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Critical Issues for Future sub-Saharan agriculture

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A contribution to the discussion on

Critical research issues for future sub-Saharan African agriculture

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**Critical research issues for future sub-Saharan
African agriculture**

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Foreword

Agriculture, food security and poverty alleviation are strongly interconnected in sub-Saharan Africa. The increase in agricultural productivity and production and connected positive developments seen in other parts of the world have not happened to the same extent in sub-Saharan Africa. The reasons for this are complex but we believe that multi- and interdisciplinary science at different scales could make a positive change in this context.

The Future Agriculture programme at the Swedish University of Agricultural Sciences (SLU) has taken on this challenge by creating a working group with researchers from several institutions in Sweden: Lund University, Nordic Africa Institute, Swedish Defence Research Agency and SLU.

The approach has been forward-looking by using scenario methodology based on previous work at Future Agriculture and broad by including several academic disciplines.

We hope that this report will contribute to tackling the challenges of improved food security and reduced poverty in sub-Saharan Africa by stimulating discussions and actions among colleagues and stakeholder on national and international arenas.

Uppsala June 2012

Ingrid Öborn
Programme Director for Future Agriculture
– Livestock, Crops and Land Use



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Nordiska Afrikainstitutet
The Nordic Africa Institute

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1. Introduction

The primary, overarching UN Millennium Development Goal (MDG) is to 'To halve extreme poverty and hunger from 1990 to 2015' (UN 2000; see Box 1). Clearly, agriculture must play a key role in reaching this goal. In most of the sub-Saharan Africa (SSA) countries, agriculture is also a basis for economic development, because large parts of the population are actively engaged in agriculture (World Bank 2007). The importance of agriculture for development is reflected in the target stated in the African Union's Maputo Declaration of 2003, for member governments to allocate 'at least 10 percent of national budgetary resources to agriculture and rural development policy implementation within five years' (Maputo Declaration 2003). Unfortunately, several SSA countries have not yet reached this target.

It is often held that a 'revolution' in smallholder productivity is needed to initiate the required growth in agriculture. However, mimicking the green revolution that occurred in Asia during the 1970's does not seem to be an option since agricultural conditions, structures and institutions differ markedly between Asia and Africa (Ejeta, 2010). For the development of African agriculture we believe that new knowledge generated through science can make a difference, and thus improve food security¹ and reduce poverty. It is well established that agricultural growth can substantially alleviate poverty; often more than growth in other economic sectors (World Bank 2007; Thornton *et al.* 2011).

Our aim here is to contribute to the discussion on research issues of importance for SSA agriculture. Given the complexity of the task, we have taken a broad inter-disciplinary approach and also made an attempt to have a long-term perspective. Obviously, there have been several other analyses

of research concerned with SSA agriculture, and attempts to identify the major issues that need to be addressed (for instance (IAASTD 2009; Cilliers *et al.* 2011; CGIAR 2011; FARA 2011). Various approaches have been applied in these analyses. For instance, some have been based on contributions from a limited group of scientists and others on broader expert and stakeholder consultations (but generally with a specialized research focus). The time frames of future projections have varied substantially, and there have been varying risks of bias, since the scientists and stakeholders involved have inevitably had different interests, agendas and/or prejudices, which have not been clarified in the process.

To reduce these risks, in the presented study a scenario technique was applied, in which a multi-disciplinary panel of scientists all considered the same range of possible futures (similar to e.g. MA 2005 ; Öborn *et al.* 2011; Paillard *et al.* 2011). The use of scenarios for identifying possible research areas is helpful for anchoring the required interdisciplinary approach in conditions that are relevant to particular disciplines while not detracting from the bigger picture. The use of the scenario technique also gives us the possibility to look further into the future, in this case towards 2050, compared to many other research programs.

There are several methods for developing scenarios, ranging from free narrative to highly structured approaches (for a review see Bishop *et al.* 2007) In this study we have used general mor-

¹'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. (World Food Summit, FAO 1996)

phological analysis, a highly structured method for scenario construction. In morphological analysis it is possible to create as many scenarios as wanted and all the factors (dimensions) used are coupled to each other in a traceable and transparent way (see Zwicky 1969; Ritchey 2011; Stenström 2012). The scenarios (presented in section 3) are explorative, and portray a range of differing but possible futures for SSA. The scenarios opened up a broad testing ground for stimulating new thoughts and ideas about future challenges, lacunae in knowledge and interdisciplinary research questions. Consequently, they are not intended to present the most desirable or probable visions of the future. The multi-disciplinary panel of scientists (natural, social and economy) developing the scenarios were from the Swedish University of Agricultural Sciences, the Nordic Africa Institute,

Lund University, and the Swedish Defence Research Agency (FOI).

Hence, here we report the scenarios considered (designated Changed Balance of Power, A World in Balance, A Fragmented World and An Over-exploited World), and four categories of research issues that were generated from a workshop with research colleagues and stakeholders and from the inter-disciplinary considerations of the scientist panel involved (i.e. the authors of this report). Firstly, we describe the factors taken into account when building the scenarios, then the scenarios as such and finally the research issues generated. We hope that the scenarios and the research issues generated will stimulate and be useful for colleagues and various stakeholders with an interest in development of SSA agriculture. ■

Box 1. The Millennium Development Goals for 2015

The eight Millennium Development Goals (MDGs) were officially established following the UN's Millennium Summit in 2000. They form a blueprint, agreed by all the world's countries and leading development institutions, and have galvanized unprecedented efforts to meet the needs of the world's poorest. The MDGs constitute an important part of the background for the present report and are used, among other things, as criteria for defining whether conditions improve or deteriorate in SSA under the considered scenarios, relative to today.

- 1. Eradicate extreme poverty and hunger**
- 2. Achieve universal primary education**
- 3. Promote gender equality and empower women**
- 4. Reduce child mortality**
- 5. Improve maternal health**
- 6. Combat HIV/AIDS, malaria and other diseases**
- 7. Ensure environmental sustainability**
- 8. Develop a global partnership for development**

2. Important factors influencing the future in sub-Saharan Africa and their possible states

As a starting point we used four out of five global scenarios developed in a previous scenario analysis of agriculture and land use focusing on Europe (Öborn *et al.* 2011), viz. Changed Balance of Power, A World in Balance, A Fragmented World and An Overexploited World. We also surveyed the literature to include considerations from other scenarios describing SSA. After thorough, externally facilitated discussions the multi-disciplinary working group had identified seven major factors affecting agriculture in SSA (Figure 1).

These factors can be related to the established 'STEEP' (Social, Technology, Economic, Environment and Politics) analytical framework for context (NIC 2012). It should also be noted that the quality of results of scenario work depends heavily on the composition of the working group and the presence of an external unbiased facilitator during the discussions.

In this section, we discuss the seven major factors used when developing the scenarios for SSA, their present and possible states with focus on SSA, and the subfactors included in the models. In the following text, for convenience we sometimes state that circumstances will change in a certain way when referring to changes predicted under our scenarios, or cited scenarios.

2.1. Global climate change, agriculture and access to natural resources

Climate

There is fair consensus about likely climatic changes in Africa during the coming century. Mean temperatures are expected to increase by about 1-2° C by 2050 (UNEP 2006; Toulmin 2010; Thornton 2011), but this will vary across the continent. In the dry interior parts of Southern Africa average temperatures may increase as much

as 3-5° C (South African Risk and Vulnerability atlas; <http://www.sarva.org.za/2010>). However, as rainfall and water availability limit agricultural production more than temperature in Africa, changes in the distribution of rainfall (which are highly uncertain) are likely to be more important. The distribution of rainfall is predicted to become more uneven, and extreme weather events such as droughts and heavy rains, more common (UNEP 2006; Collier *et al.* 2008; Toulmin 2010). Dry areas in the Sahel and Southern Africa are expected to become even drier, while rainfall remains high or increases in other parts, for example, central and eastern Africa, according to Collier *et al.* (2008) and Cilliers *et al.* (2011). Dai (2010), on the other hand, forecasted severe droughts in large parts of Africa by 2060, under the assumption that the trend since the late 1900s of increasing aridity continues. In any case, with the projected increasing demands on water resources from agriculture and other socio-economic sectors, water stress and water scarcity are predicted to become more common, even in countries with relatively good supplies of water. For instance, water in the Nile river basin, serving 11 countries in North-East and Central Africa, will have to serve 800-900 million people in 2050, compared to 400 million today (UN 2011a).

Deteriorating and extreme weather, droughts and floods will increase risks of land degradation and erosion, affect human health and livelihoods, decrease food security (UNEP 2006; Collier *et al.* 2008; Toulmin 2010) and may increase the risk of conflicts (see below). Infrastructure to counteract these increased risks is needed, but even if the required infrastructure is constructed, climate change will make it difficult to reach the MDGs in Africa (Toulmin 2010) – some authors even regard it as almost impossible (Cilliers *et al.* 2011).

1. NATURAL RESOURCES										
Area used for live-stock	Area used for crops	Fertility of arable land, potential for production and ecosystem services	Access to commercial agricultural inputs	Pests and diseases on live-stock and crop	Water access	Wild fish and aquaculture				
2. DISTRIBUTION OF POWER, GOVERNANCE AND POLICY										
Distribution of power	Capacity and internal role of the state ¹	Conflicts	Agricultural policy of the surrounding world towards SSA	Agricultural policy within SSA	Social movements affecting development					
3. HUMAN POPULATION GROWTH										
Health and education	Settlement patterns	Population 2050	Proportion of people in productive age	Migration out of, into and within SSA						
4. ECONOMIC DEVELOPMENT										
Economic development	Growth sectors	Regional food production per capita		Infrastructure						
5. ACCESS TO ENERGY RESOURCES										
Oil and natural gas extraction	Biofuel production			Development and deployment of small-scale energy technology						
6. AGRICULTURAL PRODUCTION SYSTEMS										
Right of use of agricultural land	Social institutions at society level	Social institutions at individual level	Distribution of productive resources	Development and spread of production technology						
7. NUTRITION										
Level of nutrition	Consumption of plant- versus animal-based food			Consumption of animal-based food (distribution)						

¹ The state's capacity and role are related to the ability to carry out the state's policies, and the extent of the state's power, administration, and commitment to public goods.

Figure 1. The seven major factors (upper case) and sub-factors (lower case) used in the scenarios for SSA. All factors and states are for a time frame of 40 years (to 2050) unless otherwise stated in the text.

In the scenarios considered by our working group (outlined below), temperature changes in Africa range from relatively minor increases of 1–2°C, on average, if strong global climate policies are rapidly implemented, to >4°C increases, if current predictions prove to be too optimistic by 2050. In all of these scenarios ('the scenarios' hereafter, for convenience) it is assumed that water becomes more unevenly distributed and that extreme weather events become more common.

Crop production and agricultural inputs

Crop production is predicted to decrease as the climate becomes drier, although crop production potential may increase in East and Central Africa

(Collier *et al.* 2008). Large proportions of Africa's agricultural soils are regarded as impoverished (Wanzala & Roy 2007) and need inputs of nutrients (N, P, micronutrients) and organic matter for production to increase. However, in addition to the availability of inputs such as fertilizers and energy, factors such as production technology, infrastructure, incentives to increase labour inputs and access to indigenous fertilizers may also be important determinants of Africa's food production but incentives for increased labour inputs, and access to indigenous fertilizer must be developed (Pretty *et al.* 2011). Thus, the implementation of policies that improve the availability of inputs would be beneficial for Africa's food produc-



The implementation of policies that improve the availability of inputs would be beneficial for Africa's food production. Here, an automatic irrigation system on a farm in the Western Cape of South Africa.

tion. Sanchez (2010) suggests that public measures geared towards raising the productivity of smallholders growing major staples, such as maize, combining fertilizer subsidies, soil conservation, health and infrastructure, could increase production by more than 100 % (e.g. in Malawi).

The availability of agricultural inputs in the scenarios ranges from relatively high, with low prices, due to the implementation of favourable global policy measures and development of recycling technologies, to low and uncertain, with high prices. These trends will have major consequences not only for agricultural production but also many other factors.

The area potentially available for crop production in Africa is substantially larger than the area used today, especially if forests are transformed into cultivated lands. However, such a conversion entails substantial risks and environmental costs regarding e.g. biodiversity and carbon sequestra-

tion. Nonetheless, it has been estimated that land for crop production could increase by at least a third by 2050 (FAO 2009), although considerable investments in land improvement and productivity would be needed (cf. above). Thus, in the scenarios we have assumed that the cropland area either increases or remains stable (if increases through these investments are counterbalanced by factors such as land degradation and climate change).

Livestock

Not only crop production, but also livestock husbandry and the availability of rangelands will be affected by climate change. Increased risks of extended droughts will result in higher uncertainty and lower production potential in many dry areas. On the other hand, if the weather is also more variable in croplands, some of them may be converted to rangelands (Thornton 2010), although the livestock may still be limited by water availability and heat stress. In addition, changes in rangeland vegetation from grasses and forbs to



Changes in rangeland vegetation from grasses and forbs to scrub-dominated systems may lead to changes in livestock breeds or species, from cattle to camels and goats, or cattle breeds capable of feeding on bushes.

scrub-dominated systems may lead to changes in livestock breeds or species, from cattle to camels and goats, or cattle breeds capable of feeding on bushes (Jones & Thornton 2009).

Changes in area of grazing lands in Africa in the scenarios considered range from increases, mainly in drier areas, through remaining approximately the same as today, to decreasing due to some of today's rangelands being used for crop production to feed increased populations. Contraction towards the equator is a possibility if the climate becomes warmer and drier. It is also possible that animal production may intensify, thus decreasing the area of traditional rangelands.

Ecosystem services, pests and diseases

The degree to which ecosystem services and soil fertility are maintained or restored, and production is sustainably increased, are related factors (although declines of ecosystem services and soil

fertility may be partly masked by increases in energy and nutrient inputs). The only scenario considered here in which ecosystem services and soil fertility improve is 'A world in balance', in which active policies enhance them, while in the three other scenarios it is assumed that ecosystem services and soil fertility decline.

Other important factors affecting agricultural production are pests and diseases of crops and livestock. Climate changes may promote the spread of pathogens to new areas with non-immune and susceptible populations. In addition, increased trade and new farming practices may contribute to the transmission of pathogens. Many pests and diseases can only be successfully controlled or eradicated by national or international control programs, emphasising the importance of policies and functional institutions for public goods to enhance food security with respect to these factors. Most scenarios assume that the prevalence

of pests and diseases will increase in many parts of Africa, due to a combination of climate warming and poor institutions (see below), although their prevalence may fall under one scenario ('A world in balance') due to the effects of functional institutions and relatively minor climatic changes.

Wild fish and aquaculture

Globally, most fish stocks are fully exploited and many are diminishing. Aquaculture has the potential to enhance fish production, although its potential varies with both fish species and water availability. In Africa as a whole fish consumption has decreased, and aquaculture contributes little to fish supply. There is substantial potential for aquaculture to enhance food security in SSA (Machena & Moehl 2000), but to develop this sector major shifts in policy are required (both to promote it and address its potential environmental effects). We have assumed that aquaculture will increase in Africa under most scenarios, except in 'A fragmented world', in which relevant institutions and policies are assumed to be weak or non-existent. Depending on fisheries policies (both global and within SSA), the supply of wild fish has been assumed to either increase or decrease in the future.

2.2. Distribution of power, governance and policy

Global and regional power relationships

MacDermott *et al.* (2010) provides an overview of African security issues in a 20-year time horizon, which has been used as a background for the present discussion despite the shorter time frame. In a 20 year perspective, power relations within SSA are likely to be dominated by some strong states driving regional economic and political development (MacDermott *et al.* 2010). Some of these states will most likely experience internal political problems of various sorts. African states are likely to have weak negotiating positions generally, regarding economic, environmental and other developmental trends and agreements. However, globalisation will affect African states differentially, increasing growth and welfare in some but not in others. Many states are likely to be weak and poorly functioning, with a lack of internal capacity

and increasing social inequality. Regionalisation is expected to continue. Many people will also continue to live in poverty, even in countries that experience economic growth. The capacity of many states may also be impaired if well-educated and younger people leave them. Grey economies, with unclear boundaries between state and private interests, may lead to increased corruption. In addition, violent power and government transitions, similar to those that have recently occurred in northern Africa, have been predicted for central and southern Africa when 'long-time' leaders die or parties that have dominated since independence face stronger opposition. Internal conflicts and social frustration will create instability and pose challenges for democratisation processes, as well as making the stronger states more unstable. Global, regional and local inequality will also continue to pose serious social and political challenges. Increased tensions between the rich and the poor may increase violence, frustration and social problems, leading to instability.

We have assumed that over the 40-year time perspective in the scenarios, the distribution of power within Africa may essentially evolve in one of three directions. Pan-African collaboration may become stronger, some strong states may dominate, or most African states may be weak while private companies play a strong role in future development.

Global power relations with regard to agriculture and natural resources are also likely to affect power relations within Africa. The purchase or leasing of fertile agricultural land by China, India, Middle East countries, sovereign wealth funds and various foreign corporations may have substantial effects on regional, national and local power relations, if current trends continue. However, the extent and nature of the effects will be highly dependent on both the policies of these external drivers, and their relations with traditional holders of regional and local power. The changes may increase stability, enhance infrastructure and lead to technological upgrading, or alternatively to xenophobia, social unrest and instability. China is already the largest exporter of weapons to Africa,

and this trend is predicted to continue, fuelling conflicts (MacDermott *et al.* 2010). On the other hand, China may increase its support for UN-actions, thus strengthening UN capacity and stability in the region. If the dominance of the west continues, interest in African welfare may decline, but it is also possible that strong social (consumer) movements in the west/north result in changes in western policy. In the scenarios foreign land use/ownership ranges from limited (and focused on production for both local and export markets) to very extensive, exploitative and focused solely on production for commercial export.

Increased competition for natural resources and climate change are further possible factors that may foster social unrest and instability in many African states. In several scenarios, major structural reasons for conflict will persist in Africa, including poverty, inequality, population growth, urbanisation and few work opportunities for high proportions of young people.

Agricultural policy

Most authors agree that the state has played (and will continue to play) a central role in the development of the agricultural sector in Africa. Liberalisation during the 1980s and 90s largely failed to develop markets for inputs, e.g. fertilizers, agricultural products and credits (Dorward *et al.* 2005, Havnevik *et al.* 2007). Thus, improved coordination of the state, markets and producers will be important for development. Enhancement of the small-scale agricultural sector, in particular, will require state-sponsored improvements in productivity and market orientation, through knowledge acquisition (and/or transfer), and improvements in both technology and the provisioning of mechanisms for risk management (see, for instance, Scoones 2005, Hårsmar 2006). The state should also be responsible for providing several basic prerequisites for agricultural and socio-economic development, such as functioning healthcare and education systems, and infrastructure. International trade policies affecting exports from Africa, and the activities of international food retailers in Africa, are other factors influencing the development of the agricultural sector in SSA.

Regarding agricultural policies in SSA, the scenarios depend on both global agricultural policies and policies within Africa. Several aspects of both need to be considered, including whether global agricultural trade policies actively support development or are largely passive, the scale of the global market and trade with Africa, and the degree to which World Trade Organization (WTO) standards are maintained, strengthened or collapsed. Agricultural policies within African countries may actively aim to promote diversification of the agricultural sector, including activities of smallholders, to enhance particular production forms, such as plantations or meat production, or be passive, perhaps largely driven by interests outside Africa.

Social movements

Various kinds of social movements in Africa may also influence policies and governance. Social capital and social movements are prerequisites for democracy and a functioning civil society. However, social movements that emerge from social frustration and poverty can take diverse political and religious forms, not all of which contribute to good governance and agricultural development. In the scenarios, social movements in Africa range from strong and authoritarian, through strong and non-authoritarian, to weak.

2.3. Population growth, age distribution and migration

Populations

The UN predicts that the global population will rise to between 9 and 10 billion people by 2050 (UN 2011a). In the global scenarios considered here, the global population may increase more slowly than this prediction, to around 8 billion people (an optimistic scenario), agree with UN predictions, or increase more rapidly than predicted to at least 11 billion people by 2050. However, in all cases Africa faces a number of challenges with regard to population growth in the coming decades. By 2050, its share of the global population may reach more than 20 % and considerably exceed the populations of both China and India (Cilliers *et al.* 2011). This may increase Africa's importance in the world. More-



Deep Freeze, Cape Town, South Africa - January 31, 2012: Residents of Deep Freeze on the outskirts of Macassar burn tires and blockade roads in protest to upcoming municipal water cuts. Increased competition for natural resources and climate change are factors that may foster social unrest and instability in many African states.



Africa faces a number of challenges with regard to population growth in the coming decades. By 2050, its share of the global population may reach more than 20 % and considerably exceed the populations of both China and India.

over, its population will be in the first phase of a demographic transition and hence still growing. The demographic balance within Africa is predicted to shift towards eastern and western Africa because fertility rates are highest in these regions (Cilliers *et al.* 2011). Africa is also rapidly urbanising, and it is predicted that more than half of its population will live in urban areas by 2030 (UN 2011b). This rapid growth could have some positive, in addition to negative, effects. For example, a large proportion of Africa's population will be in working ages, which together with urbanisation may contribute to economic growth that may affect rural populations and agricultural production. However, it may also be socially destabilising, especially if jobs are not created, since as noted by Cilliers *et al.* (2011), 'unemployed young men are notoriously disruptive and globally the major source of crime and violence'.

The increased population will put further pressure on already limited resources, for example, water.

Since this resource is already stretched, the risks of increased deficits and conflict are obvious, and the development of alternative ways of using water is essential.

In the scenarios, we have assumed that the population in SSA will be between 1.5 and 2 billion, depending on the scenario. Urbanisation will probably continue, but the trend may be mitigated if policies emerge that promote the development of agricultural production and rural communities. Indeed, in one scenario ('A world in balance') we have even assumed that such policies provide opportunities for urban residents to move back to rural areas in parts of SSA.

For the demographic transition to be completed during this century, a number of requirements must be fulfilled. These are that economic development, democracy and respect for human rights increase, bringing about higher living standards, general education, better healthcare and sanitary

conditions; these factors are likely to enhance women's rights and reproductive health.

Public health and education

Although there are severe public health problems in parts of Africa, there are some signs of improvements. The prevalence of HIV/AIDS is decreasing in several countries, and the use of anti-retroviral medicines is increasing (WHO 2006). Similarly, although most malaria cases globally are in Africa, access to adequate treatments and protective measures is increasing. On the other hand, low sanitary standards in many households cause problems. The enrolment rate in primary education has increased a lot during the last decade and is now (2006) about 70 % in SSA, but there is significant variations between countries (Unesco 2009). Considerable public investments in safe water supplies and both healthcare and education systems are needed, but it is uncertain if they will be made in all areas. We have used three possible combinations of trends in the scenarios: improvements in health and education (with higher proportions of populations acquiring at least general education), improvements in health but not education, and deterioration in both public health and education levels.

Transboundary Migration

Migration within SSA and from SSA to other regions will continue to be important factors for SSA's development. In regions where most people are poor and there are large differences between the rich and poor, both the uneducated and educated are likely to have incentives to migrate out of the region or the continent. The extent of this may largely depend on developments outside Africa, especially in Europe. Large-scale migration will result in a brain-drain and loss of people in working ages, but remittance of money from emigrants may increasingly influence development in many countries (MacDermott *et al.* 2010). In some areas migration into SSA may also occur, through the establishment of permanent settlements of Asian citizens, associated with the purchase or tenancy of land for agriculture (and perhaps loss of production potential in their home countries). Large-scale migration within Africa

is likely for diverse reasons, e.g. climate change, urbanisation, food and water scarcity, and social unrest. We have considered various combinations of large- and small-scale migration within and outside SSA in the scenarios. Notably, the better the policies and development (agricultural and social) in SSA, the less migration is assumed.

2.4. Economic development

Rapid economic growth, of around 5 % or more, has occurred in many countries in SSA during the last decade, even during the recent financial crises (IMF 2010). This growth, which also implies economic per-capita growth, has been driven partly by exports of raw materials, but also partly by improvements in domestic demand, governance and macroeconomic stability. The largest economies (*inter alia* South Africa, Nigeria, Angola and Kenya) are expected to continue to grow – although for different reasons – which is also likely to enhance economic growth in neighboring countries. In the longer term, whether the high growth will continue or not will at least partly depend on the development of the global economy. The presence of natural resources, particularly oil and important minerals like zinc, copper and coltan, in some African countries may contribute to economic growth, if governance in these states is improved (Sachs & Warner 1995; Collier & Benedikt 2008; Brunschweiler 2008). Prospects for more broadly based growth are dependent on the internal capacity to utilize the demographic dividend of a young population, referred to above.

African international trade patterns have changed in recent years, in particular trade with China has grown and is expected to increase further (ADB 2012). For some countries mainly exporting natural resources, Asia is now a more important trade partner than Europe, and this trend is likely to continue.

However, there is a risk that some countries will experience strong economic growth while others will continue to lag behind. Such 'growth divergence' has been noticed between different categories of developing countries. The lack of growth in some countries has been attributed to

badly functioning institutions and geographical conditions, such as lack of access to coastlines and other handicaps (Rodrik *et al.* 2004; Sachs 2003). Other important factors for economic growth are the extent and quality of the infrastructure, especially roads and electricity supplies (Ndulu 2006). Agricultural development is also important for economic growth in most African countries (World bank 2007). When large parts of the population are actively engaged in agriculture, agricultural development can foster general economic growth, due to the links between agriculture and other economic sectors, thereby improving livelihoods in general and food security.

In the scenarios, global economic development has been assumed to be either high or low in the Global North (Europe, North America) and high, lower or low in the Global South. In SSA, economic growth per capita has been assumed to be high with decreasing gaps between rich and poor (falling GINI coefficients), high but

with increasing divergence, or lower than today with increasing differences between rich and poor (rising GINI coefficients). Sectors that make important contributions to economic growth may include various combinations of manufacturing industries, agriculture and the production of raw materials, such as minerals, oil or gas. Food availability in SSA has been assumed to either increase or decrease compared to today (see above for production potentials), while food production per capita within SSA has been assumed to range from higher to lower. Finally, infrastructure has been assumed to be better, unchanging or worse than today.

2.5. Energy

A basic assumption in the scenarios is that there will be no absolute natural limits to energy availability globally during the coming 40-50 years, since although oil is becoming more expensive, there is plenty of coal and other energy sources to substitute within this timeframe (Brandt *et*



African international trade patterns have changed in recent years, in particular trade with China has grown and is expected to increase further.

al. 2010). A similar conclusion was reached by Nehring (2009), who argued that fossil fuels will have reached a plateau within 40 years, but with decreasing availability after this. This means that limits to the use of fossil fuels during the period until 2050 will mainly be environmental and political, depending on whether societies are willing to risk severe climate warming and other environmental effects (Öborn *et al.* 2011). However, energy prices may increase substantially because of increasing costs of production from less accessible coal, oil shale, oil and natural gas deposits, and the environmental costs of utilising these energy sources may be large. The global production of biofuels will be related to these driving factors, and whether candidate biofuels are considered environmentally acceptable or not. Accordingly, the global energy factors affecting SSA in the scenarios encompassed low and high supplies of fossil energy (with high and low prices, respectively), and both high and low bioenergy demands, with consequent areal demands for growing biofuels (Öborn *et al.* 2011).

Global competition for cheap energy is increasing the demand for African oil production, and countries outside Africa are increasingly making bilateral agreements with oil producers in SSA to ensure access to oil. China, especially, will become more influential, but India and the USA will also become more interested in African affairs and more politically active in strategically important regions (MacDermott *et al.* 2010). In addition to increasing global demands, energy consumption within Africa will also increase. Thus, the question is not if, but how much, oil and natural gas extraction will increase in SSA. Bioenergy production trends, on the other hand, are more difficult to predict, partly because there are trade-offs between most bioenergy and food production that make predictions about both the technical and social potential for increasing bioenergy production in Africa highly uncertain (Offerman *et al.* 2010). It is also highly uncertain what second and third generation biofuels may contribute, both globally and specifically for Africa. Predictions regarding this will largely depend on assumptions regarding technology development within and outside the energy sector.

The pace of development of small-scale energy technology, globally as well as in Africa, and the extent to which policies and infrastructure are in place to spread new and efficient technology to potential users in Africa, will also strongly influence access to energy in SSA in the future.

In the scenarios, the oil and natural gas extraction in SSA is assumed to increase or increase a lot. For the biofuel production, three alternatives are given in the scenarios: high production in plantations, high production by smallholders or low production. Also, for the sub factor about development and deployment of small-scale energy technology, three different states are given: rapid development and deployment, slow development as well as deployment or slow development but rapid deployment.

2.6. Agricultural production systems and social institutions

We have regarded the future agricultural production systems in Africa as highly intertwined with issues of social institutions and access to land, and therefore discuss these simultaneously (cf. Thornton *et al.* 2010). Since social institutions are key determinants of the nature and productivity of future agricultural production systems in SSA, special attention has been paid to them. This has resulted in substantial complexity in the number of possible states in different scenarios (see below).

Africa faces a number of demographic challenges related to rising population densities, rapid urbanisation to a large degree on productive land and increasing migration rates. One of the main challenges is finding ways to achieve broad-based economic growth in the smallholder sector (Kirimi *et al.* 2011). On the positive side, technological advances may potentially provide opportunities for commercializing agriculture by smallholders (in addition to corporations) in the Guinea-Savannah Zone (World Bank 2009), and some governments (especially in Malawi and Rwanda) have combatted food insecurity by introducing public measures geared towards raising the productivity of smallholders growing major staples, such as maize. One of these measures is



The existence of national legislation recognizing women's rights to land has had negligible impact in rural areas. The picture is from Kenya, where women make up 80 % of all farmers.

subsidising mineral fertilizer (Sanchez 2010).

One of the many consequences of urbanization and increasing population pressure on land is the diversification of incomes, both within and outside agriculture (Bryceson 1999; Bryceson 2002; Haggblade *et al.* 2007; Lay and Mahmoud 2008; Jirström *et al.* 2010). Notably, livelihoods are likely to become increasingly 'multi-spatial', involving remittances and transfers both in cash and in kind (Baker 1995; Bah *et al.* 2003; Foeken and Uwuour 2008; Andersson 2002; 2010). Such linkages may place increasing strains on household systems, but also provide important possibilities for on-farm investments with the potential to raise smallholder productivity. Access to urban cash incomes through non-resident family members has a decisive influence on poverty levels in many rural societies.

Since the nineteenth century, access to land for cultivation in SSA has been based on 'bundles of rights' held by individuals and groups. In general, several individuals could hold different kinds

of rights over the same plot of land, by virtue of their social status as members of villages or kinship groups. In many countries such systems persist today, in which user rights to land follow patrilineal inheritance and/or are allocated by village chiefs or headmen. In much of SSA, land rights are derived from overlapping principles and systems of allocation based on multiple social relationships and national legislation. The effects of such land rights on productivity and equality of access to land vary considerably (Peters 2004). In Ghana, collective land rights and restrictions on private land transfers to households outside the lineage have been put forth as major sources of inequality and tension, both economic and political (Amanor 2010). On the other hand, agricultural intensification and private land rights were associated with increased economic differentiation in Kenya, according to Murton (1999). However, the results of privatization of land from corporate kinship, and community-based systems in Africa and elsewhere have usually been negative for many people (Shipton 1992). Titling often disen-

franchises women and the poor, initiates a process of land alienation and increases inequalities (Bassett 1993), and has been argued to negatively affect agricultural productivity (Berry 1993; Peters 2004). In contrast, other non-capitalist forms of land rights can effectively ensure long-term security of access. In many documented cases, sustainable and highly productive agriculture has been based on corporate rights through village and/or lineage membership (e.g., Hill 1963; Toulmin 1993; Sheridan 2008).

Generally speaking, women have had (and still have) weaker rights to use land than men. (Håkansson 1994; 2003). Freehold tenure – as found in Kenya for instance – may enhance women's access to land through enabling land purchases. However, in Kenya the dual legal system, recognizing so-called customary law, severely disadvantages women by excluding them from inheritance in patrilineal societies (e.g. Oboler 1985; Håkansson 1988; 1994). This also seems to hold in SSA in general (Joireman 2008). The existence of national legislation recognizing women's rights to land has had negligible impact in rural areas (Joireman 2008; Andersson Djurfeldt & Wambugu 2011). Weaker land rights among female-headed households and poorer access to productive resources are considered major reasons for the lower productivity of farms headed by women and relatively slow increases in productivity in smallholder-based agriculture in Africa as a whole (FAO 2011). Therefore, resolving gender-based differences in access to land is crucial for enhancing productivity as well as reducing poverty in rural Africa.

Since the nineteenth century, most agriculture in SSA has also been, and still is, small-scale and family-based. In most SSA countries land is vested in the state (Djurfeldt 2011), which usually does not respect traditional land-user rights. This is especially true for public lands (commons that are not under permanent cultivation or other use, but almost always traditionally utilized by someone) (Wily 2011). More recently international actors and national elites have acquired long-term leases covering large areas for commercial agricultural production (of biofuel, food or forest products,

for instance) (Cotula 2011). This has been arranged through deals with governments, in which traditional rights of local communities and rural poor people have frequently not been respected (Anseuw *et al.* 2012). However, state institutions have also been weakened by structural adjustment policies. Foreign aid and trade policies have played a major role in agricultural development in SSA, but have often resulted in strengthening political control over the countryside by the recipient state and enriching the elites rather than improving food production and general living standards (Davis 2006; Ferguson 2006).

The extent and forms in which these developments will continue are included as factors in the scenarios. The productivity of land and sustainability of its use are dependent on the sustained investment of labour and capital through corporate institutions, family or hierarchical patron-client networks. Thus, special attention was paid to social institutions since they are important for future agricultural production systems in SSA, resulting in a number of different possible states in the scenarios.

Ownership and rights to use farmland can be realized as formalized ownership, formalized rights to use it, and informal – including traditional – rights to use it. At the same time, given the increased interest in agricultural land in Africa from countries in other continents, we have allowed foreign use of land to range from small to large scale in different scenarios.

Social institutions of importance for agricultural production can have effects (and be affected by changes) at both societal and individual levels. Social institutions of importance for agricultural production can play out both at societal and individual levels. Collective networks and traditional social insurance institutions based on ethnicity or religion may become either stronger or weaker in the future. A weakening would entail increased individualization in society, which could result in livelihoods becoming more uncertain and less secure. However, in reaction to increased individualization, family-household relations could

become more important, or modern welfare state institutions could replace the traditional safety nets for individuals.

More equal distribution of productive resources across genders and income levels is important for enhancing agricultural production in Africa. Women contribute most to food production in many SSA countries, but have fewer rights to tenure and less power over investments in land and technology (see above). Lower levels of input use by women, rather than better farming skills among men, have been argued to be the cause of lower productivity among female-headed households. Thus, the degree to which women gain (or lose) power over productive resources will influence the prospects for raising agricultural productivity in Africa (FAO 2011).

The equality of the distribution of resources has also been considered to be important, both between poor and rich, and among different groups in multi-cultural societies. Thus, more equal distribution of income and resources for investments, e.g. agricultural inputs and technology, could make an important contribution to increasing agricultural production too.

Finally, the diffusion of agricultural technology, and functional extension services and training (education), are important. These factors clearly require more attention in the future, as emphasised by e.g. Thornton (2010); Pretty *et al.* (2011); Giller *et al.* (2011).

To summarize, we have allowed all of these factors to vary in the scenarios to assess their effects. This reflects the substantial complexity of the issues involved in assessing future production systems in SSA.

2.7. Nutrition

Adequate nutrition is an important factor for human well-being for obvious reasons. Malnutrition and starvation entail a large waste of human lives and human capacity. Besides the humanitarian and ethical aspects of nutrition, the economic costs of malnutrition are very high – in the order

of billions of dollars a year in terms of lost gross domestic product (GDP). It has been argued that specific investments in nutrition can accelerate improvements in nutrition, and that relying on markets and economic growth alone will not solve the malnutrition problem within the time-frame of the present analysis (World Bank 2012). Nutrition has both food quantity (energy, here expressed in calories, in accordance with most pertinent literature) and quality (diversity, protein content and micronutrient composition) aspects. In the SSA, there are large variations in food dietary energy deficiencies, which affect, for example, 37 % of the population in Uganda and up to 76 % of the population in Ethiopia (FAO 2007). However, there is a low association between diet quantity and diet quality. Poor diet quality is the major cause of malnutrition. Socioeconomic conditions in a household, besides the obvious poverty-wealth aspect, may also affect food security. For instance, in southern and eastern Africa male-headed households and households in urban areas generally have higher quality diets than female-headed and rural households, respectively (Smith *et al.* 2006).

The adequacy of the nutrition of the population is thus an important factor to consider when discussing possible futures in SSA, and it is strongly linked to other aspects of economic growth and agricultural productivity. We have considered three indicators of dietary adequacy in the scenarios: the energy contents of people's diets, the animal-based protein content (as a %age of total protein or total calories) and the relative amounts of protein from different animal sources. Concerning nutrition levels, given the large projected population growth in SSA and low levels of income (high poverty) in many countries, we have considered it unlikely that SSA as a whole will be able to eradicate both starvation and malnutrition, even with high economic growth. Data from FAOSTAT 2007 (FAO 2007) has been used as a starting point for the relative changes in consumption patterns in the scenarios. The most optimistic scenario ('A world in balance') assumes that famine and starvation are no longer threats to people in SSA, but that there will still be mal-



In the SSA, there are large variations in food dietary energy deficiencies (which affect, for example, 37 % of the population in Uganda and up to 76 % of the population in Ethiopia). However, there is a low association between diet quantity and diet quality.

nutrition in some places. The most pessimistic scenarios assume that famines and starvation are still common, while starvation under 'A changed balance of power' has become rare but malnutrition is still commonplace. In the most positive scenario, meat and fish consumption has been assumed to reach 15 % of total calorie intake, which is lower than in most OECD countries but close to the global mean today. In the intermediate case, animal protein consumption is close to rates in Tanzania today, 6 % of total calories, while in 'A fragmented world' animal protein accounts for only 2 %, the lowest level in SSA today. The contributions of calories from different animals vary among the scenarios. The contributions from cattle, sheep and goats, including milk, are more than half of the animal protein intake in some ca-

ses, but much lower in others. The contributions of pigs, poultry and eggs may also vary, as may fish consumption. These variables are uncertain, and will depend on both global development and policy towards smallholder farmers, pastoralist and other animal production forms, urban food production, and aquaculture (see above). ■

3. Scenarios for sub-Saharan Africa

We used scenarios as common, explicit frameworks for the group of researchers and stakeholders involved to interactively identify future research issues. All participants thus had the same 'gestalt' of the future in mind during the workshop discussions. The rationale was that this would promote interdisciplinary dialogue since the participants would be encouraged to jointly identify story lines, problems, opportunities and challenges in the different scenarios. The common problem focus, we postulated, would reduce the bias when the group in a second step identified research issues, with the additional input from the stakeholders. In contrast to this top-down approach, a bottom-up approach, in which all participants are initially asked to formulate solutions individually in a free brainstorming session, will not give this result.

Hence, in this study the scenarios (presented below) are thus explorative, that is they served as conceptual laboratories for finding future challenges and research questions to address them; to stimulate new thoughts and ideas about future challenges, lacunae in knowledge and interdisciplinary research questions. Consequently, the scenarios are explorative and not intended to present the most desirable or probable visions of the future.

The method used to construct the scenarios is called general morphological analysis (Zwicky 1969; Ritchey 1997a; 2006), described in detail by Stenström (2011). It was developed to analyse complex and multi-dimensional problems in which several of the factors to be analysed are not quantitative (Ritchey 1997b; Carlsen & Dreborg 2008). Using morphological analysis very complex problem areas are divided into smaller areas (here called 'factors'), analysed separately and then joined together in the different scenarios. The method allows complete traceability of all choices

made and analysis of the relations between different factors. Morphological analysis does not, however, require knowledge of the causal relation between factors, only knowledge that the factors are related to each other in some way. Each scenario was constructed from a number of factors that can adopt more than one state (value).

The four scenarios for SSA described here are based on four global scenarios that had been constructed previously (described in Öborn et al. 2011) in an effort to identify research issues for future agriculture globally and in Europe. The global scenarios are called Changed Balance of Power, A World in Balance, A Fragmented World and An Overexploited World. A fifth scenario constructed by Öborn *et al.* (2011), The World awakes, was not used because, for the present purpose, it was regarded to be similar to A World in Balance as regards Africa, albeit with a somewhat later implementation of the necessary process towards the latter scenario (see below).

The scenarios were constructed for SSA, because the Sahara is a logical delimitation both geographically and culturally. There are obviously large differences between areas and countries south of the Sahara, regarding, for example, geography, population, history and economy, but a higher level of resolution would not have been possible given the framework for the work. This means that not all sections of the scenarios are always applicable to all the SSA regions. The time horizon is approximately 2050, as in the global scenarios.

Based on the content in the global scenarios the working group, i.e. the authors of this report, with expertise covering both socio-economic and bio-physical aspects of African agriculture was recruited. The working group first identified



Oil platform off the coast of Angola. In the scenario ‘Changed balance of power’ oil and gas production in Africa is greatly increasing.

main factors that would profoundly affect future agricultural production and related socio-economic developments in SSA in each global scenario. Then sub-factors that were regarded as likely to have a major influence on agriculture in SSA in the future were identified and scrutinized by the group. The seven main factors, each with three to seven sub-factors, are listed in Figure 1. Each sub-factor can have different states, based on the considerations in the preceding section. All seven main factors, and one or two states of each sub-factor (of 3–6, in total) were used to construct each scenario, in order to create a highly diverse range of scenarios (see Appendix 1). During the process the factors, their states and combinations were continuously assessed and refined by the team.

The global scenarios, each followed by the respective scenario for SSA, are described below.

3.1. Changed balance of power

Global

- World population 8 billion
- Temperature increase 3–4°C
- Rapid technological development

The global balance of power has been displaced towards India and China, where the economic development is very strong. The global economy is characterized by deregulation and free trade.

Global population growth has dipped below UN forecasts, mainly because of rapid economic development in Asia. Political ambitions regarding climate and the environment are low. There is good availability of fossil fuels (mainly coal), and the prices for these fuels are relatively low. The agricultural land area is about the same as it is at present globally, but it is being displaced towards the poles and the equator in response to climate

change. The consumption of animal products has increased globally.

Sub-Saharan Africa

There are several strong states in SSA and many states are illegitimate. The states' effectiveness and roles vary and depend to a large extent on whether they collaborate with Asian superpowers, and if so which superpowers. China, for example, which now has one of the strongest economies in the world, only negotiates bilaterally and will only collaborate with effective states or states that can become so with China's support. There are large economic and social differences within regions, depending to a large extent on where foreign investors have influence. There are large risks for local conflicts, but the Asian superpowers have a stabilizing effect in areas where they have economic interests. In areas where China is dominant, social movements are weak and have little influence on development. However, in other areas they can be important. The world market is deregulated and driven by East Asian purchasing power and interests. Nevertheless, the WTO contributes some stability to the world market. A relatively large proportion of what is produced in SSA is exported to Asia, but there is also a local market. Within SSA there is an active agricultural policy focused on food production. Plantation agriculture and animal production are the dominant systems.

Both gross national product per inhabitant and domestic food production per inhabitant are increasing. However, differences in income are too. Growth sectors are the agriculture, mining, oil and gas industries. Asian investments have resulted in the development of functioning infrastructures, but with large variations among regions. Oil and gas production in SSA is increasing greatly. Rich countries in Asia are eager to buy SSA oil and gas to reduce their dependency on regimes in the Middle East. The production of biomass for biofuel production, mainly in plantations, is high and small-scale energy technology is developing slowly, but spreading relatively quickly.

A large proportion of land is utilized by foreign

actors. Land ownership has been formalized through officially documented contracts. However, land use may be either formally regulated or based on informal agreements. Family and relationship-based safety nets have been weakened and not replaced by any other form of security. Women have little power and there are no movements to change this. The gulf between rich and poor in society is increasing. Production technology is rapidly developing, driven mainly by China and India. New technology is spreading and being used in areas of SSA where economically strong Asian states are investing and introducing new technology that can be relatively easily transferred to African conditions.

Africa is a supplier of raw materials to a number of Asian countries. The area of farmland for livestock and arable production is the same as today, but has shifted towards the equator because of climate change, which has caused extreme drought in previously cultivated regions. Due to their strong economic growth the Asian superpowers are investing in SSA. This, however, mainly takes the form of leasing large areas through long-term contracts. In these areas arable land is increasing and grazing of livestock is intensifying, while there is a decrease in other areas of SSA. The Asian superpowers contribute to development that is in part positive in the regions where they are investing, by improving infrastructure and public health. Production of animal-based food is mainly increasing through intensification and the introduction of large-scale livestock husbandry. Availability of agricultural inputs is good and their prices low. Soil fertility, production potential and ecosystem services are declining, but this is partially disguised by the availability of cheap fertilizers. Productivity is high when fertilizer is used. Pests and diseases of crops and livestock are increasing due to climate change. Newly cultivated areas where populations are neither resistant nor immune are especially vulnerable. Pesticides are widely used, which lessens the effects of plant pests. However, this leads to high concentrations of pesticides in both soil and water in many areas, and sometimes also to the emergence of pesticide-resistant pests. Access to water is approximately

the same as today overall, but more unevenly distributed. Climate change leads to unpredictable and more extreme weather conditions with downpours, flooding and drought. Availability of wild fish is declining due to environmental destruction and overfishing. However, aquaculture is increasing so the overall availability of fish remains unchanged, although often at the cost of increased environment degradation.

The SSA population is 1.7 billion in 2050, which is the level the UN forecast. Education levels are low. There are large ranges of public health, demographic and urbanization parameters within SSA. There are functioning public health systems in areas with foreign investors, but the rest of Africa suffers from widespread health problems. Average life expectancy is generally low. Urbanization is rapid and in areas with foreign investors there is also rural development. There is considerable migration to SSA from Asia and high mobility of people within SSA. Many people also make their way to Europe in search of a better life.

In this scenario sections of the population are starving and there is widespread malnutrition. Calorie intakes are on average 94 % plant-based, which is approximately the same as today in SSA. Consumption of animal-based food is also approximately the same as today's average in SSA.

3.2. A world in balance

Global

- World population 8 billion
- Temperature increase 1–2°C
- Global agreements and strong environmental policies

Population growth has been slower than UN forecasts. Climate change is modest due to reinforced and efficient political activities. Economic development is strengthened in many regions of the world. Strong intergovernmental actors are reaching global agreements. Rapid technological development within the energy and agricultural sectors, together with an even distribution of new techniques, are a prerequisite of this scenario.



Fruit and vegetables for sale at a market in Mali. In the scenario 'A world in balance' the development of business enterprises in rural areas provides favourable conditions for people to live in the country.

Thus, pressure on land resources is relatively low. Soil fertility, productivity and the availability of ecosystem services are increasing globally.

Sub-Saharan Africa

Pan-African collaboration is being driven by some strong states, which push economic and political collaboration at both national and continental levels. Most of the African states are legitimate and have functioning state administrations, although there are exceptions. The strong, legitimate states act as role models for other states and thus propel positive changes throughout the region. However, among the legitimate states there are differences in effectiveness and ability to implement policies. In many states local, traditional power structures must be overruled by central authorities in order to implement policies at the local level. There are strong social movements that campaign about issues within the constitutional framework, which contributes to stability in many states.

Many countries outside Africa have adopted trade policies that favour development, and hence promote economic and social development in SSA. Most states in SSA have small economies, thus if they can successfully promote economic development they can fairly quickly achieve economic stability. Improved living standards result in reduced risks for conflicts. Most countries in SSA pursue active agricultural policies and agriculture is differentiated. There are many forms of production systems of varying sizes and types, such as mixed smallholdings, plantation agriculture and livestock farming, which produce many types of products for different markets.

Gross national product per inhabitant is increasing and income divides are decreasing. Domestic food production per capita is also increasing. The fastest growing sectors are agriculture and manufacturing (especially processing) industries. Regional



In the scenario 'A fragmented world', climate changes will cause more extreme weather events such as recurring down-pours resulting in flooding.. Picture from Rwanda.

trade is fairly extensive and infrastructure well organized. Oil and gas production in SSA increases as SSA countries negotiate a larger share of global production. China imports oil (among other products) from SSA. In many SSA regions there is considerable local production and use of biofuels among smallholders. New technologies related to small-scale energy systems, such as solar energy and biogas, develop and spread rapidly.

In this scenario foreign utilization of land is limited. Land ownership has been formalized and there are formal rights to use land, often secured through agreements with local leaders. Social networks, such as family and other group relationships, are weaker and less important for the identity of individuals. Social and economic safety nets have been modernized, for example through increases in the extent and importance of insurance. Social divides have decreased at several levels. Women have acquired greater power in the family and society compared with today. Development has led to a more equal distribution of resources between different groups in society and between rich and poor. Due in large part to the increased stability, with accompanying investments in new technology and its distribution, production technology develops and spreads rapidly in SSA.

Meat production is increasing in this scenario, partly due to the emergence of more effective, integrated crop and livestock production practices, resulting in the area allocated to grazing land decreasing and the released land being used for crop production. Partly for this reason, and partly because much previously unexploited land in eastern and southern SSA is being cultivated, the area of arable land is increasing. Arable land is used for both food and animal feed production. Since the climate changes are minor they cause less spread of plant and animal pests and diseases to new areas than in the other scenarios. In fact, the development of effective, integrated plant protection practices and access to new technology lead to reductions in pest and disease problems in many parts of SSA. Similarly, improvements in the animal health programmes, nutrition and genetic material used in livestock farming further

reduce the prevalence of animal diseases. There is good availability of agricultural inputs at low prices, mainly because phosphorus recycling technology has been developed. Local inputs, such as animal manure and food waste, also contribute to keeping demand for inputs relatively low in relation to availability. Soil fertility, production potential and ecosystem services are improving because knowledge about sustainable cultivation is good, and sufficient inputs are available. Access to water is the same as today, but is more unevenly distributed. However technological development in this area lessens the effects of uneven distribution of water.

The population has increased to 1.5 billion by 2050, lower than the UN forecast. Living standards and levels of education are higher than today. People are healthier and consequently live longer, which has led to a higher average age, but fewer children are being born. There is rapid urbanization, but people are also returning to rural communities. The development of business enterprises in rural areas within, for example, agriculture, service enterprises and small-scale industries provides favourable conditions for people to live in these areas. Rural communities become more concentrated in some regions and rural industrial estates are established. Due to relatively good living standards people have no reason to move, so migration is low.

Strong economic development has helped to end famine and malnutrition is at a low level. Plant-based food accounts for 85 % of calorie intake, similar to today's global average. However, consumption of pork, poultry and fish is increasing.

3.3. A fragmented world

Global

- World population 11 billion
- Temperature increase 3–4°C
- Weak intergovernmental actors and nations

Population growth is high and has exceeded the UN forecasts. The absence of dominant nations or intergovernmental actors ensures that power relations are unsettled and that failures in inter-

national negotiations occur. Private companies dominate. Technical evolution is slow and the distribution of new technologies is uneven. Fossil fuels (coal) dominate the energy market. The high food demand increases the need for agricultural land. Water resources are scarce, soil fertility and ecosystem services are decreasing. The consumption of animal products is low globally as the result of poverty.

Sub-Saharan Africa

In this scenario many states are weak and in SSA most states are illegitimate. Large companies have great power, as do various interest groups, religious and ideological organisations. Social movements are strong, but they are authoritarian and often lead to increased repression. There are a few strong and effective states in Africa. Since most states are ineffective, there are great risks of both regional and local conflicts. The world market is small and buying power in Europe and the West weak, providing small export opportunities for Africa. The WTO's present system of sanitary and phytosanitary standards for trading food, plants and animals has collapsed. Agricultural policies are passive both towards and within Africa.

Economic development is weak. GDP per capita and domestic food production per capita are lower than today. The only growth sectors in this scenario are the mining, oil and gas industries. There is a large increase in oil and gas production in Africa. Production is possible, despite the unstable situation, because of heavy security provided by strong companies. There is little bioenergy production and new small-scale energy technology develops and spreads slowly. The weak economy has resulted in poorer infrastructure compared with today.

In this scenario there is limited use of land by foreigners for food production (but land owned by foreigners is exploited for other purposes). Land use is informal because states, and hence state institutions, are weak. Family and relationship-based safety nets are getting stronger. There are large economic divides in society and women have little power both within the family and in

society. Due to deficits of both incentives and ability, production technology is developing and spreading slowly.

In this scenario there are many conflicts, leading to a decrease in the area of grazing land. The area of arable land is the same as today, but has contracted towards the equator as a result of drought caused by climate change in regions that are cultivated today. A large population increase leads to pressure for new arable land, consequently in many areas grazing land and forest is brought under cultivation. Since states are weak, environmental policies are also weak or non-existent. Soil fertility, production potential and ecosystem services decline. Many cultivated soils are prone to erosion. Availability of agricultural inputs is low and uncertain and their prices are high, which together with poor availability of public goods leads to low crop and livestock productivity. Climate change results in crop and livestock pests and diseases posing greater problems than today. There is less access to water and it is more unevenly distributed than today. This is accentuated by more extreme weather events, such as recurring downpours resulting in flooding. Overfishing and widespread environmental destruction results in decreased availability of fish.

The population is 2 billion in 2050, higher than the UN forecast. Education levels are low and health problems widespread among the population. Children form a large proportion of the population. There is rapid urbanization and slums are spreading. Rural areas are undeveloped, with the exception of a few limited regions that have been able to develop. Migration both within and from SSA is high.

Famine is widespread and plant-based foods account for 98 % of calorie intake, equivalent to the highest proportion in any SSA country today. A larger proportion of animal-based protein than today comes from eggs, pigs and poultry. These animals do not require much land, are fairly cheap and easy to keep near the home and therefore are often preferred by poor farmers.



In the scenario 'An overexploited world', famine is widespread and plant-based food accounts for 94 % of calorie intake, approximately the same as today in SSA.

3.4. An overexploited world

Global

- World population 11 billion
- Temperature increase 3–4°C
- Shortage of fertile land

Population growth has exceeded the UN forecasts. Poverty is prevalent. There is a unipolar world order in which the USA dominates and the Western world is achieving strong economic development. Europe has a protected market and a well developed supranational institution. There are no political restrictions on energy consumption. The demand for land resources is high owing to the increased use of biofuels. This leads to the expansion of land areas used for agricultural production and livestock grazing. Soil fertility, water resources and ecosystem services are in decline as the result of overexploitation. Globally, the proportions of animal and plant-based food are the same as they are today.

Sub-Saharan Africa

Large companies have great power. Many states are weak and have difficulty drafting and implementing effective domestic policies. This gives rise to great risks for local conflicts. There are, however, strong social movements, especially global interest organisations that work to improve society. The world market is large, but the WTO has lost its role. Africa's agricultural policy is largely determined from outside by the agricultural policies of external actors rather than being set by internal agenda.

GDP per capita is low and gaps between rich and poor have increased compared with today. Growth sectors are agriculture and the mining, oil and gas industries. Infrastructure is at the same level as today, in other words, poor. Oil and gas production has increased substantially in Africa. Biofuel production, mainly from biomass grown in plantations, is also high. However, the development and spread of small-scale energy technology are slow.

Land use is widely controlled by foreigners. Family and relationship-based networks are decreasing in importance. Economic divides between different groups increase in this scenario. Production technology develops slowly, but spreads quickly in SSA.

The area of grazing land increases, while that of arable land remains unchanged compared with today, but both of these land types become concentrated closer to the equator due to climate change. Soil fertility and ecosystem services decline and environmental degradation increases. Availability of agricultural inputs is low and their prices are high. There is less access to water than today and it is more unevenly distributed. In addition, climate change is causing more extreme weather conditions with severe drought, downpours and flooding. Consequently, areas with suitable conditions for both plant- and animal-based food production decrease. Environmental destruction and overfishing lead to reductions in fish stocks, but aquaculture has been developed and partly compensates for the reductions.

By 2050 the African population has increased to 2 billion, larger than the UN forecast. The average age is low. Levels of education are also low and there are widespread health problems. Many people move to the big cities, but there are few opportunities for making a living in them. Rural areas remain undeveloped. There is large-scale migration within SSA, but not much migration

from Africa due to restrictive immigration and refugee policies in, for example, Europe.

Famine is widespread. Plant-based food accounts for 94 % of calorie intake, approximately the same as today in SSA. A larger proportion of animal protein comes from milk, beef, sheep and goat compared to today. ■

4. Critical areas and research issues

As outlined in the 'Introduction', a workshop with stakeholders and researchers with different backgrounds was arranged. In this workshop the scenarios were used as starting points to identify and discuss future needs, gaps in knowledge and major research issues. The results from the workshop provided a basis for the working group to identifying four critical areas of factors for the future of agriculture, and thus food security and poverty reduction, in the SSA:

- Governance and infrastructure for agriculture,
- Sustainable and productive farming systems,
- Investment and risk management in agriculture,
- Innovation and adoption of technology in agriculture.

Within each of these critical areas important research issues were generated by using the conditions in the four scenarios for posing the questions: 'How do we reach or maintain this good condition?' or 'How do we avoid ending up in this bad condition?' In other words, what are the opportunities and challenges, respectively? Here, 'good' and 'bad' conditions are defined as situations in which all or several of the UN MDGs are fulfilled, and situations in which the goals are not fulfilled, respectively. To develop cost-efficient and robust tools for assessing impact of interventions is an important and crosscutting research theme within all four areas.

The overarching goal of research related to all four of these critical areas is to identify possible ways to use agriculture for producing food for the growing African population sustainably (economically, ecologically and socially), recognizing that the extent to which this can be accomplished

strongly depends on the status of the factors varied in the scenarios.

In addition to producing food for a growing population, the scenarios lead to different critical challenges and opportunities depending on the conditions for SSA in the different scenarios. For Changed Balance of Power and An Overexploited World, the additional major challenge would be to reduce the negative effects of large climate change and strong foreign influence over large sectors of African agriculture. In A World in Balance the additional major challenges concern the role that agriculture must play in order to reach other UN MDGs, and identifying ways to remain in this favourable state. In A Fragmented World, mitigation of the adverse effects of this scenario and identifying ways to avoid them are central challenges. It is acknowledged, as general outcome from the analyses, that other activities but agriculture play a role in reducing rural poverty.

Notably, two key issues are pertinent to all of the challenges: the distribution of any increases in food production and wealth (for instance, the relative proportions reaching elites, urban middle classes and poor rural populations); and women's involvement in development, which should be beneficial both for enhancing its efficiency and from a rights perspective.

4.1. Governance and infrastructure for agriculture

Governance and infrastructure are central issues for developing African agriculture. Aspects warranting research attention include governance per se, institutions and markets, policies for providing public goods in society, and both physical and institutional infrastructure, all of which should ideally be examined on different levels, from local



What are the roles of and needs for public goods like animal health service systems, plant pest control, plant and livestock breeding stations, crop and livestock extension services?

to national and regional. Key issues include how to establish good governance and institutions, how elements of social structures like gender, ethnicity and power relations affect land use and rights to use land, and how to enhance capacity for international negotiations. In addition, the relationships between governance and infrastructure and changes in society, technology and agricultural production need to be better understood.

Important specific research questions are:

- o How can agriculture be used as a lever for economic development? What social and technological advances and institutional frameworks are needed? What can be learnt from history?
- o What are the threats and opportunities for SSA states under different assumptions of governance and institutions? How do these differences affect the sustainability of food production, social responsibility and environmental issues? Are there differences in wider implications for Africa between adoption of private company US/West-driven large-scale agriculture and production driven by different Asian states or companies?
- o How are smallholder farmers, pastoralists and other marginalized groups affected under different scenarios, and how are the effects related to global trends regarding ethics and equity among consumers and private

companies? What are the roles of local power relations and rights to use and own land for agriculture and grazing?

- o How do differences in national governance influence international private companies – where profits are made, where taxes are paid, and how SSA incomes and resources can be used to develop SSA agriculture and welfare?
- o Governance and agricultural transitions – what can be learned from history? How do effects of interventions supporting small-holders differ from those supporting large scale farming with respect to promoting economic development and/or food security?
- o What is the role of logistic, physical and institutional infrastructure for access to and integration with global markets. What are the obstacles and opportunities regarding negotiation capacity in SSA with regard to global markets?
- o What is the role of physical and institutional infrastructure for access to formal markets for smallholder farmers? What bottlenecks restrict small-scale farmers' access to formal domestic urban markets?
- o What are the roles of and needs for global, regional and/or local public goods like animal health service systems and plant pest control, plant and livestock breeding stations, crop and livestock extension services, and other facilities or services for capacity building etc.?

4.2. Sustainable and productive farming systems

In all scenarios, sustainable, productive farming systems will be crucial for African development. Farming systems are defined as integrated ecological, social, technological and economic production systems. Hence exploring all pertinent social, economic and ecological facets of such systems at various spatial and temporal scales are crucial tasks for researchers. Important facets include how production is organized socially, and the roles of gender, equity and international institutions for economic development. In the scenarios, development of SSA will involve different mixtures of small-scale subsistence farming,

large-scale plantation production for global or regional markets, urban food production, crop and livestock production and fisheries or aquaculture. In all scenarios food production needs to increase in SSA, but they differ in the ways that this could be accomplished and the extent to which it could succeed in feeding increased SSA populations.

Major specific research questions include:

- o What are the natural and social obstacles for increasing the productivity of African agriculture? How can post-harvest losses be reduced to contribute to improved food security?
- o How can small-scale farming systems be made more productive and more attractive for the rural population? What incentives and social institutions can strengthen small-scale farming?
- o How can the potential of agriculture on marginal lands, dryland agriculture, land restoration, and unused land for sustainable food (or biofuel) production be exploited? What is the role of connections between urban and rural areas for robust and resilient farming systems and livelihoods?
- o What are the pros and cons of expanding urban agriculture systems?
- o What are the roles of livestock in food production and social systems, as food, capital, buffer and manure producers?
- o How can appropriate aquaculture be developed for SSA conditions?
- o What knowledge and strategies are needed to manage, socially and environmentally soundly, consequences of increased food production in plantation agriculture?
- o How effective are extension services for building agricultural capacity, and what are the optimal extension methods? What can improvements in extension services contribute to sustainable increases in agricultural production and food security?
- o How can the effects of climate change be used effectively in agriculture?
- o Can agriculture driven by international actors and private companies enhance food production and economic development in



Development of SSA will involve different mixtures of small-scale subsistence farming, large-scale plantation production for global or regional markets, urban food production, crop and livestock production and fisheries or aquaculture.

- SSA (and if so how, and to what extent)?
- Which are the differences between SSA and other regions in the world in this respect?
- o How can experiences from other parts of the world regarding mitigation of possible adverse social and environmental effects be considered while intensifying agriculture in SSA?

4.3. Investment and risk management in agriculture

There is an international consensus that investment in African agriculture is inadequate. This is likely partly due to an unfavourable balance between capabilities to manage risks and the returns in agriculture. The investments have several aspects like time, political, educational and

financial investments. Hence, risk factors, analyses, perceptions and the ability to adequately manage risks may vary substantially between domestic and international investors, between small- and large-scale farming systems etc., or the risks may be similar in all cases. Several of these issues benefit from being addressed along value chain models.

Important specific research needs and questions include:

- o Inventories and analyses of risk perception among different categories of farmers and investors and along different value chains.
- o Analysis of the global, regional and local drivers and buffers of commodity volatility, including the possibility of controlling markets for buffering risks in food production.
- o What means are available to reduce the risks arising from disasters affecting crop and livestock production, especially droughts, floods, pests and diseases?
- o How can access to agricultural inputs such as phosphorus, energy etc. be secured?
- o How can efficient and lasting financial and other insurance systems for agricultural production be designed and improved?
- o How do agricultural production and practices change with global, regional and/or national increases in political, economic and climatic uncertainty?
- o How do agricultural production and practices change with increases in political and economic stability?
- o How can robust production systems and social security systems be designed for small-scale farmers? What is the role of livestock in risk management? How can agriculture contribute to investment and risk taking for economic development? Is this different in SSA compared with other parts of the world?
- o What is the role of non-farm incomes as a risk management strategy in rural livelihood?
- o How can 'catastrophe farming systems' be developed that optimize self-sufficiency in rural and urban agriculture during times of catastrophes and scarcity?

4.4. Innovation and adoption of technology in agriculture

Several innovations and new technologies are available that could be applied in SSA agriculture and increase its sustainability and productivity. Sometimes such adoption occurs and sometimes not. Understanding the social, economic and cultural reasons and mechanisms behind successful adoption of innovations and new technologies is crucial for positive development of SSA agriculture.

Important research needs and questions in this context include:

- o What are the roles of different socio-technical systems for innovation and adoption of new production technologies in agriculture? How do such local systems relate to regional or global use of new technologies?
- o Inventories and analyses of patterns of adoption of innovations and new technology in agriculture in different cultural settings, among men and women, in urban and rural areas, among pastoral and crop culturing communities, and for small-scale and large scale farming systems?
- o How can successful strategies for efficient adoption of productivity-increasing technologies be identified and developed (and bottle-necks identified and eliminated)?
- o What are the consequences of increases in agricultural productivity for family structures, income and other social and economic aspects of rural societies? ■

5. Concluding remarks

Four different future scenarios for SSA that were derived from four global scenarios are described in this report. This enabled an analysis of issues related to agriculture and food security on the global level, the SSA-level and the local village or household as well as the interrelationship between these levels. Further, by including a wide range of factors influencing the future in the scenarios, several scientific competences were needed to properly address the issues at hand. Hence, the research questions highlighted here are on different scales and covering a range of scientific disciplines. The cooperation over disciplinary and national borders is imperative for such a thematic approach and this report is our contribution to this very complex task. Other readers may perhaps reach slightly different conclusions, as evident in other analyses of the future of agriculture and food production in SSA, but we hope that our scenarios and research questions will contribute to broaden the minds of our readers, acknowledging the unpredictability of the future, the diversity of possible ways forward and the need for different scientific disciplines and stakeholders to work together for the development of agriculture in SSA.

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Appendix

Legend to matrices with factors and states used to construct the scenarios

Scenario	Factors
Actual scenario	State for the actual scenario
Other scenario	Not chosen state for the actual scenario

Changed balance of power

Natural resources

Scenario	Area used for livestock	Area used for crops	Fertility of arable land, potential for production and ecosystem services	Access to commercial agricultural inputs	Pests and diseases on livestock and crop	Water access	Wild fish and aquaculture
Changed balance of power	Area grazing land increasing	Area arable land in increasing	Increased	Good. Low prices	Situation worse than today	Access to water same as today, distributed as today	Availability of wild fish same as today. More aquaculture
A world in balance	Area grazing land same as today, situated the same	Area arable land same as today, situated the same	Same as today	Little. High prices	Same as today	Access to water same as today, less equally distributed than today	Availability of wild fish same as today
A fragmented world	Area grazing land the same as today, shift towards the equator	Area arable land same as today, contracted around the equator	Decreased	Uncertain availability	Situation better than today	Less access to water than today, less equally distributed than today	Decreased availability of wild fish. Aquaculture makes up the difference
An over-exploited world	Area grazing land decreasing	Area arable land decreasing a lot				More extreme conditions (drought, flooding)	Decreased availability of fish

Distribution of power, governance and policy

Scenario	Distribution of power	Capacity and internal role of the state	Conflicts	Agricultural policy of the surrounding world towards SSA	Agricultural policy within SSA	Social movements affecting development
Changed balance of power	Pan-African cooperation	Legitimate. Good governance. Large role	Large risk for large conflicts	Development friendly trade policies	Active. Diversified	Strong social movements. Non-authoritarian
A world in balance	Some stronger states	Legitimate. Good governance. Small role	Large risk for local conflicts	Large world market	Active. Focus on smallholders	Strong social movements. Authoritarian
A fragmented world	Equally strong states	Legitimate. Ineffective. Large role	Smaller risk for conflicts	Collapse of current WTO SPS standards	Active. Focus on plantation production	Weak social movements
An overexploited world	Weak states. Large corporations have power	Legitimate. Ineffective. Small role		Current WTO SPS standards maintained	Active. Focus on food production	
		Illegitimate. Effective. Large role		Small world market. No imports from Africa	Active. Focus on cash crops	
		Illegitimate. Effective. Small role		Continued subsidising of own products	Active. Focus on livestock farming (meat production)	
		Illegitimate. Ineffective. Large role		Passive	Passive. Directed from outside	
		Illegitimate. Ineffective. Small role			Passive	

(Continuing: *Changed balance of power*)

Human population growth

Scenario	Health and Education	Settlement patterns	Population 2050	Proportion of people in productive age	Migration out of, into and within SSA
Changed balance of power	Healthier, better educated population	Continued urbanisation. Developed rural areas	2.0 billion	Pyramid with a broad base	Large within SSA. Little out of SSA
A world in balance	Healthier. Low education level	Continued urbanisation. Under-developed rural areas	1.7 billion	Pyramid with a narrower base	Large within SSA. Large out of SSA
A fragmented world	Large health problems. Low educational level	Urbanisation halted	1.5 billion		Little within SSA. Large out of SSA
An overexploited world	Large health problems. High educational level	Move back to rural areas. Developed rural areas			Little within SSA. Little out of SSA
					Large into SSA

Economic development

Scenario	Economic development	Growth sectors	Regional food production per capita	Infrastructure
Changed balance of power	Higher GDP/cap. Fewer inequalities (Gini)	Manufacturing industry	Higher	Developed infrastructure
A world in balance	Lower GDP/cap. Fewer inequalities (Gini)	Agriculture	Unchanged	Unchanged
A fragmented world	Higher GDP/cap. Larger inequalities (Gini)	Service	Lower	Deterioration in infrastructure
An overexploited world	Lower GDP/cap. Larger inequalities (Gini)	Mining, oil, gas, etc.		

Access to energy resources

Scenario	Oil and natural gas extraction	Biofuel production	Development and deployment of small-scale energy technology
Changed balance of power	Large increase	High productivity. Plantations	Rapid development and deployment
A world in balance	Increase	High productivity. Smallholder based	Slow development and deployment
A fragmented world		Low productivity	Slow development and rapid deployment
An overexploited world			

Agricultural production systems

Scenario	Right of use of agricultural land	Social institutions at community level	Social institutions at individual level	Distribution of productive resources	Development and spread of production technology
Changed balance of power	Formalised land ownership	Increasingly identity based	Modernisation of safety net	Increasing power to women	Rapid development. Rapid spread in SSA
A world in balance	Formal tenancy rights for land	Decreasingly identity based. Increasingly individual based	Family- and relation-based safety net	Little power to women	Rapid development. Slow spread in SSA
A fragmented world	Informal tenancies		Depleted safety net	Polarised horizontal access to productive resources	Slow development. Slow spread in SSA
An overexploited world	Limited foreign use of land			More equal horizontal access to productive resources	Slow development. Rapid spread in SSA
	Large foreign use of land			Polarised vertical access to productive resources	
				More equal vertical access to productive resources	

Nutrition

Scenario	Level of nutrition	Consumption of plant-versus animal-based food (% of calorie intake)	Consumption of animal-based food (% protein)
Changed balance of power	Widespread famine (calorie deficit)	Plant-based 85%. Animal including fish 15%	Beef, lamb, goat inc. milk 67%. Pork, poultry, eggs 33%. Fish same as today
A world in balance	Famine occurs (calorie deficit). Widespread malnutrition	Plant-based 94%. Animal including fish 6%	Beef, lamb, goat inc. milk decreasing. Pork, poultry, eggs increasing. Fish decreasing
A fragmented world	No famine. Some malnutrition (deficit of certain nutrients)	Plant-based 98%. Animal including fish 2%	Beef, lamb, goats inc. milk decreasing. Pork, poultry, eggs increasing. Fish increasing
An overexploited world	No famine. No malnutrition		Beef, lamb, goats inc. milk increasing. Pork, poultry, eggs decreasing. Fish same as today

A world in balance

Natural resources

Scenario	Area used for livestock	Area used for crops	Fertility of arable land, potential for production and ecosystem services	Access to commercial agricultural inputs	Pests and diseases on livestock and crop	Water access	Wild fish and aquaculture
Changed balance of power	Area grazing land increasing	Area arable land in increasing	Increased	Good. Low prices	Situation worse than today	Access to water same as today, distributed as today	Availability of wild fish same as today. More aquaculture
A world in balance	Area grazing land same as today, situated the same	Area arable land same as today, situated the same	Same as today	Little. High prices	Same as today	Access to water same as today, less equally distributed than today	Availability of wild fish same as today
A fragmented world	Area grazing land the same as today, shift towards the equator	Area arable land same as today, contracted around the equator	Decreased	Uncertain availability	Situation better than today	Less access to water than today, less equally distributed than today	Decreased availability of wild fish. Aquaculture makes up the difference
An overexploited world	Area grazing land decreasing	Area arable land decreasing a lot				More extreme conditions (drought, flooding)	Decreased availability of fish

Distribution of power, governance and policy

Scenario	Distribution of power	Capacity and internal role of the state	Conflicts	Agricultural policy of the surrounding world towards SSA	Agricultural policy within SSA	Social movements affecting development
Changed balance of power	Pan-African cooperation	Legitimate. Good governance. Large role	Large risk for large conflicts	Development friendly trade policies	Active. Diversified	Strong social movements. Non-authoritarian
A world in balance	Some stronger states	Legitimate. Good governance. Small role	Large risk for local conflicts	Large world market	Active. Focus on smallholders	Strong social movements. Authoritarian
A fragmented world	Equally strong states	Legitimate. Ineffective. Large role	Smaller risk for conflicts	Collapse of current WTO SPS standards	Active. Focus on plantation production	Weak social movements
An overexploited world	Weak states. Large corporations have power	Legitimate. Ineffective. Small role		Current WTO SPS standards maintained	Active. Focus on food production	
		Illegitimate. Effective. Large role		Small world market. No imports from Africa	Active. Focus on cash crops	
		Illegitimate. Effective. Small role		Continued subsidising of own products	Active. Focus on livestock farming (meat production)	
		Illegitimate. Ineffective. Large role		Passive	Passive. Directed from outside	
		Illegitimate. Ineffective. Small role			Passive	

(Continuing: *A world in balance*)

Human population growth

Scenario	Health and Education	Settlement patterns	Population 2050	Proportion of people in productive age	Migration out of, into and within SSA
Changed balance of power	Healthier, better educated population	Continued urbanisation. Developed rural areas	2.0 billion	Pyramid with a broad base	Large within SSA. Little out of SSA
A world in balance	Healthier. Low education level	Continued urbanisation. Underdeveloped rural areas	1.7 billion	Pyramid with a narrower base	Large within SSA. Large out of SSA
A fragmented world	Large health problems. Low educational level	Urbanisation halted	1.5 billion		Little within SSA. Large out of SSA
An overexploited world	Large health problems. High educational level	Move back to rural areas. Developed rural areas			Little within SSA. Little out of SSA
					Large into SSA

Economic development

Scenario	Economic development	Growth sectors	Regional food production per capita	Infrastructure
Changed balance of power	Higher GDP/cap. Fewer inequalities (Gini)	Manufacturing industry	Higher	Developed infrastructure
A world in balance	Lower GDP/cap. Fewer inequalities (Gini)	Agriculture	Unchanged	Unchanged
A fragmented world	Higher GDP/cap. Larger inequalities (Gini)	Service	Lower	Deterioration in infrastructure
An overexploited world	Lower GDP/cap. Larger inequalities (Gini)	Mining, oil, gas, etc.		

Access to energy resources

Scenario	Oil and natural gas extraction	Biofuel production	Development and deployment of small-scale energy technology
Changed balance of power	Large increase	High productivity. Plantations	Rapid development and deployment
A world in balance	Increase	High productivity. Smallholder based	Slow development and deployment
A fragmented world		Low productivity	Slow development and rapid deployment
An overexploited world			

Agricultural production systems

Scenario	Right of use of agricultural land	Social institutions at community level	Social institutions at individual level	Distribution of productive resources	Development and spread of production technology
Changed balance of power	Formalised land ownership	Increasingly identity based	Modernisation of safety net	Increasing power to women	Rapid development. Rapid spread in SSA
A world in balance	Formal tenancy rights for land	Decreasingly identity based. Increasingly individual based	Family- and relation-based safety net	Little power to women	Rapid development. Slow spread in SSA
A fragmented world	Informal tenancies		Depleted safety net	Polarised horizontal access to productive resources	Slow development. Slow spread in SSA
An overexploited world	Limited foreign use of land			More equal horizontal access to productive resources	Slow development. Rapid spread in SSA
	Large foreign use of land			Polarised vertical access to productive resources	
				More equal vertical access to productive resources	

Nutrition

Scenario	Level of nutrition	Consumption of plant-versus animal-based food (% of calorie intake)	Consumption of animal-based food (% protein)
Changed balance of power	Widespread famine (calorie deficit)	Plant-based 85%. Animal including fish 15%	Beef, lamb, goat inc. milk 67%. Pork, poultry, eggs 33%. Fish same as today
A world in balance	Famine occurs (calorie deficit). Widespread malnutrition	Plant-based 94%. Animal including fish 6%	Beef, lamb, goat inc. milk decreasing. Pork, poultry, eggs increasing. Fish decreasing
A fragmented world	No famine. Some malnutrition (deficit of certain nutrients)	Plant-based 98%. Animal including fish 2%	Beef, lamb, goats inc. milk decreasing. Pork, poultry, eggs increasing. Fish increasing
An overexploited world	No famine. No malnutrition		Beef, lamb, goats inc. milk increasing. Pork, poultry, eggs decreasing. Fish same as today

A fragmented world

Natural resources

Scenario	Area used for livestock	Area used for crops	Fertility of arable land, potential for production and ecosystem services	Access to commercial agricultural inputs	Pests and diseases on livestock and crop	Water access	Wild fish and aquaculture
Changed balance of power	Area grazing land increasing	Area arable land in increasing	Increased	Good. Low prices	Situation worse than today	Access to water same as today, distributed as today	Availability of wild fish same as today. More aquaculture
A world in balance	Area grazing land same as today, situated the same	Area arable land same as today, situated the same	Same as today	Little. High prices	Same as today	Access to water same as today, less equally distributed than today	Availability of wild fish same as today
A fragmented world	Area grazing land the same as today, shift towards the equator	Area arable land same as today, contracted around the equator	Decreased	Uncertain availability	Situation better than today	Less access to water than today, less equally distributed than today	Decreased availability of wild fish. Aquaculture makes up the difference
An overexploited world	Area grazing land decreasing	Area arable land decreasing a lot				More extreme conditions (drought, flooding)	Decreased availability of fish

Distribution of power, governance and policy

Scenario	Distribution of power	Capacity and internal role of the state	Conflicts	Agricultural policy of the surrounding world towards SSA	Agricultural policy within SSA	Social movements affecting development
Changed balance of power	Pan-African cooperation	Legitimate. Good governance. Large role	Large risk for large conflicts	Development friendly trade policies	Active. Diversified	Strong social movements. Non-authoritarian
A world in balance	Some stronger states	Legitimate. Good governance. Small role	Large risk for local conflicts	Large world market	Active. Focus on smallholders	Strong social movements. Authoritarian
A fragmented world	Equally strong states	Legitimate. Ineffective. Large role	Smaller risk for conflicts	Collapse of current WTO SPS standards	Active. Focus on plantation production	Weak social movements
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		Illegitimate. Effective. Small role		Continued subsidising of own products	Active. Focus on livestock farming (meat production)	
		Illegitimate. Ineffective. Large role		Passive	Passive. Directed from outside	
		Illegitimate. Ineffective. Small role			Passive	

(Continuing: A fragmented world)

Human population growth

Scenario	Health and Education	Settlement patterns	Population 2050	Proportion of people in productive age	Migration out of, into and within SSA
Changed balance of power	Healthier, better educated population	Continued urbanisation. Developed rural areas	2.0 billion	Pyramid with a broad base	Large within SSA. Little out of SSA
A world in balance	Healthier. Low education level	Continued urbanisation. Under-developed rural areas	1.7 billion	Pyramid with a narrower base	Large within SSA. Large out of SSA
A fragmented world	Large health problems. Low educational level	Urbanisation halted	1.5 billion		Little within SSA. Large out of SSA
An overexploited world	Large health problems. High educational level	Move back to rural areas. Developed rural areas			Little within SSA. Little out of SSA
					Large into SSA

Economic development

Scenario	Economic development	Growth sectors	Regional food production per capita	Infrastructure
Changed balance of power	Higher GDP/cap. Fewer inequalities (Gini)	Manufacturing industry	Higher	Developed infrastructure
A world in balance	Lower GDP/cap. Fewer inequalities (Gini)	Agriculture	Unchanged	Unchanged
A fragmented world	Higher GDP/cap. Larger inequalities (Gini)	Service	Lower	Deterioration in infrastructure
An overexploited world	Lower GDP/cap. Larger inequalities (Gini)	Mining, oil, gas, etc.		

Access to energy resources

Scenario	Oil and natural gas extraction	Biofuel production	Development and deployment of small-scale energy technology
Changed balance of power	Large increase	High productivity. Plantations	Rapid development and deployment
A world in balance	Increase	High productivity. Smallholder based	Slow development and deployment
A fragmented world		Low production	Slow development and rapid deployment
An overexploited world			

Agricultural production systems

Scenario	Right of use of agricultural land	Social institutions at community level	Social institutions at individual level	Distribution of productive resources	Development and spread of production technology
Changed balance of power	Formalised land ownership	Increasingly identity based	Modernisation of safety net	Increasing power to women	Rapid development. Rapid spread in SSA
A world in balance	Formal tenancy rights for land	Decreasingly identity based. Increasingly individual based	Family- and relation-based safety net	Little power to women	Rapid development. Slow spread in SSA
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An overexploited world	Limited foreign use of land			More equal horizontal access to productive resources	Slow development. Rapid spread in SSA
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Scenario	Level of nutrition	Consumption of plant-versus animal-based food (% of calorie intake)	Consumption of animal-based food (% protein)
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An overexploited world

Natural resources

Scenario	Area used for livestock	Area used for crops	Fertility of arable land, potential for production and ecosystem services	Access to commercial agricultural inputs	Pests and diseases on livestock and crop	Water access	Wild fish and aquaculture
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		Illegitimate. Ineffective. Small role			Passive	

(Continuing: An overexploited world)

Human population growth

Scenario	Health and Education	Settlement patterns	Population 2050	Proportion of people in productive age	Migration out of, into and within SSA
Changed balance of power	Healthier, better educated population	Continued urbanisation. Developed rural areas	2.0 billion	Pyramid with a broad base	Large within SSA. Little out of SSA
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Access to energy resources

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A fragmented world		Low productivity	Slow development and rapid deployment
An overexploited world			

Agricultural production systems

Scenario	Right of use of agricultural land	Social institutions at community level	Social institutions at individual level	Distribution of productive resources	Development and spread of production technology
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An overexploited world	Limited foreign use of land			More equal horizontal access to productive resources	Slow development. Rapid spread in SSA
	Large foreign use of land			Polarised vertical access to productive resources	
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Nutrition

Scenario	Level of nutrition	Consumption of plant-versus animal-based food (% of calorie intake)	Consumption of animal-based food (% protein)
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An overexploited world	No famine. No malnutrition		Beef, lamb, goats inc. milk increasing. Pork, poultry, eggs decreasing. Fish same as today



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