

Globally, agriculture produces 17% more calories per person than it did 30 years ago, despite a 70% population increase. At present, agriculture produces 2,720 kilocalories per capita, several hundred more than most adults need. However, it is a common

occurrence that famine and bumper crop harvests are experienced at the same time in countries where famines are frequent. In addition, most of the food insecure countries of Africa export food commodities to the west and Asia; for example tea, coffee, cocoa, etc from East and West Africa. Therefore, for people to be effectively fed, improvements in performance of crop and agriculture are important, but only as a component of an elaborate system that addresses food distribution as well as storage systems.

Home production of food ensures both food availability and access to those who have adequate land and labour. However, for everyone else there must be food available in the markets at affordable prices. However, when either of these fail, safety nets and other emergency interventions are needed, which is sometimes achieved through emergency food assistance and distribution of food in kind. Any comprehensive food security strategy therefore involves a broad range of measures to ensure availability and access.

Availability and access to food are often hampered by conflict, which is a major driver of food insecurity in Sub-Saharan Africa. Conflicts are driven by ethnic competitions, rebellion, religious oppositions, political opposition, state collapse, boarder disputes, and land conflicts between farmer and pastoralists (Nhema and Zeleza, 2008). Conflicts destroy infrastructure and property and affect food production and businesses, as rebels may burn crops, destroy farm land, and limit access to the market. Even after the conflict has ended, some people may have experienced disability due to injury that may hinder or limit their participation in agricultural production or income generation. Conflicts may also lead to household food insecurity if there is a loss or displacement of a breadwinner.

At state level, conflict forces the reallocation of resources that could have been used to improve food production to military expenditure (Nhema and Zeleza, 2008). Conflicts may lead to mass migration, forcing people to flee their homes, villages or countries seeking refugees. Over 30 percent of refugees worldwide come from Africa, mainly Sudan, Somalia, Democratic Republic of Congo, Burundi, Eritrea, Liberia, Rwanda, Western Sahara and Ethiopia (UNHRC, 2006). Refugees may not have access to land and if they do, they may not have the ability to invest in agricultural production. In receiving countries, the influx of refugees may put pressure on land and other natural resources. Because of refugee influx, prices of food in the host countries may increase due to higher demand for food, which affect poor people's ability to purchase food. It has been estimated that Africa has lost over \$120 billion worth of agricultural production during the last third of the 20th century because of political conflicts (IFPRI 2004).

Access to food may be improved by various forms of social protection, such as subsidy programmes, food for work programmes and conditional or unconditional cash transfers. Though these are important mechanisms for the provision of food for the vulnerable, their effectiveness is contested and it is important "not to view social protection policies uncritically" (Foresight 2011, p. 122). The relatively short-term nature of these mechanisms in providing access to food enables them to "compete with agriculture for political support, especially in government budgets, as they are seen as simpler and more amenable to demonstrating impact. They are typically affordable only for the poorest 10% of the population, and this means they are politically difficult to sustain and can be divisive at the local level" (Foresight 2011, p. 122). Policy initiatives for food security and poverty alleviation must therefore prioritise longer-term initiatives based on agriculture-led growth, which can yield more long-lasting, sustainable and self-perpetuating results.

2.8 Summary

African agriculture faces complex challenges. Alongside improvements in food distribution and access, production will need to be intensified whilst maintaining or improving the social-ecological systems upon which further increases depend. Such intensification is called 'sustainable intensification'.

Sustainable intensification is likely to require a renewed commitment to agricultural investment. In order to meet these challenges, food production will have to increase substantially. Increased production will need to come from existing areas rather than through the spread of cultivated land. In other words, agriculture will need to be *intensified*. The spread of agriculture to new lands is made difficult by competition from other human activities and the growing urgency of protecting vital ecosystem services (e.g. carbon storage in rainforest or services provided by non-farm biodiversity) (MEA, 2005; Pretty *et al.*, 2011). In Sub-Saharan Africa for example, only 7% of land is under crops, and the potential for further expansion of land is limited (FAO, 2011c). Raising food production is not the only avenue to increasing food availability. Better distribution, for example, can improve food availability by 30-45% without the use of any additional water, soil or energy for crop production.

Section 3: The potential for sustainable intensification in Africa

3.1 Introduction

Cases of sustainable intensification across 20 African countries between the 1990s and 2000s are described within this chapter. These cases show that farmers have been able to increase their yields in one of two ways. First, there have been *multiplicative* increases – yields per hectare have increased as a result of the use of new and improved varieties and the deployment of improved management practices. Second, there have also been *additive* benefits: farmers have been able to diversify into the production of new crops, and added new system components such as trees, livestock, and crop varieties. The cases describe improvements to both ecosystems and practices, and show that yield improvements can generate both yield increases and significant, positive, environmental externalities, such as improvements to soil fertility, reductions in the use of synthetic fertilisers and pesticides, and greater diversity in both cropped and non-cropped habitats (Pretty *et al.*, 2011).

3.2 Ecosystems and practices

A number of factors threaten the biophysical basis of agricultural livelihoods across the African Union (see Chapter 2, this report). A variety of technologies and practices can help to improve land health while sustaining or improving yields. These include agroforestry, the use of fertilizer trees, soil and water conservation, conservation agriculture, making the most of patches, integrated pest management, techniques for improved horticulture and improvements to crop varieties and cultivation techniques.

The Foresight cases illustrate how packages of technologies are more effective than the application of single techniques. Adopting more than one management practice produces cumulative gains through cost-effective synergies that boost crop production more than the singular application of increased fertilization or increased water. For instance, decision-makers often view increased irrigation as a general panacea for boosting crop production in drylands, but restoring soil health alongside rain ensuring the effective use of rainwater may be a more cost-effective and sustainable option (FAO, 2011c).

These technologies and practices have resulted in improvements across wide areas and resulted in increased yields (Table 3). They help to mitigate existing degradation and are an important part of the suite of strategies which will be required in order to mitigate or adapt to the impacts of climate change at plot, farm and landscape level.

Table 3: Summary of productivity outcomes from case studies. Source: Foresight 2011b (nd = no data)

Thematic focus	Area improved (ha)	Mean yield increased (ratio)	Net multiplicative increase in food production (1000 tonnes/year)
Crop variety and system improvements	391,060	2.18	292
Agroforestry and soil conservation	3,385,000	1.96	747
Conservation agriculture	26,057	2.20	11
Integrated pest management	3,327,000	2.24	1,418
Horticulture and very small-scale agriculture	510	Nd	Nd
Livestock and fodder crops	303,025	Nd	Nd
Novel regional and national partnerships and policies	5,319,840	2.05	3,318
Aquaculture	523	Nd	Nd
Total	12,753,000	2.13	5,786

3.3 Agroforestry and soil conservation

Within the African Union, the West African Sahel has been the site of remarkable improvements, particularly within Burkina Faso and Niger, as a result of soil and water conservation across some 3 million hectares and the planting of approximately 120 million trees. In Niger, some 300,000 ha of degraded land has been rehabilitated, and much of the landscape has been transformed since the 1970s. The adoption of tree-planting has seen significant increases in the country. (In the 1980s, farmers thought that trees belonged to the state). The follow-on benefits from agroforestry are significant, and include rejuvenated aquifers, increased availability of fodder and fuelwood and a concomitant decrease in the amount of time spent by women in collecting firewood. Women's incomes have also increased as a result of these initiatives, as the increased availability of fodder allows them to own livestock. Soil conservation structures, together with the planting of trees and the application of organic fertilizer, have been instrumental in stabilising and increasing the yields of staple crops in Burkina Faso and are thus a vital support for food security in the country.

Soil conservation initiatives, in combination with water conservation and the addition of new system components such as trees and livestock can improve the productivity of staples and increase farmers' incomes. Soil conservation is a collective action challenge. As it usually takes place across whole landscapes, it requires the cooperation and active participation of several landowners.

A Foresight case-study (Sawadogo, 2011) describes how soil and water conservation techniques, in conjunction with tree planting, have rehabilitated degraded land in Burkina Faso and thus contributed to food security and poverty alleviation. Traditional techniques

include the construction of Zaï, rock bunds, stone lines and half moons. Zaïs are traditional constructions used to increase soil moisture and organic content. Farmers place organic matter, such as composted manure, into circular holes 20cm across and 15cm deep. These create a micro-environment that allows crops such as sorghum and millet to flourish despite poor soils and dry conditions. Traditional Zaï constructions have been improved by individual innovators and technical experts from OXFAM UK's agroforestry project and subsequently disseminated. The technology is currently used extensively across northwestern Burkina Faso, covering between 30,000 and 60,000 ha. Tests of the impact on soil fertility and yields show that Zaï can produce significant increases in soil moisture and organic content; under certain conditions, crop yields have been shown to double or even quadruple.

Rock bunds, another traditional soil conservation measure, were also developed via OXFAM UK's Agroforestry Project and spread across Burkina Faso via training programmes. As with Zaï, rock bunds have a significant impact on yields. In regions where soils were treated with rock bunds and compost manure, yields have increased by between 77 to 130%.

Half moons, a relatively new innovation, were first introduced in the late 1950s. These consist of semi-circular bunds, within which dryland crops such as sorghum and millet can be planted. Whereas the approach was not widely adopted initially due to a lack of technical assistance for farmers, the spread of training programmes has ensured that the approach is now widely adopted in Burkina Faso.

Nair *et al.* (2009, in FAO 2011c) estimate that some 1023 million ha are covered by agroforestry initiatives around the world. Agroforestry and the planting of fertilizer trees yield several social, economic and environmental benefits. Increased availability and proximity of firewood has reduced the foraging time for women, and greater availability of fodder has increased their ability to keep livestock and therefore boosted their income. Environmental gains include increases to the water table, decreased soil erosion, significant carbon sequestration and increased soil nitrogen. Fertilizer trees are being adopted as a result of participatory trials and on-farm testing. As a result of direct stakeholder involvement, many innovations have come from farmers themselves.

In Africa, agroforestry initiatives in Cameroon, Malawi, Mozambique, Tanzania and Zambia have yielded significant increases in maize production. Pretty *et al.* (2011, p. 14) describe how "soil-improving plants still result in an improvement in total maize production, with total maize production of eight tonnes compared with five tonnes over the five-year period." The addition of leguminous trees and shrubs has been shown to increase maize yields by some 70% in Cameroon (Degrande *et al.* 2007 Asaah *et al.* 2011). In Malawi, field trials indicate 54-76% increases in maize yields in agroforestry systems compared with traditional practices (Garrity *et al.* 2010).

Within the group of Foresight case studies, Asaah *et al.* (2011) describe the process by which agroforestry has been used by the World Agroforestry Centre (ICRAF) to rehabilitate degraded lands and boost food security in Cameroon. Here, results from a range of initiatives indicate that agroforestry is associated with yield increases of about 70% (Degrande *et al.*, 2007 in Asaah *et al.*, 2011), and in places, up to four-fold gains have been noted. Starting in 1997, ICRAF began to domesticate indigenous fruit and nut trees, selected with a focus on farmers priorities and with their active participation. More recently, ICRAF has implemented Agroforestry Tree Domestication projects funded by external donors and the Government of the Republic of Cameroon. These aim to use

agroforestry to deliver multifunctional agriculture, through which to accomplish the overlapping goals of poverty alleviation, boosting food security and alleviating environmental degradation. The projects integrate “agriculture, agroforestry, the marketing of agricultural and tree products, microfinance and small post-harvest machinery through a self-help package for poor smallholder farmers based on capacity building, communication and community development.” Critically, the project’s philosophy was “to provide knowledge, but no money”. Farmers were taught simple, low-cost methods of tree propagation and did not have to buy any equipment. Knowledge was spread through ‘training the trainers’ and farmer-to-farmer exchange. Adoption was accomplished by matching the programme closely to farmers’ needs and priorities.

Where adopted, agroforestry has resulted in many gains for farmers. Alongside improved nutrient balance, there is “a significant increase in the productivity of staple food crops and... food security” (Asaah *et al.* 2011, p. 115). Increased yields mean that farmers can grow a smaller area of land under food crops, allowing them to diversify to other crops or agricultural products according to their needs. For instance, the authors describe how farmers have become bee-keepers, enabling community-members to access honey. An especially encouraging example of the multiple benefits of agroforestry is detailed by Asaah *et al.* (2011, p. 115-6), who describe changes brought about by tree planting. Before the project, “the 7ha RIBA site was completely bare and degraded, and had been abandoned by farmers.” After the project, “the soils have been rehabilitated and the yields of wheat, maize, beans and potatoes doubled. In addition, the plot has a diverse range of tree species for other purposes. For example, in addition to providing fuel-wood, boundary trees act as windbreaks, a woodlot on the hilltop provides fodder for livestock and forage for bees, and the fields also contain local indigenous fruit and medicinal plants as well as some exotic fruits.”

These initiatives, set up with relatively low investment, yield significant income over time. For instance, eight relay organizations described by Asaah *et al.* generated a total of US\$69,584 over five to 10 periods of collaboration with ICRAF. With the ability to grow crops for sale has come the opportunity to add value through additional processing and the production and packaging of a range of products. This sets up chains of entrepreneurship, production and sales where none previously existed, creating small businesses and local non-farm jobs, and allowing farmers to “become processors, value-adders, traders, fabricators of processing equipment and so on” (Asaah *et al.* 2011, p. 118). Farmers are also assisted in securing short and small-scale loans to grow their operations. The spread of these microfinance initiatives has led to further increases in crop production and “secondary benefits from the use of these loans for casual labour have included the release of children from farm work so that they can attend school” (Asaah *et al.* 2011, p. 117). Overall, the Foresight case study from Cameroon highlights “the importance of building rural development from the grassroots, using technologies that are simple, practical and easy to implement without spending large amounts of money... Once established, these activities are self-supporting.” (Asaah *et al.* 2011, p. 119).

In another Foresight case study, Ajayi *et al.* document the success of fertilizer tree systems (FTS) in Malawi, Tanzania, Mozambique, Zambia and Zimbabwe. They, too, highlight how fertilizer trees “are inexpensive technologies that significantly raise crop yields, reduce food insecurity and enhance environmental services and resilience of agro-ecologies” (Ajayi *et al.* 2011, p. 129). As with the Cameroon case study (Asaah *et al.* 2011), adoption and spread of fertilizer tree systems in these countries has been very encouraging. Ajayi *et al.* describe how “the end of the project report of Zambesi Basin

Agroforestry Project revealed that about two-thirds of the roughly 400,000 smallholder farmers had adopted FTS in the five countries” (p. 131). The adoption of FTS potentially implies the reduced use of expensive mineral fertilizers. Ajayi *et al.* cite a study showing that “over a five-year cycle, the net profit from unfertilized maize was US\$130 per hectare compared to US\$269 and US\$309 for maize growing with *Gliricidia* or *Sesbania*, respectively” (in Ajayi *et al.* 2011, p. 133).

As a result of the social and ecological benefits from the widespread adoption of agroforestry, these and similar initiatives are being recognized as an important tool through which to implement pro-poor ‘Payments for Ecosystem Services’ schemes (Herren *et al.*, 2012). These are expected to significantly raise farmer’s incomes whilst contributing to wider agendas of carbon sequestration and resource conservation through aid. Herren *et al.* cite the pioneering efforts of the ‘Kenya Agricultural Carbon Project’ set up via a collaboration between the World Bank and the NGO Vi Agroforestry. Under the nine year project, some 40,000 smallholders in western Kenya are expected to adopt a variety of sustainable agriculture practices including soil conservation and forestry, and it is anticipated that farmers will earn nearly US\$2 million from PES payments in addition to boosting their income through improved yields and diversification as a result of the adoption of these practices.

3.4 Conservation agriculture

Conservation agriculture (CA) is growing globally by some six million hectares per year (45 million ha in 1999 to 72 million ha in 2003 (FAO, 2011c). In Africa, adoption is still relatively low in many countries (FAO, 2011c). Foresight cases document how the adoption of CA packages has led to improvements over some 26,000 ha, with a mean yield increase ratio of 2.20 and annual net multiplicative yield increases in food production of some 11,000 tonnes/year.

Likoti in Lesotho

In Lesotho, Silici *et al.* (2011) document increases in yields of food crops using a CA practice locally known as *likoti*. The method was developed by studying innovations in South Africa, and has been spread through Lesotho as a result of NGO initiatives. Silici *et al.* highlight several important features of CA as a cost-effective method with high returns. First, interviews with households practicing *likoti* indicate “suggest that the adoption of CA is not hampered by the lack of assets and income...” (Silici *et al.* 2011, p. 140). As with agroforestry initiatives described above, significant positive externalities, each with cost-saving or income-boosting effects, have accrued from the adoption and spread of *likoti*. These include improved soil structure and fertility, increased yields of food crops, the generation of profits. Silici *et al.* highlight that “poor resource farmers obtain higher yields, improve household food security and possibly, in the longer run, will be able to make a living from farming” (p. 142).

Conservation Agriculture in Tanzania and Zimbabwe

In Zimbabwe, CA has been promoted since 2003 by a CA Task Force, consisting of a consortium of NGOs, CGIAR centres, universities, the FAO and the Ministry of Agriculture. CA has subsequently spread rapidly, with farmers adopting it even without the promise of any supports or incentives. Yields have increased, and several other positive externalities are being observed, such as a comparative resilience to climate-related shocks, decreased rates of erosion and increased soil carbon and water

productivity (Marongwe *et al.* 2011). In Tanzania, CA is spread through a network of farmer field schools (FFSs), first set up as part of a programme of the German Ministry of Agriculture and the FAO. Members of these FFSs built up significant knowledge of CA practices and innovations, and reported significant increases in yields.

Reporting on yield increases in Tanzania, for example, Owenya *et al.* (2011) cite increases from an average of 2.05 tonnes/ha in 2004 to 14.00 tonnes/ha in 2009. These outcomes were also resilient to shocks and stresses that lowered yields in neighbouring areas: during the drought and elephant crop damage in 2009, farmers in the study area “harvested 20,000kg maize from the 12 acres (4.2t/ha) 1,800kg pigeon pea (375 kg/ha) and 840kg *lablab* (175kg/ha) (Owenya *et al.*, 2011, p. 149). Adopters of CA listed a range of improvements to their lifestyle as a result, including the ability to carry out household repairs, education for children, food security, the ability to save or invest in livelihood diversification and reduced debt (*Ibid.*)

3.5 System of rice intensification

In Mali, Styger *et al.* (2011) describe how the system of rice intensification (SRI) has been used to increase yields by transforming rice cultivation practices, without the addition of expensive and unnecessary inputs. Within the Timbuktu region of Mali, traditional rice cultivation has depended on the annual flooding of the Niger River. Here, the US organization Africare has worked with local farmers to adapt SRI principles to local conditions and evaluate the potential of SRI to increase rice yields and thus food security in the region. The project began informally, with a single volunteer farmer and no external funding. An SRI plot and a control were set up side by side. The performance of rice plants in the two plots was compared and neighbouring farmers and local leaders were invited to observe the results. This first test demonstrated that even without the adoption of some SRI principles, the SRI plot yielded 34% more than the control. Following this initial test, Africare obtained funding to spread the same type of comparison further. 60 farmers set up SRI and control plots. They were given a thorough briefing on SRI principles, but no firm directives, incentives or material support. Farmers were allowed to adapt SRI principles according to the conditions on their farms, and management practices and progress was monitored weekly.

At the end of the farming season, SRI plots had outperformed control plots and surrounding fields, yielding 66% more than farmers test plots and 87% more than surrounding rice fields. SRI plots used substantially fewer seeds per hectare (85-90% less than conventional plots), 30% less inorganic fertilizer and 10% less irrigation water. SRI plots yielded between 2.1 and 2.4 times more revenue than control and neighbouring rice plots. From here, Africare decided to spearhead the wider spread of SRI principles in the region, and organized farmer exchange visits and community-led knowledge transfer and experimentation. Communities themselves decided how many farmers would test SRI, and there was limited technical supervision to enable farmers to experiment on their own. Over three years, SRI spread “from one to 66 to 450 (farmers)”, across five of Mali’s eight regions.

3.6 Integrated pest management

Foresight case studies document gains across 3,327,000 ha as a result of Integrated Pest Management (IPM), spread through innovating capacity-building and institutional support. Improved pest management practices have led to the redesign of agricultural

systems, often adding many components which further improve natural and social capital. For example, in Senegal, Mali, Burkina Faso and Benin, the spread of integrated plant and pest management (IIPM) has led to the increased use of composting, market groups and the spread of new crops. There has been a 90% decrease in pesticide use, resulting in measurable decrease in pesticide residues in nearby surface waters, and seed use has fallen from 80 to 50kg ha⁻¹.

A conservation agriculture approach to pest management and soil health

Khan *et al.* (2011) document the spread of IPM as part of an integrated system of pest, weed and soil management in mixed crop-livestock systems. The system was developed by the International Centre of Insect Physiology and Ecology (ICIPE), collaborating with UK-based Rothamsted Research, the Kenyan Agricultural Institute and other national partners, and funded principally by the international charitable and aid organizations. As with the initiatives described above, smallholder farmers were directly involved from the early stages of the research and development strategy, and subsequent spread was achieved through trained farmer teachers and farmer field schools. Khan *et al.* describe how “the technology is highly appropriate for smallholder farmers who do not purchase seasonal inputs, and has consequently been adopted by over 30,000 farmers in the East African region to date with relatively small resources expended on technology transfer so far” (p. 164). They go on to describe significant increases in yields of maize and sorghum and positive externalities such as increased animal fodder and milk production and relatively higher returns on land and labour compared with conventional farmer practices. Overall, the package of technologies involved with push-pull systems has been described as “the single most effective and efficient low-cost technology for removing major constraints faced by the majority of smallholders in Eastern Africa resulting in an overall and significant improvement of their food security and livelihoods” (Fischler 2010 in Khan *et al.* 2011, p. 167).

Payne (2011) reports on the biological control of Pearl Millet head miner, via the GIMEM project funded by the McKnight Foundation’s Collaborative Crop Research Programme. The project involves agricultural research institutions, extension services, local development projects, NGOs and farmers organizations. The project has successfully adapted the rear-and-release system for *H. hebetor* for local conditions, released the parasite in 385 villages, covering some 200,000 ha. and benefitting some 700,000 farmers.

3.7 Crop variety improvements

A number of Foresight cases documented efforts to develop crop varieties, including new varieties of cassava, plantain, sweet potatoes, tef, pigeon pea and soyabean. These efforts have led to improvements over some 391,060 ha, a mean yield increase ratio of 2.18 and a net multiplicative annual increase in food production of 292 thousand tonnes per year. A striking feature of these improvements was that “in every case, participatory approaches to link with farmers were central (including participatory research, varietal testing and breeding)” (Pretty *et al.* 2011, p. 11). Improvements focused on a range of ‘orphan crops’ – those which have traditionally been neglected by crop breeding programmes and institutions. These improvements have benefitted poor farmers who were previously unable to access improvements in the past. Benefits include improved health (from improved availability of nutrients in improved crops), yield increases, increased social capital (through the formation of shareholder and business groups to process and sell cassava, for example), and positive environmental externalities (such as

the cultivation of *Quncho* Tef in Ethiopia without the use of pesticides and with only few herbicides.) Investment in building and scaling up these approaches will make a significant contribution to improved rural incomes and food security. As the cases described below indicate, investment in innovative and participatory approaches to crop development are quickly self-sustaining and result in a number of positive social and environmental externalities which are in turn cost-saving and income-generating.

Quncho Tef in Ethiopia

Assefa *et al.* (2011) describe the development of *Quncho*, a Tef variety released in 2006. *Tef* demonstrates a number of positive agroecological traits which help farmers build or maintain natural capital and resilience. It has a very broad and versatile adaptation to a variety of environments, good tolerance to moisture stress and does not suffer from pests. It is a good candidate crop for using under conditions of climate change and environmental degradation.

A number of agricultural and institutional innovations contributed to its success and spread, including participatory variety selection and plant breeding and an innovative approach to agricultural extension. These innovations have contributed to remarkable spread: “In the four years (2006-2009), the number of farmers’ households directly involved in the scaling up increased from 300 to 7,741. The average annual increment in each year varied from 69 percent in 2007 up to 454 percent in 2009... (not including) farmers adopting the variety through farmer-farmer exchange, farmers once involved in scaling up activities and not participating again as they are supposed to use their own-saved seeds, and farmers obtaining the technology through the regular extension system...” (Assefa *et al.* 2011, p. 29). The success of this approach is demonstrated by the fact that after the initial investment and effort, Assefa *et al.* state that “presently, the dissemination of the *Quncho* variety is a state of ‘self-drive’ that apparently needs no further popularization and demonstration since the demand for it is increasing steadily” (p. 32).

Orange-fleshed sweet potato in Uganda

In Uganda, the Uganda Sweet Potato Program developed new orange-fleshed cultivars to respond to the challenge of developing varieties which combined high resistance to pathogens and high concentrations of nutrients. The process of developing the new cultivar relied on a highly collaborative, international research and development effort, well-supported by international and national donors. Households adopting the new cultivar have been able to boost income and nutritional security. Mwanga and Ssemakula (2011) describe how “a single farmer can earn about US\$400 per month from the sale of planting materials and sweet potato products” in Eastern and Central Uganda. The cultivar has contributed to improving the vitamin A status of children and overall, “there is compelling evidence... of the potential contribution of OFSP to improved nutrition... replacing white-fleshed varieties with OFSP varieties could reduce the vitamin A deficiency (VAD) burden by 15-22 percent” (Mwanga and Ssemakula 2011, p. 47). Mwanga and Ssemakula add that “OFSP varieties are especially important because they are ideal in addressing hunger, poverty, and macro and micro undernutrition due to their ability to generate superior levels of food per unit area per unit time during relatively short rainy periods, giving them advantage over major staples” (p. 47).

Cassava in Uganda

Also in Uganda, the Maendeleo Agricultural Technology Fund (MATF) supported a project to revitalize cassava production through the introduction of disease-resistant

varieties in order to improve food security and incomes. The development of improved varieties was accomplished through the work of the Namulonge Crop Resources Research Institute, with the input of representatives from the local farming community and the support of the local government. Alongside the introduction of new cassava varieties, farmers were supported by cassava-processing facilities funded by international donors and managed by a consortium of local groups. Extension and spread was achieved through the training of ‘farmer-trainers’. This approach has built significant human and social capital: 43 percent of new adopters during a one-year extension phase were women; it has “brought about social cohesiveness among the farmers as the cassava forums are also used to discuss other matters, including HIV/AIDS and general community development” (Roothaert and Magado 2011, p. 79).

Soybean in Zimbabwe

In Zimbabwe, the Soyabean Promotion Task Force (SPTF) aimed to promote crop diversification away from an exclusive reliance on maize; farmers and scientists were interested in soyabeans’ potential “improve soil fertility through biological nitrogen fixation... (and provide) cash income, household nutrition, livestock feed and increased maize yields in rotation” (Giller *et al.*, 2011, p. 50-51, parentheses added). Notably, alongside research and development of specific soybean varieties, the case study demonstrates the importance of adequate training and support to farmers, including a comprehensive ‘input package’, assistance with marketing from communal farming areas and “substantial background research... to gain a better understanding of the benefits and constraints of growing soyabean on smallholder farms” (Giller *et al.*, 2011, p. 53), including economic assessments of the market demand for soyabean and the assessment of models for the involvement of farmer’s organizations (Rusike *et al.* 2000 in Giller *et al.*, 2011). Other factors contributing to the subsequent spread of soyabean cultivation included the “strong commitment of the SPTF to demonstrate the multiple benefits of soyabean to farmers... and the timely engagement of relevant stakeholders at each stage of the value chain” (Giller *et al.* 2011, p. 55). As with all other cases described within the Foresight report, significant, positive and income-generating / cost-saving externalities resulted – notably the doubling of maize yields as a result of the addition of nitrogen from soyabean cultivation. Building upon these successes, a initiative called ‘Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa’ aims to replicate this initiative across eight countries of sub-Saharan Africa.

3.8 Making the most of patches with vegetables and aquaculture

The cultivation of vegetables on raised beds involving the intensive use of small patches of land outside the normal boundaries of fields allow the revival and spread of traditional vegetation, improving the productivity and the availability of vegetables during the dry season. Pretty *et al.* (2011, p. 15) describe how “...farmers have been able to obtain greater returns from markets as well as use 50% less fertilizer and 30% less pesticide than for conventionally grown vegetables.” Making the most of patches is also seen in the construction of farm ponds or tanks in which to raise fish. Besides producing nutritional benefits for farm households, “market demand for fish is high, and this is partly driving the emergence of small businesses raising catfish and tilapia” (Pretty *et al.*, 2011, p. 16).

In 2004, FARM-Africa funded a project of the World Vegetable Centre to “increase the productivity, utilization and marketing” of African Indigenous Vegetables (AIV) in Tanzania and Kenya in order to “enhance the economic empowerment of vulnerable

members of society, mostly women farmers, through enterprise development” (Muhanji *et al.* 2011, p. 195-196). The project promoted vegetable species through the ‘training of trainers’, the support of business groups, linking producer groups. The contribution of vegetable cultivation offers a very effective and efficient way to boost food and nutritional security: “AIVs (were perceived by farmers) to be nutritious, easily available at little cost, taking less time to cook, bridging food gaps during dry periods and offering income to women without men’s interference” (Muhanji *et al.* 2011, p. 199). Positive externalities include cost-savings (as fewer inputs are required to support the cultivation of indigenous vegetables compared to exotic varieties); the start-up of small initiatives to process vegetables (e.g. the creation of dried vegetable business ventures); the development of social and human capital, especially for women (e.g. through womens’ groups and the training provided to them). Production practices were also designed to maintain or build natural capital – cultivators used integrated pest management, avoided the use of inorganic inputs or used them only sparingly, and the conservation of the genetic diversity of indigenous varieties.

Aquaculture, especially when integrated within crop cultivation, is also a form of patch management. Integrated aquaculture-agriculture (IAA) in Malawi and Cameroon has been reviewed by Brummett and Jamu (2011). They describe the outcomes of a project undertaken by the WorldFish Centre, supported by various donors, and partnered by international and national research and rural development agencies as well as local farmers. These partnerships began to explore the potential of spreading IAA in the early 1990s. Where successful, IAA has been found to contribute to “a 40% improvement in farming system resilience (i.e., defined by the ability to maintain positive cash flows through drought years), a 50% reduction in nitrogen loss and improved nitrogen-use efficiency.” Agricultural productivity has increased, as as per capita farm income, and per capita consumption of fish.

In Nigeria, the rise of peri-urban aquaculture “brings into focus several innovative ‘firsts’ in African aquaculture development” (Miller and Atanda 2011, p. 276). Aquaculture has progressed from a subsistence-focused activity to one connected to a growing market: Miller and Atanda report “a remarkable 20% increase in growth per year for the past six years, with high growth in small-to-medium-scale enterprises and a number of large-scale intensively managed fish farms” (p. 274). Aquaculture here is primarily focused on the African catfish (*C. gariepinus*), and is characterized by a highly developed production chain of suppliers, processors and marketers, supported by private-sector technical staff, a growing competence with public extension services, government support via livelihood programmes and credit support from lenders. Nigerian catfish aquaculture is estimated to provide some 17 per cent of the country’s total domestic fish production. Producers have been able to diversify into further animal husbandry, keeping cows, pigs, goats and sheep. Aquaculture also supports crop cultivation, via the supply of irrigation and fertilization from fish ponds.

3.9 Livestock rearing

Foresight cases specifically focused on improved livestock production have focused on improved disease management, the spread of new, locally-developed breeds and the cultivation of new fodder crops. These developments have resulted in gains across some 300,000ha across Africa (Pretty *et al.*, 2011). In addition to projects specifically targeting livestock management and fodder crops, many of the Foresight cases demonstrate how improved land and water management has supported livestock management. For

example, the rehabilitation of degraded land in Niger has increased the availability of fodder, with the result that 80% of women now own livestock (Pretty *et al.*, 2011).

Meru dairy goat rearing in Kenya

Peacock and Hastings (2011) describe the strategies used by FARM-Africa to improve the prospects for the rearing of dairy goats in Kenya. The project described involves the crossing of imported breeds with local goats, to produce an improved local breed that is faster growing and produces more milk for sale. In addition to the breeding programme is a system of community-based animal healthcare, affordable to even the poorest beneficiaries.

The system of community-based breeding and healthcare has resulted in significant productivity improvements. Peacock and Hastings state that “The current average annual milk yield is 21 litres for non-participants owning local goats and 463 litres for both project and private breeders owning ¾-cross coats, which demonstrates that milk yields have increased by 2200 per cent for farmers following the goat model” (p. 207). As a result of the community-based animal healthcare component, project beneficiaries recorded a 60% reduction in the incidence of disease among their animals. Peacock and Hastings report evidence of better surveillance and control of diseases such as Newcastle disease and anthrax. Community-based animal healthcare has spread beyond the aid given to goats reared under the programme: “75% of treatments mentioned by farmers questioned in 2003 (are) given to animals other than goats” (p. 209), and other animals being reared in the study area benefit from preventative healthcare via vaccination programmes coordinated by community groups set up under the project.

Livestock disease management in Mali and Burkina Faso

Another case study describes a project to improve the management of African animal trypanosomiasis (AAT) amongst villages in Mali and Burkina Faso. Liebenehm *et al.* (2011) report that participants in a disease management programme, which involved training farmers in the management of AAT, with a view to preventing the development of widespread resistance as a result of the incorrect administration of treatment. The project involved several techniques to disseminate information on AAT and its management. Management principles were disseminated to animal healthcare providers, farmer-experts and ‘paravets’ and directly to farmers. During the second (scaling-up) phase, information on disease management and drug resistance was broadcast via radio and via a comic book developed by a communication specialist. When participants and non-participants knowledge was tested via survey, Liebenehm *et al.* found that participants were relatively more successful in treating AAT than non-participants, and that participation in the programme was associated with higher revenue.

Fodder shrubs in East Africa

A case study on improved fodder shrubs (Wambugu *et al.*, 2011) describes how through on-farm experimentation, farmers have begun to incorporate fodder shrubs into the daily rations given to their animals, resulting in substantial increases in milk production and the ability to tide over feed shortages during the dry season. The case study describes how, following research on suitable fodder crop varieties in the 1980s, a number of international, national and regional organizations initiated projects which promoted the use of species such as *Caliandra calothyrsus*, *Leucaena spp.*, *Chamaecytisus palmensis*, *Sesbania sesban*, *Morus alba* and *Gliricidia sepium* as fodder. Following these projects, demand for seeds increased substantially and a system evolved to ensure that farmers had access to the required planting materials. A number of

communication strategies were also deployed, to raise awareness, disseminate information and mobilize community participation. Wambugu *et al.* estimate that by 2005, some 205,000 smallholder farmers, just under half of them women, planted fodder shrubs across Kenya, Rwanda, Tanzania and Uganda.

Rakai chicken

Roothaert *et al.* (2011) describe the impacts of improved breeding and management techniques for poultry in Uganda. In addition to a controlled breeding programme, poultry keepers were also instructed in improved poultry feeding, housing and healthcare. Additional support was provided by giving assistance to build rainwater harvesting tanks (to mitigate the impact of drought), and child-headed families (i.e., those who had lost adults to HIV/AIDS) were given support with various tasks, enabling them to benefit on par with adult farmers. The project enabled households, and especially women and children, to benefit from the increased production of meat and eggs for personal consumption and sale, poultry manure for the fields, and helped to raise incomes and thus yield other improvements for households and communities. For example, Roothaert *et al.* describe how “it has enabled farmers to purchase household property, pay the school fees of their children, meet their basic needs, build houses, establish solar power and buy a few cows, among others” (p. 227).

3.10 Summary

These improvements to ecosystems and practices show how both agricultural and environmental benefits can be maximised under systems which complement biological and ecological processes. Practices have involved complex mixes of plant and animal species and associated management techniques built on new skills and knowledge developed by farmers and outside organisations. These practices have increased yields, and contributed resilience, while creating significant positive externalities, including increased carbon sequestration in soils, nitrogen-fixation, reductions in the use of synthetic pesticides, reduced run-off and soil erosion, increased groundwater, and greater diversity of habitats and species.

Section 4: Institutions and policies for spread and scaling-up

4.1 Institutional capacity and support

All the Foresight case studies demonstrate the importance of a strong network of partnerships, helping to develop innovations, disseminate them, support their spread and add value through additional processing and commercialisation. Partnerships involve linkages across institutions, sectors and scales. NGOs and other civil-society organizations, research organizations, farmer groups, businesses, banks, government agencies and policy bodies have all had a contribution to make in each case of sustainable intensification.

Two important aspects of these partnerships are the central role played by various forms and levels of social capital, and the role of the private sector.

The case studies show how the development of social capital helps to develop, spread and sustain innovations, allowing farmers and communities to make the most of the investment in agricultural development. Social capital encompasses the relationships between people and between groups in cultural and economic life. It is built upon relations of trust and reciprocity, and maintained through norms and sanctions. Social capital is an important prerequisite for the successful and sustained adoption of agricultural innovations and sustainable behaviours and technologies. Pretty *et al.* (2011) describe how “almost all the 40 projects analysed are engaged in the development and formation of new forms of social capital, which when connected together has resulted in the emergence of a new social infrastructure in rural areas” (p. 17). This infrastructure, which includes farmer field schools (FFS), cooperatives, rural resource centres, business groups, common interest groups, micro-credit groups and catchment management groups, allows the spread of innovations much more effectively than the old ‘transfer-of-technology’ style of extension.

Many projects have shown that “farmers are also entrepreneurs and business people”, even though they “are rarely thought of in this way” (Pretty *et al.* 2011, p. 18). Links between farmers, private sector organisations and public sector groups and organisations have resulted in some novel partnerships which demonstrate excellent returns. These include, for example, the Ghana Grains Partnership (Guyver and MacCarthy, 2011), the spread of sustainable tea production in Kenya (Mitei, 2011), the spread of FFSs in West Africa (Settle and Hama Garba, 2011) and partnerships to integrate aquaculture into small-scale African farming (Brummett and Jamu, 2011).

The Foresight cases demonstrate how novel partnerships and linkages have been instrumental to the development and dissemination of new crop varieties (e.g. Assefa *et al.*, 2011; Mwanga and Ssemakula, 2011; Giller *et al.*, 2011), the spread of better practices (e.g. Ajayi *et al.*, 2011; Khan *et al.*, 2011), and the creation of new market linkages and value-chains (e.g. Guyver and MacCarthy, 2011). Notably, the cases demonstrate the importance of a range of partners, across different scales, supporting different aspects of each development effort, from funding, to research and development, dissemination, providing support and opportunities for value-addition, to marketing and sales. Smallholders have been active local partners, and the direct beneficiaries.

Multi-agency partnerships are particularly important against the context of weak extension and support systems. In the case of *Tef* development in Ethiopia (Assefa *et al.*, 2011), for example, *Quncho* tef was spread via a mix of different extension and support systems, including the use of farmers' fields as demonstration plots, the provision of a revolving seed loan, the provision of regular farmers' training, inputs, market options and regular follow-up and supervision. Given that Ethiopia's formal seed system supplies only a minority of the country's total demand, access to informal partnerships and strong social networks are essential for farmers seeking to capitalise on new developments.

The private sector has a potentially beneficial role to play in sustainable intensification, through the provision of knowledge, innovation and markets. These can help to ensure that increased crop production translates into higher incomes for farmers. Farmers are keen to engage with well-regulated and fair markets. The Foresight cases show that where this is possible, farmers have emerged as entrepreneurs and business people, though previously, they have rarely been thought of this way (Pretty *et al.*, 2011). It is also clear that globally, the private sector is a key source of much-needed investment in agriculture.

Partnerships between the public- and private sectors have been shown to yield significant positive results. For example, Mitei (2011) describes a private-public partnership between Lipton Tea and the Kenya Tea Development Agency (KTDA). The partnership received financial support from the UK's Department for International Development (DFID) and input from the Tea Research Foundation of Kenya, Wageningen University and the NGO ETC Africa. The aim of the project was to improve farmers' incomes and spread the use of good agricultural practices (GAP) amongst smallholders. The Project used a FFS approach to disseminating information, with "the role of the extension worker or scientist ... to be a facilitator, rather than a teacher" (Mitei 2011, p. 60). The initial FFS pilot project won funding of £509,000 from DFID, who saw the approach as "a pilot for a process that could eventually improve the livelihoods of an enormous number of farmers, farms and farming communities, to reach over a million people" (Mitei 2011, p. 61). The FFS model resulted in the development of a strong network of relationships at local level between farmer's facilitators, managers and partners (Mitei, 2011).

These relationships and the trust and cooperation they embodied were perceived as highly beneficial by the farmers, who reported that they "observed positive changes in their livelihood (including) better empowerment, access to information, personal development, conflict resolution, relationship with the factory and leadership ability" (Mitei, 2011, p. 62). The 'high-level' partners (Lipton and the KTDA) too "had to develop a more collaborative and trusting working relationship, across very different business cultures with different expectations and priorities" (*Ibid.*) FFS training allowed the local tea factories who bought from the farmers to apply for Rainforest Alliance certification, and "it is expected that the improved water and waste management practices that are a requirement for Rainforest Alliance certification will continue to produce environmental benefits in the years to come" (Mitei, 2011, p. 64).

Overall, the partnership leveraged the DFID grant of £509,000 and:

- Built upon existing relationships between an international buyer (Lipton) and national authorities (the KTDA), using funds from an international development agency (DFID);

- Built significant human and social capital at local level, between farmers and across different FFSs;
- Allowed for the dissemination of information more effectively than the conventional approaches to extension spread information on sustainable practices, allowing for Rainforest Alliance certification and
- Demonstrated that “smallholder farmers have enormous potential for improving yields and producing high-quality produce (Mitei, 2011, p. 65).

Another Foresight study to describe a private-public partnership describes the Ghana Grains Partnership (GGP) (Guyver and MacCarthy, 2011). In Ghana, “current development objectives place a great deal of emphasis on broad-based, pro-poor agricultural growth with an emphasis on expansion of high-value and export-oriented cash crops and improved production of food crops” (Guyver and MacCarthy 2011, p. 35). The GGP aimed to lessen shortfalls in maize and other grains by developing the appropriate value chains within a supportive policy environment. The partnership involved: private actors (Yara and Wienco); the Africa Enterprise Challenge Fund; farmers and farmers associations, the Ministry of Food and Agriculture, commercial banks; the NGO, Technoserve and output buyers and traders. Advisory services were provided by Prorustica and its local partner, MCM Associates. The main commercial partners provided technical and financial assistance for the establishment of the Masara N’Arziki Association in 2009, which aims to grow rural communities and economies through developing maize cultivation.

Guyver and MacCarthy (2011) describe how the GGP demonstrates three innovative aspects. First, it demonstrates a ‘twinning’ of both commercial and non-commercial objectives at national level; second, it meets the needs of Ghanaian farmers holistically, through attention to complete agricultural value chains, delivering “realistically priced, agronomically and economically efficient inputs and finance, as well as addressing the constraints to more effective agricultural commodity output markets” (p. 36); and third, it encourages open and well-informed dialogue between public and private sectors. The partnership has facilitated the supply of inputs and credit facilities to farmers and provided training on good agricultural practices. Guyver and MacCarthy describe how the partnership model has built upon existing relationships and enabled “private-sector led, small-scale farmer growth” (p. 39), helped to increase yields and spread commercial and profitable maize cultivation. The model is being replicated in Malawi, Tanzania and Mozambique.

The Oxfam Strategic Cotton Programme aimed to change the lives of poor cotton producers in West Africa and particularly in Mali, by “improving organisational capacity, building local ownership, empowering women, reducing vulnerability to the impacts of climate change, giving a voice to poor producers and diversifying income sources” (Traore and Bickersteth, 2011, p. 83). In this case, the partnership was developed by the international development NGO Oxfam, building upon an evaluation of the constraints facing Mali’s cotton sector. Partners included Oxfam GB and Oxfam America and a range of national and international organisations.

In Cameroon, the FAO, in partnership with the Cameroon government, set up projects in order to establish smallholder seed enterprises (SSEs) to provide smallholders with access to high quality rice, millet, sorghum and maize seeds. The projects provided training on all the technical aspects of seed production, with an emphasis on “the

development of the groups as business entities” (Guei *et al.*, 2011, p. 93). Farmers were first made aware of the potential benefits of embarking on seed production as a group. Groups were created as formal organisations, and given status as legal entities. They were provided with training on the production of quality seeds. Partnerships were established with research organisations, the extension system, the national seed service and credit and finance institutions. These partnerships, along with the training given to seed groups, enabled groups to establish themselves as sustained and successful small business enterprises with significant positive results for agriculture.

Guei *et al.* report that “rice seed production increased from 267 tonnes at the beginning of the project in 2005 to 800 tonnes at the end of the project in 2006. Seed production has been sustained since the project ended” (p. 96). For other crops, they report 30 percent increases in the production of maize, millet and sorghum seeds between 2008 and 2009. The seeds thus produced and sold are driving substantial yield increases, income increases, and following from this, allow farmers to diversify into other income-generating activities such as animal husbandry and vegetable cultivation. Guei *et al.*, emphasise the importance of partnerships at all levels and across sectors in bringing about these successes: “Developing a national seed sector... requires cadres of skilled and knowledgeable people at all levels in the seed ‘chain’, and therefore training at all levels, from farmers to scientists and policy makers. Financial and technical support for seed production from governments, donors and extension services is essential during the early stages of development of seed enterprises” (p. 99).

Multi-agency partnerships have also been vital to providing training to farmers on various aspects of sustainable intensification. In West Africa, Settle and Garba (*op. cit.*) describe how some 116,000 smallholders have benefited (as of the end of 2010) from training on various aspects of sustainable intensification via a farmer-field schools approach by the IIPM programme.

Overall, the Foresight cases show that “the greatest gains would be achieved through a range of parties working within an integrated framework to deliver the sustainable intensification of agriculture designed around local circumstances” (Foresight 2011, p. 128).

4.2 Building supportive policies

A supportive policy environment would act as a significant catalyst for sustainable intensification. However, in general, Pretty *et al.* (2011) conclude that “many successes have emerged despite policy rather than because of policy” (p. 19), adding that “The exceptions, however, show that activities can be greatly scaled up with the appropriate policy support” (*Ibid.*)

There is scope for greater support through investment. On average, African countries spend between 4-5% of their national budget on agriculture, compared with 8-14% in Asia (Fan *et al.* 2008 in Pretty *et al.* 2011). The Foresight cases which demonstrate the beneficial impacts of supportive policy environments are summarised below.

Policy support for innovation of plantain banana in Western and Central Africa

Policy support for innovation is illustrated by the case of the African Research Centre on Banana and Plantain (CARBAP) in a case study by Tomekpe *et al.* (2011). The CARBAP

provides a regional framework for research, training and support for agricultural development with a focus on banana and plantain. The partnership was formed by an intergovernmental agreement across 5 countries (Cameroon, Congo, Cote d'Ivoire, Ghana and Nigeria), and thus represents an example of how policy support can drive agricultural development beyond the national scale.

Malawi's agricultural input subsidy programme

Dorward and Chirwa (2011) describe the implementation of Malawi's programme of subsidies for fertilizer and seeds and review its operation from 2005 to 2009. Based on experience gained from earlier programmes from the 1970s onwards, the Malawian subsidy programme began in 2005, to target around 50 percent of the country's farmers as beneficiaries of subsidised fertilizers for maize and tobacco, and improved seed varieties. The programme aims to improve small farmers' access to inputs, so as to increase their and national food self-sufficiency and incomes. The programme has resulted in a net reduction of maize imports from 132,000 in 2005 to 1,000 tonnes in 2008-9. Maize production has increased by between 406-866,000 tonnes per year. Poor households have reported income increases of 10-100 percent. Whereas earlier subsidy programmes between the 1970s and 1990s failed, the 2005-6 programme has grown steadily. In part this may be attributed to innovations and adaptations which allowed for improvements to be made; a supportive policy environment and effective governance mechanisms have contributed significantly to these improvements.

Extension policy in Kenya

Policy support is also important for improved extension services. Kiara (2011) describe the Kenyan National Agriculture and Livestock Extension Programme (NALEP) which was formulated in 2000 to address the particular needs of an agricultural sector dominated by smallholders, with high literacy levels, high population density, operating within a liberalised economy and facing environmental degradation and climate change. A key innovation has been the mainstreaming of participatory methodologies into the entire extension service, as a result of prior experience of participatory programmes in the country. Another notable feature is the 'integrated' nature of the extension service: the programme seeks to implement agriculture-based development, rather than simply provide information about agricultural innovations.

Kiara (2011, p. 252), describes how "NALEP is a broad programme that goes beyond agriculture and considers all those other services as necessary to promote rural development with a bias to agriculture." Assessments of the programme show increased yields, and decreased nutritional deficiencies due to the increased availability and sale of food. Improvements have included the spread of kitchen gardens, supplying households and local markets with vegetables. In addition to the nutritional benefits of increased vegetable consumption, poor households have benefited from the increased income.

The focus on participatory services tailored to local needs means that diverse, context-specific requirements can be catered to within the same programme. For example, in drought-prone districts, extension agents have been able to introduce drought-adapted crops such as cassava, cowpeas and sweet potatoes, thus stabilising food security in an otherwise vulnerable context.

The success of NALEP has been attributed to well-trained extension staff, a well-managed participatory extension service, partnerships with different stakeholders who can support the various needs of agricultural communities and a supportive policy

environment. Kiara (2011, p. 255) concludes, “A fourth factor (underlying the programme’s success) is the ownership of the programme by the Kenyan government. Unlike many other similar projects, NALEP was formulated by the government from within and by taking into account the lessons learnt... it was given priorities in many aspects, not least ensuring that budget is correctly reflected in development estimates, funds are taken up as planned to implementing stations... adequate staff are deployed to manage and implement, important lessons learnt are adopted in similar projects or within government institutions, used to inform policy formulation and sometimes used to justify the need for additional development assistance from other donors.”

4.3 Constraints on further improvements

Continued investment in sustainable land and water management requires better knowledge of the costs and benefits of the approach, at all scales and over both short and long-term. So far, there is wide consensus on their desirability, but not enough knowledge of their worldwide scope or spread, and little precise knowledge of cost-benefit ratios (but cost-benefit ratios not only way of measuring things) (FAO, 2011c). Only recently are people beginning to work on a global monitoring and assessment standard that can compare across cases and maintain precision while transcending an exclusive focus on physical targets (FAO, 2011c).

Practices designed to improve productivity through improved agroecological management are often criticized due to a perceived need for increased labour (Tripp, 2005). However, the labour-intensity of these practices is highly site-specific. For example, in places where HIV/AIDS has removed a large proportion of the population, labour might be constrained and unavailable. In other cases, a need for increased labour helps to stem unemployment. For example, in Kenya, women have been able to employ local people to work on vegetable cultivation and marketing. In Burkina Faso, groups of young men are engaged in soil conservation through *tassas* and *zai*. Thus, increased labour-intensity has absorbed part of the labour force which would otherwise be unemployed or forced to migrate.

Where projects depend on the international transfer of knowledge, expertise or materials, long-term maintenance or spread has sometimes been constrained by regulation. For example, the Meru-goat development programme has been constrained by the import ban on European goats.

All the Foresight cases demonstrate the need for institutional partnerships between sectors and across scales. Where these are weak, initial successes cannot be replicated or spread. For example, in describing the key constraint to the wider adoption of *Quncho* tef in Ethiopia, Assefa *et al.* (2011b) describe how weak seed systems hinder the adoption of improved varieties in the country. Considerable effort was required to develop both formal and informal support for the spread of improved seeds and their further development.

Prevailing attitudes and preferences can also hinder progress. In Ethiopia, the initial development of new tef varieties was constrained by attitudes amongst farmers, extension workers and the public at large that existing varieties were not amenable to scientific improvement. The subsequent spread of *Quncho* was hindered by the preferences of private sector seed companies who focussed only on relatively profitable, high-value crops such as hybrid maize and vegetables.

4.4 Opportunities and avenues for spread

Summarising conclusions from across case studies (including but not limited to the African cases presented within this report), Foresight (2011, p. 175) presented the following five key priorities for governments in developing contexts (Table 4).

Table 4. Five key priorities for governments

1. Prioritise strategies to meet or exceed MDG hunger targets, linking as required with broader poverty alleviation and climate change response themes, building rural incomes and ensuring the urban poor have access to healthy diets. Help civil society monitor government resource flows and other actions towards these goals.
2. Give greater priority to the food production sector as an engine for both rural and urban development (for example, by meeting the African Union pledge of investing 10% of government expenditure in this area); invest in the economic, physical and social infrastructure to facilitate food production; promote entrepreneurship along supply and value chains.
3. Help smallholders increase productivity through strengthening land and water rights, microfinance, insurance, market access, extension services etc, paying particular attention to the needs of women, and building local and community capacity for resilient and sustainable production; throughout use an evidence-based approach to choose most effective interventions.
4. Work collaboratively and learn from best practice to develop scalable models of sustainable terrestrial and aquatic production across food systems
5. Support access for international food trade within broad strategies of national food supply and security, equity and sustainable resource use.

Within the African Union, the cases of sustainable intensification described within this report imply seven key requirements for the successful scaling-up and spread of sustainable intensification (Table 5).

Table 5: Seven requirements for scaling-up sustainable intensification in Africa

1. Science and farmer inputs into technologies and practices that combine crops–animals with their agro-ecological and agronomic management
2. Create novel infrastructure that results in both flows of information and builds trust among individuals and agencies
3. Improvement of farmer knowledge and capacity through the use of FFSs, farmer trainers, videos and modern ICT
4. Engage with the private sector to supply goods and services (e.g. veterinary services, manufacturers of implements, seed multipliers, and milk and tea collectors) and develop farmers' capacity to add value through crop processing and broader business development
5. Focus particularly on women's educational, micro-finance and agricultural technology needs, and build their unique forms of social capital
6. Ensure that micro-finance and rural banking are available to farmer groups (for both consumption and production purposes)
7. Ensure public sector support to lever up the necessary public goods for sustainable intensification of agriculture in the form of innovative and capable research systems, dense social infrastructure, appropriate economic incentives (subsidies, price signals), legal status for land ownership and improved access to markets through transport infrastructure

Policy support and strong institutional partnerships at every scale are critical. However in many cases, successes have emerged despite prevailing policies rather than because of them, with exceptions showing how effective policy support can result in significant

success and spread (Pretty *et al.*, 2011). It is also clear that agricultural policy needs to be integrated with other relevant policy areas (Garnett and Godfray, 2012). Policy-support for sustainable intensification of food production will not translate into food security, poverty alleviation or resource conservation if it is not well-integrated with appropriate environmental, rural development and economic policies. Without such integration, policies are likely to have short-lived or even perverse impacts. A good example of the need for policy integration is found in the complementarity between physical infrastructure and agricultural income. Where a lack of infrastructure prevents effective linkages with markets or hinders the development of value-chains, good agricultural development relies on revitalized policy support for infrastructure development.

A clear policy need is for increased state involvement in agricultural research, development and extension. These need not entail the top-down, monolithic and centralized institutional structures which characterized previous state responses to agricultural problems. Support for these centralized structures has declined as a result of their limited success and because of the growing recognition that decentralized, adaptive and flexible institutional structures produce better outcomes. However, this has resulted in disinvestment in state-support for agricultural R&D, rather than in a transformation of previous approaches. Where extension systems have been closed or underfunded, countries lack the institutions required to support farmers. Where they have been supported over the long term, significant positive gains have ensued. In Kenya for example, support for the National Agricultural and Livestock Extension Programme has enabled it to reach some 500,000 farmers each year. Initial support to 4,500 catchment groups has been extended to 7000 common interest groups (CIG) each year (Kiara, 2011). In Ethiopia, the Ethiopian Institute of Agricultural Research (EIAR) has played a significant role in scaling up the adoption of *Quncho* tef.

In part, the increased involvement of the private sector at all points in the agricultural production chain is filling this gap via a bricolage of institutions and organizations that provide different kinds of support to farmers. The engagement of the private sector cannot act as a substitute for state governance, or produce sustainable outcomes within a governance vacuum. The state has a clear role in shaping the environment within which an emergent private sector can contribute to sustainable intensification, through the provision of clear policy goals, holding private actors accountable to national laws and regulating their actions. A particular priority for the future governance of the agri-food system within Africa is navigating the past, present and future land-purchase and leasing agreements for sovereign wealth-funds and businesses (Foresight, 2011).

4.5 Summary

In summary, a number of interrelated factors have contributed to the success and spread of the initiatives described within this report.

First, it is clear that successful outcomes have taken time. They are the result of long-term research programmes which build upon each other, learning from previous projects, careful project design and good piloting. Long-term approaches require committed funding, dedicated personnel, good links along the entire value chain, robust monitoring and the ability to learn from success and failure and adapt accordingly.

It is clear that the participation of farmers and communities was important at every stage. Participatory approaches to knowledge-creation and spread have resulted in products and practices that are relevant to farmers needs and appropriate for their context. Within this arrangement, researchers have acted as facilitators, playing a coordinating and mentoring role rather than imposing externally-developed research outcomes onto local communities. The Foresight cases also emphasize the importance of low-cost, appropriate technologies, developed with a consideration for the financial constraints faced by smallholders. This approach has allowed knowledge and new practices to spread organically across communities, with farmers teaching each other and allowing people to adapt techniques to suit their own circumstances. Awareness has been spread through the use of the mass media – television broadcasting, the creation of pamphlets, the use of print media and even peer- to peer-learning using videos. In sum, upscaling has been achieved, and further spread is ensured, by developing and disseminating technologies which are low-cost, context-appropriate, amenable to sharing and adaptation, which yield widely discernable benefits and which can be adopted incrementally by smallholders who are limited in how much land, finance and labour they are able to invest.

It is also clear that learning for sustainable intensification requires more than just technical knowledge and skills. It also encompasses overcoming previous expectations about what works and what does not, what to expect from new technologies, how to share and adapt new techniques, and how to strike a balance between risk-aversion and risk-taking. Complexity is also added by the fact that sustainable intensification requires packages of technologies working together. Training and adoption is thus not a one-off event, or even restricted to a single short-term project-based approach. It is for this reason that participatory approaches conducted within a context with high social capital is vital for successful adoption and spread.

When these conditions are met, the Foresight cases show that scaling-up gathers momentum spontaneously.

An important implication of this is that policy makers, civil society and the private sector need to provide an enabling environment in which knowledge, once co-created and shared, can be successfully applied. When farmers are made aware of new practices and products, they must be able to access the credit, inputs, technologies and markets required to capitalize on new developments. In some cases within the Foresight compendium, it has become clear that the supply of inputs and products has not been able to keep pace for the demand generated by initial success.

This implies that communities and other stakeholders in sustainable intensification must plan for the long-term, beyond the scale of individual projects. Sustaining success over time requires the active support of the State. Even though successful projects are partly self-sustaining, the State remains responsible for the wider context within which communities live and work. Public sector bodies are thus responsible for maintaining an environment in which farmers can capitalize on initial investment by providing extension support, building infrastructure (especially for irrigation, transport and storage), enabling access to credit, improving the security of land tenure and providing access to equitable markets for smallholders. Strategic, long-term planning is especially required to ensure funding for continued research, investment in extension and support services, and where required, the provision of appropriate subsidies, credit and loans to local communities. This strategic planning is required at every level, from local communities reinvesting part of their returns to local and national governments planning for sustained success.

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