A MONTPELLIER PANEL REPORT 2015

THE FARMS OF CHANGE

AFRICAN SMALLHOLDERS RESPONDING TO AN UNCERTAIN CLIMATE FUTURE

AGRICULTURE FOR IMPACT
GROWING OPPORTUNITIES FOR AFRICA'S DEVELOPMENT

THE FARMS OF CHANGE
AFRICAN SMALLHOLDERS RESPONDING TO AN UNCERTAIN CLIMATE FUTURE

A MONTPELLIER PANEL REPORT 2015

This report was authored by Agriculture for Impact, with advice and inputs from members of the Montpellier Panel. The primary author Dr. Katrin Glatzel was supported by Professor Sir Gordon Conway and Emily Alpert, with contributions from Stephanie Brittain and Alice Marks. The report was designed by Robb Whiteman and Hoevel & Associates.

SUMMARY

TWO OF THE GREATEST CHALLENGES OF THE 21ST CENTURY ARE THE INCREASING DEMANDS FOR FOOD, WATER AND ENERGY FROM A GROWING POPULATION AND CLIMATE CHANGE. AGRICULTURE AND SMALLHOLDERS ARE CENTRAL TO BOTH, PERHAPS NOWHERE MORE SO THAN IN AFRICA. WHILST PROGRESS HAS BEEN MADE DURING THE LAST TWO DECADES TO REDUCE HUNGER, CLIMATE CHANGE JEOPARDISES THESE GAINS.

Africa is already battling against the impacts of climate change and smallholder farmers are amongst the most vulnerable. Rising temperatures signal more extreme weather events that will put lives and livelihoods at greater risk, increasing smallholders' vulnerability to drought, famine and disease. Mean temperatures in Africa will rise faster than the global average, exceed 2°C and may reach as high as 3°C to 6°C greater than 20th century levels. Agricultural losses in Africa will amount to 2% to 7% of GDP by 2100.[1]

Climate change affects not only yields, but also food quality and safety, and the reliability of its delivery to consumers. By 2050, hunger and child malnutrition could increase by as much as 20% as a result of climate change, reversing the gains achieved through the Millennium Development Goal (MDG) process whilst jeopardising the success of the Sustainable Development Goals (SDGs). Given the importance of agriculture as a revenue earner and as the biggest employer in most African countries, the livelihoods of millions are at stake.

At the same time, smallholder farmers can also be agents of change. When given the right options and incentives, they can drive sustainable agricultural development that builds resilience and reduces greenhouse gas (GHG) emissions. Across Africa, climate change could spur countries to invest in renewable energy technologies, create new markets for agricultural producers, and build human and institutional capacities to support a knowledge economy based on innovation, research and development. To do this requires enabling policies and incentives for smallholder farmers to invest in environmental services, preserve biodiversity, sustainably manage natural resources such as land and water, and to use energy efficiently.

Achieving the United Nations Framework Convention on Climate Change (UNFCCC) goal of limiting average global temperature rise to 2°C will be hard without leveraging the potential of the agriculture sector, both in the developed and developing world. Unlocking Africa's agriculture sector in a way that captures the synergies between adaptation and mitigation and identifies and reduces trade-offs can contribute to poverty reduction and economic growth. To achieve this, adaptation efforts need to be supported through new technologies, increased financial investments, and effective institutions and regulation.

PRIORITIES

THE CHALLENGE

The threat of climate change to food and nutrition security, arising from the severe vulnerability of agriculture and farm households, needs to be on top of the agenda of the UNFCCC and national governments.

More investments in sustainable farming systems are needed to adapt to climate change and to generate mitigation co-benefits in order to improve the livelihoods of smallholder farmers.

THE SCIENCE AND IMPACTS

National governments need to invest in better weather monitoring, data collection and modelling to provide improved estimates of climate change and the probability of extreme weather events.

International organisations, governments and the private sector must increase investments in research and local capacities to understand the responses of different crops and livestock breeds to drought, floods and heat stress.

FOOD SECURITY

Better regional and national estimates of the number of people that will suffer from food and nutrition insecurity, including micronutrient deficiencies, are needed to plan resilience-building strategies.

ADAPTATION

More investments by governments, donors and the private sector are needed to scale-up proven community-based resilient adaptation projects, in particular soil, water and nutrient management, conservation technologies and risk management tools.

CO-BENEFITS FOR MITIGATION

To keep global temperature rise below 2°C above pre-industrial levels, international organisations and governments must help smallholders to reduce and offset GHG emissions.

Investments should be directed towards interventions that sequester carbon in the soil, such as agroforestry systems and better land use management practices.

FINANCE

Climate finance mechanisms should be improved or designed so that African governments can better access funding that significantly benefits smallholder farmers.

ENABLING ENVIRONMENT

Designing and implementing adaptation and mitigation strategies that benefit smallholder farmers requires strong political leadership, functioning markets and regulatory instruments.

THE CHALLENGE

AGRICULTURE AND FARMERS ARE PART OF THE PROBLEM OF, AND PART OF THE SOLUTION TO, CLIMATE CHANGE. AGRICULTURE CONTRIBUTES TO CLIMATE CHANGE BY CREATING GHG EMISSIONS THROUGH LIVESTOCK, POOR LAND USE AND IMPROPER SOIL MANAGEMENT, BUT SMALLHOLDER FARMERS AND THEIR LIVELIHOODS ARE ALSO AMONGST THE MOST VULNERABLE TO THE ADVERSE IMPACTS.

These can already be felt in many parts of the world. Crops, grazing land, trees and livestock are negatively impacted both by rising temperatures and by climatic extremes, such as too much or too little water, too high or too low temperatures, and shifts in the length of the growing season. Moreover, millions of farmers are already living in extreme poverty; they own less than one hectare of land, survive on less than US$1 a day and do not produce enough to feed their families. They are especially vulnerable to climate change and achieving food security for all will become increasingly difficult.

At the same time, agriculture also contributes significantly to global GHG emissions. Agriculture, Forestry and Other Land Use (AFOLU) combined contribute 20% to 24% of total GHG emissions. Whilst overall AFOLU emissions decreased over the last decade, emissions from crop and livestock production increased, becoming the dominant source of AFOLU emissions. Although Africa's contribution to global GHG emissions is comparatively small, emissions from the AFOLU sector are relatively high and continue to increase by 1% to 2% per year.[2] In Africa, AFOLU emissions accounted for 28% of total GHG emissions, and for example in the Democratic Republic of the Congo, the contribution is as high as 80%.[3]

Women and girls in particular are vulnerable to climate change yet their potential to increase resilience against climate shocks remains largely untapped. Limited access to capital, extension services, inputs and other resources, as well as their demanding responsibilities for producing and preparing food and collecting domestic water supplies, leave women at a disadvantage in adapting to climate change. The projected rise in water and fuel scarcity means that girls and women will need to walk further to collect wood and water. Women have fewer assets

The threat of climate change to food and nutrition security, arising from the severe vulnerability of agriculture and farm households, needs to be on top of the agenda of the UNFCCC and national governments.

More investments in sustainable farming systems are needed to adapt to climate change and to generate mitigation co-benefits in order to improve the livelihoods of smallholder farmers.

and rights than men do and are also 14 times more likely to die than men during climate related disasters – mainly because they do not receive adequate warning, are not able to leave the house alone or because they are taking care of children and the elderly.[4] However, if given the opportunity, women have been shown to increase household and community resilience to climate change.[5]

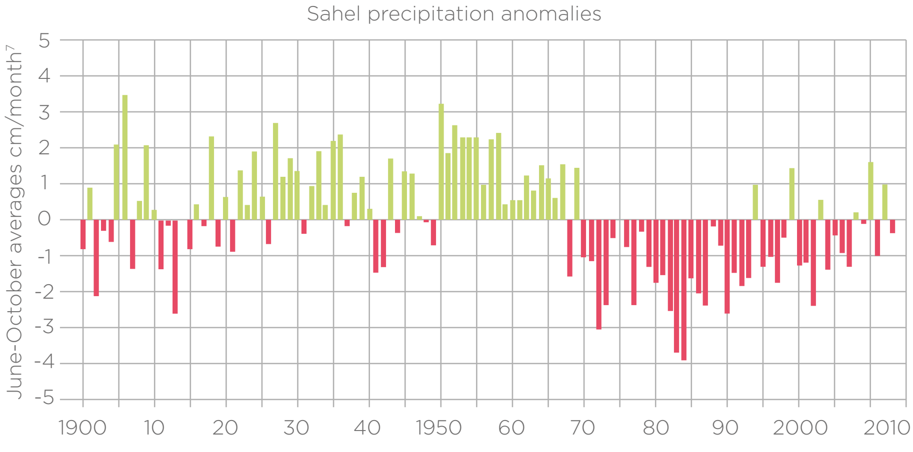
WOMEN HAVE FEWER ASSETS AND RIGHTS THAN MEN DO AND ARE ALSO 14 TIMES MORE LIKELY TO DIE THAN MEN DURING CLIMATE RELATED DISASTERS – MAINLY BECAUSE THEY DO NOT RECEIVE ADEQUATE WARNING.

Whilst climate change presents one of the most defining challenges globally and for smallholder farmers in Africa in particular, it also offers opportunities. New adaptation and mitigation technologies and processes, if carefully crafted, can provide sustainable economic benefits to smallholder farmers and entrepreneurs along agricultural value chains. Climate change is a business opportunity for new technologies and job creation in climate sensitive sectors, not only in agriculture, but also in water and energy.

THE SCIENCE AND IMPACTS

AFRICA'S CLIMATES ARE NOT ONLY DIVERSE, THEY ARE ALSO HIGHLY VARIABLE. THIS MAKES IT DIFFICULT TO SEPARATE THE EFFECTS OF NATURAL VARIATION FROM THOSE PRODUCED BY GLOBAL WARMING. NEVERTHELESS, THERE IS GROWING EVIDENCE THAT CLIMATE CHANGE IS HAVING A SIGNIFICANT AND PREDOMINANTLY DELETERIOUS EFFECT, WHICH DIFFERS FROM PLACE TO PLACE IN AFRICA AND OFTEN IN COMPLEX WAYS.

For example, the rainfall in the Sahel is naturally highly variable with decades-long phases of relatively high rainfall alternating with phases of drought. There was a nearly three decade-long phase of devastating drought beginning around 1970, the longest drought of the century. This was most likely driven by differential changes in surface temperatures in the Indian and Atlantic oceans.[6]



National governments need to invest in better weather monitoring, data collection and modelling to provide improved estimates of climate change and the probability of extreme weather events.

International organisations, governments and the private sector must increase investments in research and local capacities to understand the responses of different crops and livestock breeds to drought, floods and heat stress.

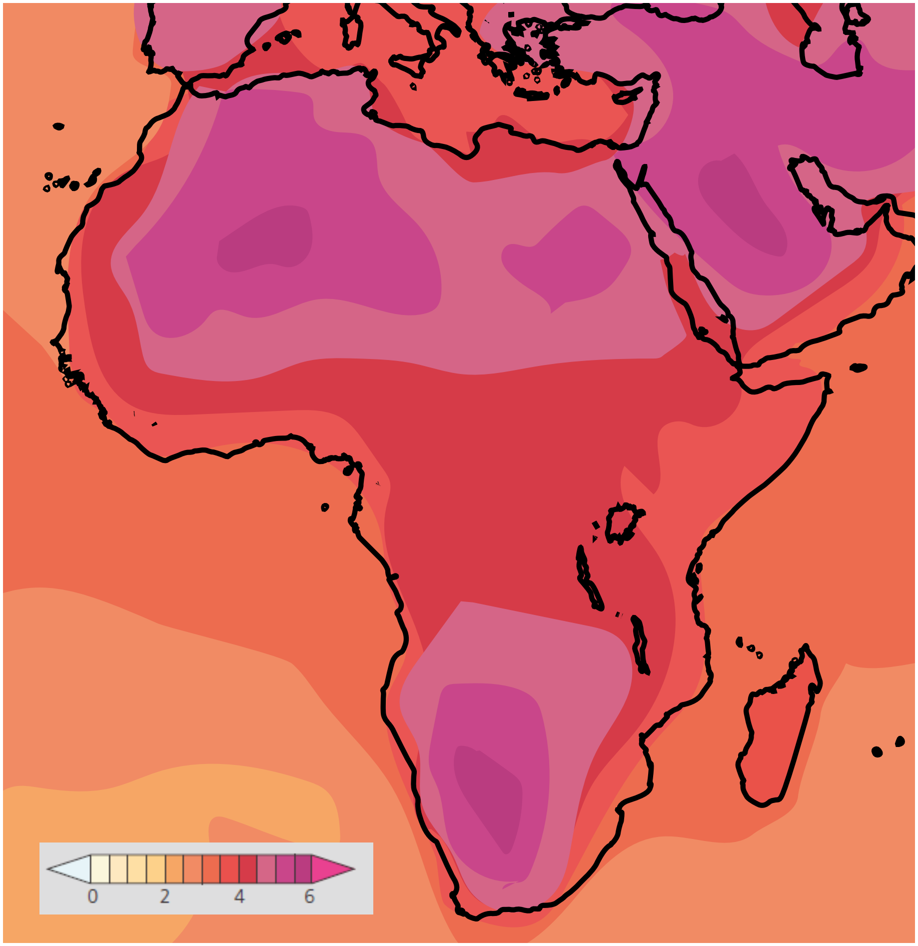
Over the last decade, however, there has been a significant increase in rainfall, including heavy rains and flooding in 2007 and 2013. One theory suggests that continuing increases in GHGs allow the atmosphere to hold more moisture, bring more rains, and shift winds, influencing the pattern of the West African monsoon.[8]

The African climate is determined at the macro-level by three major drivers: tropical convection, the alternation of the monsoons, and the El Niño-Southern Oscillation of the Pacific Ocean. The first two are local processes that determine the regional and seasonal patterns of temperature and rainfall. The third is more remote in its origin, but strongly influences the year-to-year rainfall and temperature patterns in Africa. Despite the importance of all three processes, there is a poor understanding how they interact and how they are affected by climate change.

However, as a result of anthropogenic global warming, for the past 50 to 100 years there has been an increase of 0.5°C or more in temperature across most parts of Africa. This warming — expressed through higher sea and land surface temperatures — is increasing the incidence and severity of droughts, floods and other extreme weather events.

Whilst there is a high level of confidence in future temperature increases, the changes in rainfall are much more uncertain because of the influence of spatial and seasonal factors. Over the next 100 years, with continued rapid economic growth and current energy consumption patterns heavily reliant on fossil fuels, it is likely that:

- Mean temperatures across Africa will rise faster than the global average, exceed 2°C, and may reach as high as 3°C to 6°C greater than 20th century levels.
- The drier subtropical regions will warm more than the moister tropics.
- Northern and southern Africa will become much hotter (as much as 4°C or more) and drier (precipitation falling by 15% or more).
- Precipitation trends are not yet clear in East and West Africa and elsewhere.
- Sea levels will rise, with serious consequences for agricultural and urban land in the Nile Delta and certain parts of West Africa.[9]



Projection of annual temperature change in mean °C between the beginning and end of this century under high GHG emissions (under IPCC scenario RCP8.5)[10]

FOR MAIZE IN AFRICA, EACH 'DEGREE DAY' SPENT ABOVE 30°C REDUCES THE FINAL YIELD BY 1% UNDER OPTIMAL RAIN-FED CONDITIONS AND BY 1.7% UNDER DROUGHT CONDITIONS.

THE IMPACTS

These temperature and weather changes will reduce yield levels, the quality of crops, livestock and fisheries, and directly impact the livelihoods and food security of millions of smallholder farmers across Africa. According to the Intergovernmental Panel on Climate Change (IPCC) the negative impacts of climate change will outweigh any positive effects – net global agricultural yields are predicted to decrease by up to 2% per decade.[11]

The International Food Policy Research Institute (IFPRI) estimates that by 2050 grain crop yields in sub-Saharan Africa (SSA) will shrink substantially: average rice, wheat and maize yields will decline by up to 14%, 22% and 5% respectively.[12] These decreases will take place within the context of a rapidly rising global population, where demand for food in SSA is expected to increase by 60% by 2030.[13] For maize in Africa, each 'degree day' spent above 30°C reduces the final yield by 1% under optimal rain-fed conditions and by 1.7% under drought conditions.[14] More than 60% of present maize-growing areas in Africa will experience yield losses and wheat production in northern Africa is also likely to be adversely affected.[15] For some of the other major staple crops in Africa such as sorghum and millet, on which rural populations in the drylands depend, yield declines are estimated at more than 30% and 40% respectively.[16]

Farmers in many parts of Africa who are dependent on the rains will be severely impacted by projected reductions in the amount, distribution and frequency of precipitation. Where agriculture and farmers suffer from a greater incidence and severity of extreme weather events such as drought and flooding, the prevalence of vector borne diseases such as malaria and dengue fever may worsen. This not only puts people without adequate healthcare at risk of death, but also considerably weakens families' or communities' ability to engage in any form of physical labour such as farming. In the Sahel, the risk of heat stress by the end of this century will be so high that it may constrain people's ability to engage in any sort of agricultural practices at all.[17]

Although climate models have improved and there has been an increase in available data, the uncertainties in their projections over years and decades, and at regional and local scale, have not decreased.[18] Governments, the private sector and farmers all need to be able to access better climate information on the likely incidence of extreme weather events, their impacts on food crop production, and the potential social and economic losses. To do this, national meteorological services must be better resourced and equipped to supply more reliable weather information.

IN THE SAHEL, THE RISK OF HEAT STRESS BY THE END OF THIS CENTURY WILL BE SO HIGH THAT IT MAY CONSTRAIN PEOPLE'S ABILITY TO ENGAGE IN ANY SORT OF AGRICULTURAL PRACTICES AT ALL.

FOOD SECURITY

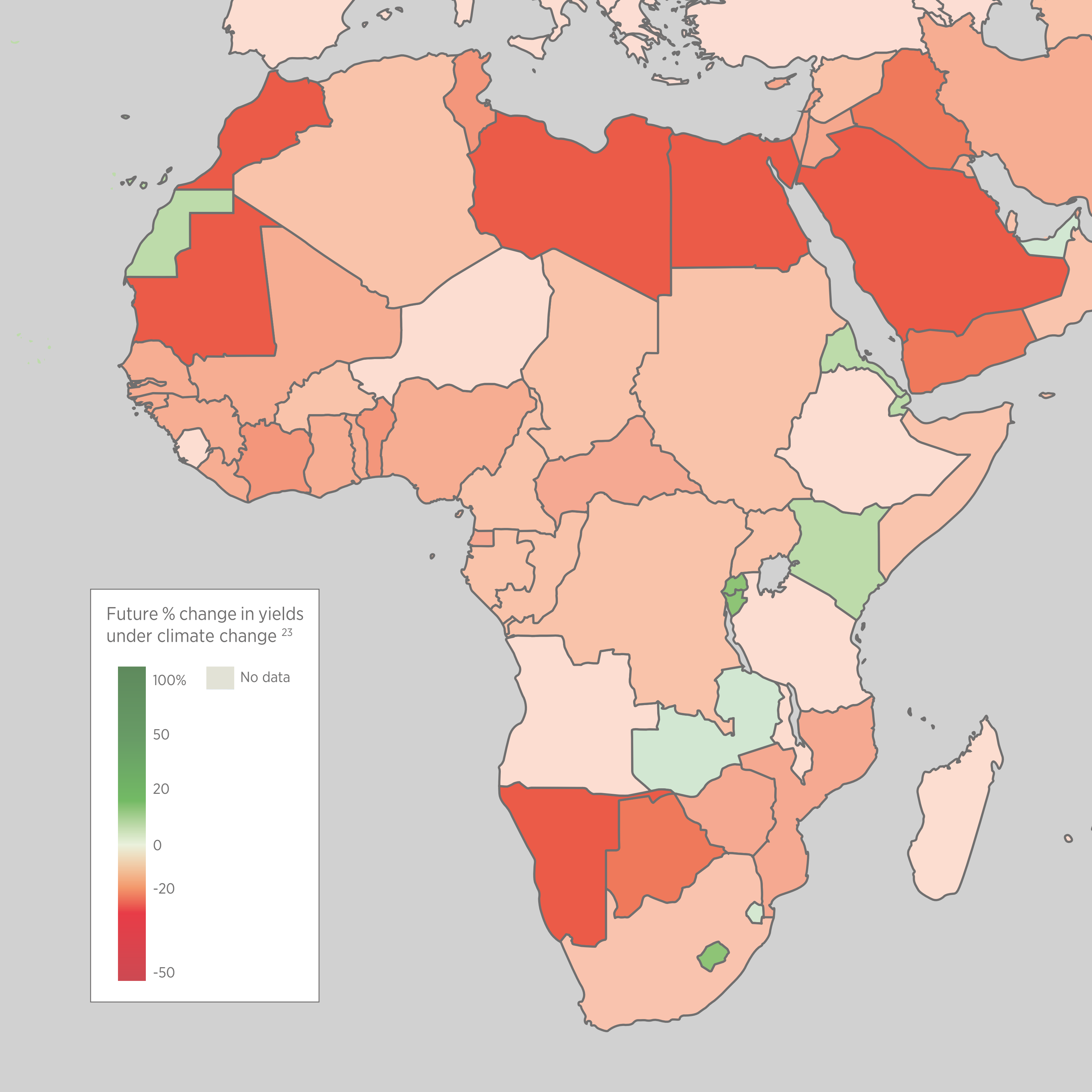
SIGNIFICANT PROGRESS HAS BEEN MADE DURING THE LAST TWO DECADES TO REDUCE HUNGER, BUT CLIMATE CHANGE JEOPARDISES THESE GAINS. ABOUT ONE OUT OF EVERY NINE PEOPLE GLOBALLY WAS CHRONICALLY UNDERNOURISHED IN 2014.[19] BY THE YEAR 2050 CLIMATE CHANGE COULD INCREASE HUNGER AND CHILD MALNUTRITION BY AS MUCH AS 20%, REVERSING THE GAINS ACHIEVED THROUGH THE MILLENNIUM DEVELOPMENT GOAL (MDG) PROCESS AND JEOPARDISING THE SUCCESS OF THE SUSTAINABLE DEVELOPMENT GOALS (SDGs).[20]

The effects of climate change on global food security will have wide-ranging impacts on health and nutrition, soil quality and water availability. Higher temperatures will reduce yields whilst changes in rainfall will affect quantity and quality of crop and livestock production, reduce the availability of water for irrigation and decrease overall soil fertility.

In Africa, low yields and high poverty rates are exacerbated by a high dependence on rainfed agriculture and limited access to agricultural inputs. As production is threatened by climate change, the prices of major crops in some countries are likely to increase. For the most vulnerable people – smallholder farmers, women and girls – who live in countries prone to natural hazards lower agricultural output will mean even lower incomes, and consequently fewer available funds to spend on nutritious food, agricultural inputs and other needs.[21]

Under climate change, maize, rice and wheat prices in 2050 are projected to be 4%, 7% and 15% higher respectively, and prices of other important crops in the region, such as sweet potato, cassava and millet, will increase by 26%, 20% and 5% respectively. These higher food prices will lower the affordability of many agricultural products, including basic staple and livestock products. As a result, per capita calorie availability in SSA is projected to decline by 37 calories per day, affecting those who can least afford to reduce their caloric intake. Child malnutrition is also likely to worsen under climate change, with an increase from 30 to 39 million children affected between 2000 and 2030.[22]

Better regional and national estimates of the number of people that will suffer from food and nutrition insecurity, including micronutrient deficiencies, are needed to plan resilience-building strategies.



Future % change in yields under climate change [23]
100%
50
20
0
-20
-50
No data

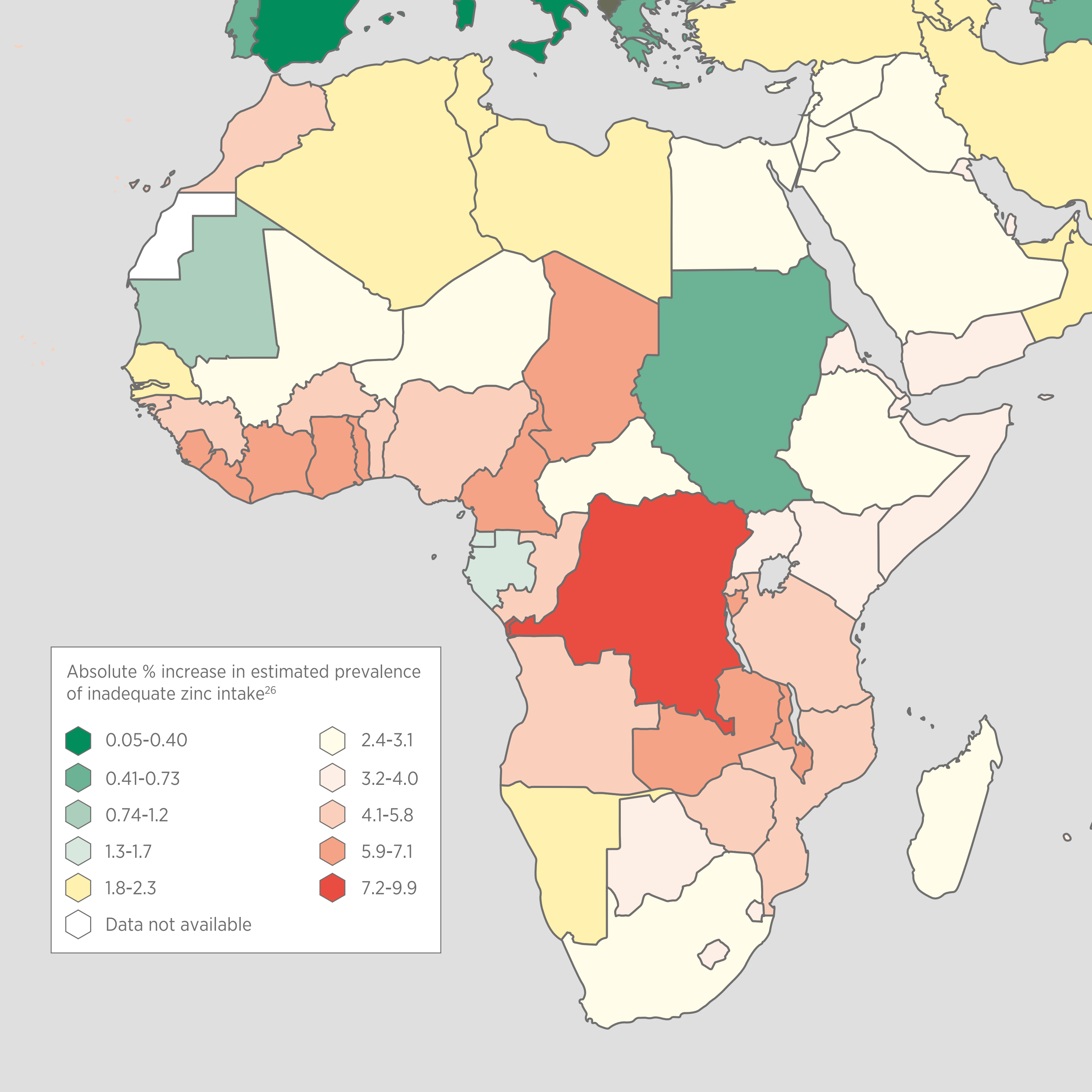
MICRONUTRIENT DEFICIENCY AND CLIMATE CHANGE

Hunger in Africa is primarily due to lack of production of, and access to, the major staple crops such as maize, rice, sorghum and cassava. However, large numbers of children under the age of five years also suffer from severe micronutrient deficiency, a lack of essential nutrients such as vitamin A, zinc and iron.[24] In most cases, the affected children will be stunted, that is under height for their age, diminishing their physical and cognitive development. Vitamin A deficiency in particular can to lead to blindness or death. Whilst reducing micronutrient deficiency requires cooperation and action across the health, education and farming sectors, one important step is increasing the availability and access to more nutrient-dense foods and diversifying diets with foods such as legumes, animal sources of protein, fruits and green leafy vegetables.

There is growing evidence that micronutrient deficiency may become worse as a result of climate change.[25] For example, field experiments have shown that elevated CO_2 concentrations in the atmosphere will significantly reduce the zinc levels in important food crops. Lack of zinc increases the risk of premature births, and later in childhood increases the risk of diarrhoea and acute lower respiratory infections. At levels of 550ppm of carbon dioxide (CO_2), which are likely to be reached within 40 to 60 years, average absorbable zinc intake in SSA will fall to a meagre 2mg per day, leaving nearly 30% of the population at risk of inadequate zinc intake.[26]

There is also evidence of reductions in iron and protein under elevated CO_2 levels.[27] A comparison of plots in eight trials in developed countries revealed that for wheat, rice and maize, iron levels declined by 5% to 6% and protein levels came down by 5% to 8%. For sorghum, iron went up slightly, but protein levels remained unchanged. For legumes such as field peas and soybeans, iron decreased by 4% whilst protein either declined slightly by 2% or remained unchanged. The physiological mechanisms involved are complex and only partly understood. However, they seem to vary from one crop species to another and within individual crop species, such as rice, suggesting a potential for breeding varieties that are less affected by raised CO_2 levels.

To achieve food security under climate change, resilience of communities and individual farmers needs to be strengthened through pro-active and longer-term adaptation actions, complemented by mitigation strategies. This can be done through diversifying livelihoods, adopting new technologies to improve water efficiency and providing insurance for farmers.


Absolute % increase in estimated prevalence of inadequate zinc intake[26]
0.05-0.40
0.41-0.73
0.74-1.2
1.3-1.7
1.8-2.3
Data not available
2.4-3.1
3.2-4.0
4.1-5.8
5.9-7.1
7.2-9.9

ADAPTATION

CLIMATE CHANGE PRESENTS SIGNIFICANT BARRIERS TO SUSTAINABLE DEVELOPMENT, AND WILL EVEN PREVENT PEOPLE FROM ESCAPING POVERTY OR PULL THEM BACK INTO POVERTY, MAKING SMALLHOLDER FARMING AN EVEN RISKIER BUSINESS.[28] AT THE FARM LEVEL, SUCCESSFUL ADAPTATION WILL REQUIRE BETTER USE OF SEASONAL FORECASTING, SOIL, WATER AND NUTRIENT MANAGEMENT, CONSERVATION TECHNOLOGIES AND FARM HOUSEHOLD DIVERSIFICATION. FARMERS, COMMUNITIES AND GOVERNMENTS ARE ALREADY TAKING ADAPTATION ACTIONS OF THIS NATURE, BUT THEY CAN AND NEED TO BE STRENGTHENED AND SCALED-UP BY ADOPTING SUSTAINABLE INTENSIFICATION (SI).

SI integrates innovations and practices from the fields of ecology, genetics and socio-economics to build environmentally sustainable, equitable, productive and resilient ecosystems that improve the well-being of farms, farmers and their families. This should be done with the goal of producing more food whilst ensuring the natural resource base on which agriculture depends is sustained.[29,30] For example, this can include nitrogen-fixing crops that improve soil quality, reducing the need for excessive fertilisers and producing a nutritious protein-rich crop or the introduction of drought-tolerant maize varieties. Farmers can also create more resilient livelihoods by diversifying into other on-farm and off-farm income earning activities.

To sustainably intensify farmers can react individually to climate change, although efforts are typically more effective when farmers act collectively as part of a farmer association. Some interventions, however, will require investment by the state or the private sector, such as for the construction of large- and small-scale irrigation systems. Crucially, interventions need to build on local experience and initiatives and ensure that top down approaches are appropriate to local conditions to avoid actions that foster adaptation in the short-term but affect communities' long-term vulnerability and adaptive capacity.

More investments by governments, donors and the private sector are needed to scale-up proven community-based resilient adaptation projects, in particular soil, water and nutrient management, conservation technologies and risk management tools.

INCREASING RESILIENCE

In the face of intensifying climatic stresses and shocks, policies that both reduce the risks posed by climate change and enhance the resilience of the agricultural sector and farmer livelihoods are ever more important. Whilst low resilience to stresses and shocks can lead to a gradual decline in agricultural productivity it can equally lead to sudden collapse without warning. Recovery may be rapid, but more often is difficult and incomplete, thereby slowing countries' overall economic and development efforts. These production and market risks make smallholders' incomes unstable and unpredictable.

Improving farmers' resilience over the long-term needs to be specific to the climate risks they face. These risks are numerous and varied, and are usually specific to the local climate, soil and agricultural production systems. Limited access to finance, markets, inputs, information and extension services together with poor infrastructure prevents farmers not only from increasing their production and revenues, but also from improving the resilience of their farms and households. When disasters strike, losses to smallholders are particularly high and usually affect entire communities.

In general, adaptation strategies that aim to increase resilience to climate risks before shocks and stresses actually occur, such as diversifying livelihoods or taking out insurance, are likely to have positive outcomes on well-being and people's livelihoods. Adaptation measures against desertification, drought, floods and soil erosion already exist, but need to be significantly scaled-up as the costs of inaction are considerably higher: for every US$1 spent preparing for disasters US$7 is saved in the cost of post-disaster recovery efforts.[31] Coping strategies adopted after shocks occur, such as selling assets, keeping children home from school or expanding agricultural production unsustainably, generally incur penalties over time including reduced incomes, resource degradation and loss of empowerment.[32]

INSURANCE

The IPCC has estimated that between 1980 and 2004 the global cost of extreme weather events came to US$1.4 trillion of which just one-quarter was insured.[33] This is likely to be an underestimate due to data gaps associated with assessing the impacts of weather extremes. Often direct effects are the only impacts that are recorded whereas the loss of cultural heritage, ecosystems services and losses to the informal or undocumented economy are particularly difficult to measure.[34]

There are many successful examples of smaller scale crop, weather and livestock-based insurance schemes. Index-based insurance programmes for managing farming risk show signs of promise. Those linked to local weather patterns provide an effective, market-mediated solution to smooth incomes and promote agricultural development and also make disaster relief more effective. However, limited regulation and inadequate infrastructure has made it difficult to bring these schemes to scale; this can now be partly achieved by using satellite data. Weather station infrastructure across Africa needs to be constructed, and where it already exists it requires modernisation to provide a sound basis for early warning systems and insurance.

INSURANCE PROJECTS IN AFRICA

AGRICULTURE AND CLIMATE RISK ENTERPRISE LTD. (ACRE)

ACRE, formerly Kilimo Salama, advises insurers on protection for African smallholders. In Kenya it protects smallholder maize and bean farmers from financial loss if their crops are damaged by weather. The partnership between Syngenta Foundation, UAP Insurance and Safaricom bundles insurance with loans for seeds, fertiliser and extension services. Eight weather stations broadcast weather updates and measure rainfall amounts; when a station detects rainfall levels that are below or above a particular crop's rainfall needs, a pay-out is triggered.

INDEX-BASED LIVESTOCK INSURANCE

In 2010 International Livestock Research Institute (ILRI), Cornell University and other partners launched an insurance scheme based on satellite imagery to predict and compensate insured pastoralists for livestock losses due to drought. The solution relies on information on the state of forage (or vegetation cover) from the NASA Normalized Difference Vegetation Index (NDVI). If the vegetation cover is insufficient over time, animals will not have enough to eat and will perish. This prediction model allowed ILRI and Cornell University to design an index-based insurance product using historical forage data that private insurers can sell to pastoralists, providing them with financial compensation when a drought occurs and forage becomes scarce.

RURAL RESILIENCE INITIATIVE (R4)

R4 is a partnership between the United Nations World Food Programme (WFP) and Oxfam America. Launched in 2011, R4 now operates in Ethiopia, Senegal, Malawi and Zambia and currently reaches more than 26,000 farmers. R4 enables the poorest farmers to purchase agricultural weather-indexed insurance. Such insurance triggers pay-outs based on pre-specified patterns of the index rather than actual yields, eliminating the need for in-field assessment. In Ethiopia, more than 24,000 farmers purchased insurance, whilst almost 8,000 farmers in 27 villages received a pay-out in 2014. In Senegal, where R4 was implemented in 2014, 6,740 participants were reached within the first year in 15 rural communities, of which approximately 2,000 were covered by insurance. Around 300 farmers in the village of Koundiaw Souare received a total payout of US$3,929 as compensation for a late onset of rains.[35]

CREATING RESILIENT ASSETS

Insurance, however, is not a panacea. A more sustainable and cost-effective approach may be to create resilient assets on the farm or in the community. One way to improve farmers' resilience is by building stronger and healthier soils that withstand or regenerate faster after climatic stresses. A promising approach is Integrated Soil Management (ISM).[36] In many environments the principles of conservation farming are appropriate - minimal soil disturbance, permanent soil cover and crop rotations. African farmers, however, need to use more inorganic fertiliser to provide the right nutrients to their crops and to achieve higher yields. They need to strike the right balance between this goal and minimising costs and environmental impacts. Microdosing – the application of very small quantities of fertiliser at the root of a young plant – reduces the amount of fertilisers applied, improves nutrient use efficiency by the soil and plants, and lowers costs for farmers, thereby increasing resilience and reducing GHG emissions.

As with improved soils, developing sustainable supplies of good quality water may be a better option than insurance. Water is an essential but scarce input for a well-functioning agriculture sector. Already one-third of Africa's population is living in water-scarce regions and water resources in particular are coming under increased stress. Population growth, industrial development, urbanisation and pollution are putting unprecedented pressure on water supplies, particularly in the semi-arid and arid regions of Africa. This is now further exacerbated by climate change. Technologies that enhance farmers' adaptive capacity and long-term resilience must include irrigation systems, water catchment and conservation practices and the development of drought-tolerant crops.

WATER EFFICIENT MAIZE FOR AFRICA (WEMA) PROGRAMME

WEMA was initiated in 2008 as a public-private partnership between the African Agricultural Technology Foundation (AATF), a Nairobi based non-profit, the International Wheat and Maize Improvement Center (CIMMYT), Monsanto and the national agricultural research organizations (NAROs) in participating countries: Kenya, Mozambique, Tanzania, Uganda and South Africa. The project aims to deliver maize varieties that will increase yields by around 20% to 35% compared to current varieties under moderate drought conditions. An estimated two million tonnes of additional food, benefitting 14 to 21 million people, could be produced. The varieties will be released royalty-free to smallholders through African seed companies and their benefits and safety will be assessed by national authorities according to the regulatory requirements of individual participating countries.[37]

In Africa, about 6% of cultivated land is irrigated, compared to 37% in Asia and 14% in Latin America, making it the lowest in the world.[38] Three countries, Sudan, South Africa and Madagascar, account for two-thirds of the irrigable area developed. Yet, potentially 20 million hectares of land could be brought under irrigation.[39] To increase the availability of boreholes, drip irrigation and water harvesting technologies, as well as larger scale irrigation schemes, where they are appropriate and environmentally sustainable, requires substantial investment from the public and the private sector.

Drip irrigation technologies can ensure that the right amount of water is placed close to the growing plant at the right time. Laying inexpensive perforated plastic hoses alongside crop beds, especially for horticultural crops, is cost efficient for African smallholders.[40] Such systems also allow farmers to adapt to shrinking water availability and become more resilient to droughts and variable rainfall patterns over time.[41]

DRIP IRRIGATION IN KENYA

Kenya suffers from unreliable rainfall leading to drought conditions that subsequently increase household vulnerability to food insecurity, especially when alternative risk management or coping strategies are unavailable or ineffective. Until recently Kenyan smallholders, who are mostly women, used hand-watering to cultivate vegetables for their families. To improve productivity, the Kenya Agricultural Research Institute (KARI) introduced smallholder farmers to drip irrigation technologies. Bucket drip kits help deliver water to crops effectively with far less effort than hand-watering and for a minimal cost compared to conventional irrigation. Use of the drip kit is spreading rapidly in Kenya and farmers reported profits of US$80 to US$200 with a single bucket kit, depending on the type of vegetable, and between US$400 and US$600 per season with the larger one-eighth of an acre kit.[42]

COMMUNITY-BASED ADAPTATION

In order to scale-up successful community-based adaptation projects, decision-making power and funding will need to shift from capital cities to local level administrations, authorities and communities. In southern Mozambique, in the village of Nwadjahane, villagers are experiencing the effects of climate change and are taking significant measures to counteract the worst impacts. Villagers irrigate both the fertile lowlands and the higher dryland fields, but severe floods and droughts increased demand from households for plots of land in both areas. Whilst the lowlands can produce good crops of rice, vegetables and potatoes, these can be destroyed during floods. Highland areas, on the other hand, can produce good crops of maize and cassava during flood years, but during drought years families rely on lowland production. To respond to this challenge, households with land in just one area developed informal farming associations to lobby those responsible for land allocation to gain access to new areas to farm. Portions of lowland and highland were reassigned, which helped farmers to improve their families' food security during droughts and floods.[43]

The farming associations have since become the focus of innovative and experimental farming practices, including experiments with drought-resistant crops. By working in groups, villagers are able to spread the risk of new practices and technologies and learn through experimentation. When successful, farmers have been able to take these lessons back to their own farms. The associations have also become particularly popular with groups of women, leading to the creation of 'Matsoni.' Whilst traditionally an informal association for exchanging ideas between women, it is now a formalised, self-organised network used by women in a fifth of all households in Nwadjahane. In addition to strengthening women's positions within the farming community, 'Matsoni' provides access to extra labourers, land and information, as well as improves solidarity between neighbours and ensures families are able to access food during times of difficulty.[44]

Community-based action creates ownership and stimulates innovation, so it is likely to be more sustainable and resilient. Similar approaches need to be taken and scaled-up across Africa. When tailored to specific agro-ecological zones and farming systems, certain adaptation actions can also offer mitigation co-benefits. However, successful adaptation will largely depend on the use of new technologies and processes. It is therefore crucial that smallholders in remote rural areas are able to benefit from modern technologies, such as mobile phone communication, to access necessary information and services in a timely manner.

INFORMATION AND COMMUNICATION TECHNOLOGY

Digital services are crucial to successful adaptation because they link farmers with information and services in a timely fashion. Today 75% of Africans own a mobile phone, making it increasingly easy to reach those located in remote rural areas. The ubiquity and rate of interconnections are similar to those in more developed parts of the world. It is this extent and speed of digital interconnection that offers the potential for agricultural transformation in Africa to go faster and at the same time deal more comprehensively with the complex challenges of establishing a 21st century food and nutrition security system in the face of climate change.

Mobile phones allow farmers to access, for example, weather forecasts and to make informed decisions on when to sow their seeds or harvest.[45] Information shared through text messages allows farmers to plan ahead and make better use of their resources, but only if supporting infrastructure exists. Digital technology can also be used to help farmers link to value chains and to local and regional trade systems, thereby increasing their resilience. By linking smallholders directly to small and larger-scale food processors, they can serve not only as suppliers, but through digital communications also become active participants in the businesses.

DIGITAL GREEN

Digital Green is a not-for-profit international development organisation that uses an innovative digital platform for community engagement. To improve the lives of rural communities across South Asia and SSA, Digital Green partners with local public, private and civil society organisations to share knowledge on improved agricultural practices, livelihoods, health, and nutrition, using locally produced videos and human mediated dissemination. In a controlled evaluation, the approach was found to be ten times more cost-effective and uptake of new practices seven times higher compared to traditional extension services. Projects are being implemented in parts of Ethiopia, Ghana, Niger and Tanzania. In 2014 Digital Green was working in over 700 African villages, and its videos presenting 30 improved practices were watched by 42,000 villagers.[46]

CLIMATE-SMART ADAPTATION

Governments, developing agencies, the private sector and farmers need to increase the resilience of their agricultural systems to withstand and to adapt to climatic stresses. Where possible and when tailored to specific agro-ecological zones and farming systems, adaptive actions can generate mitigation co-benefits. Climate-smart agriculture (CSA) combines adaptation and mitigation to help agricultural systems become better adapted and resilient to the adverse effects of climate change, whilst minimising the emissions of GHGs and restoring lost carbon into the soil.[47]

THE ECONOMICS AND POLICY INNOVATIONS FOR CLIMATE-SMART AGRICULTURE (EPIC) PROGRAMME

The Food and Agriculture Organization of the United Nations (FAO) EPIC programme works with governments, research centres, universities and other partners to support the transition to CSA. It is a programme aimed at identifying and harmonizing climate-smart agricultural policies, analysing impacts, effects, costs and benefits as well as incentives and barriers to the adoption of climate-smart agricultural practices. The programme supports developing countries to formulate agricultural investment proposals that increase resilience to climate change and promote CSA. EPIC is currently strengthening the capacity of three partner countries – Malawi, Vietnam and Zambia – to address constraints and promote CSA practices that will deliver both food security and improved livelihoods, as well as global public goods in the form of reduced GHG emissions through agroforestry, soil and water conservation and sustainable land management practices. [48,49]

CO-BENEFITS FOR MITIGATION

IN THE PAST, COPING WITH THE IMPACTS OF CLIMATE CHANGE AND ESPECIALLY THE URGENCY OF RESPONDING TO EXTREME WEATHER EVENTS HAVE TAKEN PRIORITY OVER THE NEED TO BUILD MORE LONG-TERM CLIMATE-RESILIENT APPROACHES TO DEVELOPMENT. TO ADAPT TO CLIMATE CHANGE AND IMPROVE FOOD SECURITY, APPROACHES NEED TO BE TAKEN THAT HELP BOOST AGRICULTURAL PRODUCTIVITY, IMPROVE FARMERS' LIVELIHOODS AND MINIMISE GHG EMISSIONS.

Today it is recognised that all countries need to take some action to reduce emissions, by proposing Intended Nationally Determined Contributions (INDCs) to reach the global target of keeping within 2°C of warming.[50] However, the projected estimated total of pledges that have been made through the INDC process leaves the world far from a viable trajectory for meeting the 2°C target. With agriculture as a sector unaccounted for in major emitting countries' INDCs, an opportunity to minimise global GHG emissions will be missed.

ACHIEVING THE UNFCCC GOAL OF LIMITING AVERAGE GLOBAL TEMPERATURE RISE TO 2°C WILL BE HARD WITHOUT LEVERAGING THE POTENTIAL OF THE AGRICULTURE SECTOR, BOTH IN THE DEVELOPED AND DEVELOPING WORLD.

To keep global temperature rise below 2°C above pre-industrial levels, international organisations and governments must help smallholders to reduce and offset GHG emissions.

Investments should be directed towards interventions that sequester carbon in the soil, such as agroforestry systems and better land use management practices.

THE SCALE OF THE CHALLENGE

The IPCC estimates that agriculture contributes 14% of global GHG emissions, whilst the land use, land-use change and forestry (LULUCF) sectors contributes an estimated 17%. Emissions of nitrous oxide (N_2O) and methane (CH_4), which originate from livestock and soil, are nearly 300 and 35 times more powerful than CO_2, respectively.[51] N_2O emissions from soils alone constitute around 40% of non-CO_2 emissions. During the 1990s, cutting down trees and clearing land released an average of 6.4 gigatonnes (Gt) of CO_2 per year into the atmosphere. In comparison, global emissions from crop and livestock production rose to an average of 5.2Gt in the 2000s and to 5.4Gt in 2010. Emissions from agriculture are expected to continue to grow by around 1% per year – an increase incompatible with a stable climate future.[52]

Nevertheless there are agricultural technologies and processes that, if applied on sufficient scale, could help to address this challenge. An effective approach to increase adaptive capacity, whilst reducing GHGs, is to prioritise land use and land use change strategies. For example, Africa's agricultural potential could be unlocked and the resilience of smallholder farmers also increased if irrigation capacity was significantly scaled-up beyond the current 6% of arable land, and improved land management practices and various forms of soil carbon sequestration were implemented across the continent.

Farmers can and will undertake actions that have co-benefits for mitigation, but they need to be provided with the right incentives such as payment for ecosystem services (PES), land rights, improved knowledge and training. Payments to farmers or landowners to better manage their land or watersheds, to conserve biodiversity or to sequester carbon have been shown to help conserve and restore forest areas and aquifers. In order to improve soil quality and to support local livelihoods, Niger has embraced a set of wide-ranging approaches which has helped restore arable land and increase farmers' capacity to withstand droughts.

RIGHTS TO TREES AND LIVELIHOODS IN NIGER

With no incentive to maintain trees on their property — and with families to feed — farmers in need of agricultural land regularly removed trees and other natural vegetation across Niger. This practice led to worsening soil erosion and reduced soil fertility and yields, which pushed farmers to cultivate ever more marginal lands. By the late 1960s farmers became extremely vulnerable to droughts. After independence, international NGOs and donors began to promote simple, low-cost soil and water conservation techniques combined with agroforestry to support local livelihoods. Around the same time, Niger's government reassessed its governance of rural land and natural resources. New laws and regulations strengthened local rights to benefit from trees, whilst the Forest Service was transformed from a paramilitary institution that punished farmers for cutting trees into an extension service that helped them adopt simple tree management processes. As a result, farmers began nurturing underground roots and tree stumps in their barren fields. Today, more than five million hectares of land have been revitalized by smallholder farmers. The trees that grow have enriched the soil and provide food, fodder, fuel wood and other goods. Crop yields and incomes have increased too. Moreover, the increased carbon in the trees and in the soil serves to reduce GHG emissions. [53,54]

CARBON SEQUESTRATION IN THE SOIL

Globally, the soil contains about 1,500Gt of soil organic carbon that is more than double the amount of carbon in the atmosphere and three times that in plants, animals and micro-organisms. The cumulative historic loss from ploughing and mining the soil's humus is between 50Gt and 78Gt. The process of carbon sequestration, adding more organic matter to the soil than decays, however, can help to minimise emissions. Agroforestry systems can capture carbon in the range of two to four tonnes per hectare per year – an order of magnitude higher than conservation farming.[55]

In practice, effective sequestration depends on the technologies, the soil texture and structure, climatic conditions, the farming system and associated practices of soil management. Whilst there are many successful small-scale projects, taking sequestration to scale faces many challenges. There are difficulties in measuring both the pre-existing carbon in the soil and ongoing levels. As a consequence technical skills are essential, but limited. There are also likely to be significant institutional barriers linked to issues such as determining land rights, monitoring and ensuring compliance and finally paying farmers for sequestration.[56]

SOIL CARBON SEQUESTRATION

Soil carbon sequestration is the process of removing carbon from the atmosphere and storing it in the soil indefinitely. The sequestration process takes time (five to a maximum of 50 years) to reach its optimum rate, and then continues until the soil sink capacity is reached. Putting carbon back can be accomplished by a variety of means: no-till farming, cover crops, nutrient management, manure and sludge application, soil restoration, improved grazing, water conservation and agroforestry. The technical potential to sequester carbon in the soils of global terrestrial ecosystems and restored peat lands has been estimated at around three Gt of carbon per year, the equivalent of 50 parts per million (ppm) of atmospheric CO_2 by 2100. Collectively this has the potential to offset 5% to 15% of global fossil fuel emissions and to increase annual grain production in developing countries by 24 to 32 million tonnes, which will lead to improved food security for many farmers and their families.[57]

Ahead of the Paris climate change conference at the end of 2015 the French Ministry of Agriculture submitted a proposal - '4 pour 1000' - to compensate for the total annual emissions of over 9Gt carbon through a global programme. Agronomic techniques, such as those under the heading of Sustainable Intensification, would deliver carbon sequestration at a rate of an average of four-thousands of the carbon stock in the soil. Thus, smallholders can be part of the solution to climate change through their willingness to adopt new agricultural practices that bring multiple benefits in the short-term, as well as over the longer-term. This willingness must be appropriately encouraged and requires strong political leadership and substantial investment in infrastructure, education and training and the provision of new technologies.

CLIMATE-RESILIENT AGRICULTURE IN MALI

A project in Mali supported by the International Fund for Agricultural Development (IFAD) promotes climate-resilient agriculture based on an ecosystems approach beyond the farm level, and the adoption of agroforestry as a climate resilience, mitigation and food security strategy. In the face of increasing temperatures, a gradual decrease of rainfall and more frequent and severe weather extremes, farmers and their livestock move from the north of the country to the south, putting extra pressure on natural resources. In order to reverse the trends of deforestation and clearing land for agriculture, the programme focuses on sustainable water management and land management practices that increase yields through afforestation, better cropping systems, land rehabilitation and renewable energy technologies. IFAD expects that the project in Mali will become a net carbon sink, resulting in an overall reduction of 349,068 tonnes of CO_2e (equivalent). The 'without project' scenario would have released an estimated at 533,069 tonnes of CO_2e.[58]

FINANCE

INSUFFICIENT FINANCE IS ONE OF THE MAIN CONSTRAINTS TO IMPLEMENTING CLIMATE CHANGE ADAPTATION AND MITIGATION PROJECTS IN AFRICA. WITHOUT SIGNIFICANT INVESTMENTS IN BUILDING THEIR RESILIENCE, THE WORLD'S MOST FOOD-INSECURE PEOPLE, SMALLHOLDER FARMERS, WOMEN AND GIRLS, WILL NOT BE ABLE TO BEGIN ADAPTING TO CLIMATE CHANGE OR TO TAKE ANY CONSIDERABLE MITIGATING ACTIONS.

Between 2010 and 2050 the annual cost for adaptation to climate change in SSA will be at least US$18 billion[59] and up to US$50 billion[60] for the entire continent, in addition to the funding needed to place the continent on a low-carbon development pathway.[61] The level of financing currently reaching African countries is paltry. Of the US$34 billion pledged through various climate funds, SSA received just US$2.3 billion between 2003 and 2013, of which only 45% was allocated to adaptation projects.[62] This funding gap must be met through public resources, allowing local governments to allocate funds according to need. In Copenhagen in 2009, developed countries committed to provide US$30 billion 'fast-start finance' between 2010 and 2012 to support developing countries' immediate climate efforts. Whilst slow in arriving, these funds are also largely directed toward mitigation projects, leaving a gap for adaptation funding.

This fast-start finance could, however, be a big opportunity for Africa. It will allow governments to support low carbon energy and agriculture programmes to reduce emissions from deforestation and agriculture. At the same time, if channelled properly, this finance could also address the specific adaptation needs of smallholder farmers and benefit those who need it most, in particular women and girls in rural areas.

Climate finance mechanisms should be improved or designed so that African governments can better access funding that significantly benefits smallholder farmers.

BETWEEN 2010 AND 2050 THE ANNUAL COST FOR ADAPTATION TO CLIMATE CHANGE IN SSA WILL BE AT LEAST US$18 BILLION[63] AND UP TO US$50 BILLION FOR THE ENTIRE CONTINENT.[64]

THE DIVERSITY OF CLIMATE FUNDS

For millions of the world's most vulnerable people in developing countries, international climate finance has the potential to support the policies that can build resilience against the threats posed by a changing climate. There are now 50 climate funds under a fragmented patchwork of mechanisms with a total financing pool of around US$25 billion.[65] Not all of this represents new and additional aid, and Africa receives only a small share of international climate finance. For example, Nigeria and South Africa are the only countries that have received support for developing solar and wind power through the Clean Technology Fund (CTF).[66,67] A larger group of countries including Ethiopia, Kenya and Mali, received pledges to develop solar, wind and geothermal power. However, climate finance channelled to benefit adaptation and mitigation in the agriculture sector remains insufficient.

Although climate funds have begun to help developing countries confront the implications of climate change for development, some of the larger multilateral funds, including the Green Climate Fund (GCF), need to be adequately resourced. Furthermore, funding strategies need a higher degree of risk tolerance and should consider a wider range of national and local governments, private sector, and community actors, such as farmer associations, as fund recipients. This requires greater emphasis on building national capacity to apply for and absorb climate finance.

The GCF is now the largest and fastest-growing climate fund established to provide future climate financing in support of developing countries pursuing adaptation and low-carbon-resilient agricultural development. The GCF must allocate half of its funds to adaptation, and of this at least half to local-level funding mechanisms, ensuring that they reach and benefit local communities. More than 30 governments have pledged US$10.2 billion, of which US$5.8 billion has been converted to signed contributions. The three largest contributors are the United Kingdom, Germany and Japan, with signed contributions exceeding US$100 million each. The European Union as a whole signed contributions totalling US$3.7 billion.[68] As the GCF funds its first projects, it must build and improve on the achievements and experiences of existing funds. It will need to find innovative ways to support national stakeholders and priorities, take a gender-sensitive approach, and improve engagement with the private sector.

CARBON MARKETS

Carbon markets could be a powerful policy instrument to leverage private capital for green growth, including climate-smart agriculture activities. Carbon markets put a price on carbon, which helps stimulate abatement, encourage technology transfer and drive investment in low carbon technologies and services. Appropriately designed carbon markets have the potential to direct private sector investment at scale into the agricultural sector, underwriting the training of farmers in new practices, the provision of inputs such as improved seeds and targeted fertiliser use, and the establishment of systems to track carbon and agricultural benefits that accrue. However, carbon markets related to international off-sets, including the voluntary carbon markets, may not necessarily offer the best way to channel financing to smallholder farmers due to the high levels of bureaucracy and costs involved; the process is widely seen as too complex and costly for many developing countries to navigate or, in the case of small projects, simply too costly. The costs of defining, establishing, maintaining and transferring carbon credits need to be reduced in order to make, for example, the Clean Development Mechanism (CDM) accessible and feasible for smallholder farmers.

The CDM is an arrangement under the Kyoto Protocol allowing countries with GHG reduction commitments to invest in emission-reducing projects in developing countries as an alternative to making costlier emission reductions in their own countries.[71] One intention of the fund is to bolster Africa through technology transfer, capacity building and enhanced private sector investment. However, only 3% of current CDM projects are located in Africa, compared to over 80% in the Asia and Pacific region.[72]

MULTILATERAL FUNDING MECHANISMS BENEFITTING SMALLHOLDERS

Green Climate Fund (GCF) - A financial mechanism of the UNFCCC with equal representation of developed and developing countries, expected to become the main multilateral financing mechanism to support climate action in developing countries, mobilising US$100 billion by 2020.[69,70]

Climate Investment Funds (CIF) - The CIF provides developing and middle income countries with funds to mitigate and adapt to climate change. It supports investments in clean technology, renewable energy, sustainable management of forests, and climate-resilient development. A total of US$8.1 billion have been pledged so far. Financing is allocated through funding windows, including the CTF and the PPCR.

Clean Technology Fund (CTF) – The US$5.3 billion CTF provides scaled-up financing to middle income countries for the deployment and transfer of low carbon technologies with a significant potential for long-term GHG emissions savings.

Pilot Program for Climate Resilience (PPCR) – The US$1.2 billion PPCR helps developing countries integrate climate resilience into development planning and offers funding to support public and private sector investments. The fund is particularly important for channelling funding to agriculture and for strengthening the resilience of smallholder farmers.

Given the high degree of land degradation in many countries across Africa and the heavy dependence on wood resources for energy, afforestation and reforestation projects would be suitable under the CDM. The comparatively low technology requirements to grow trees should make this type of project very accessible even to rural communities. Yet, Africa's CDM participation for this type of project is especially low. The reasons vary by country, but include the complexity of the processes for developing projects to completion, lack of institutional capacity for implementing all the requirements of CDM participation, or simply identifying eligible projects.[73]

Carbon markets should be designed in such ways that they do not establish a disincentive for food production. Carbon market expansion could be an opportunity for Africa, being a biomass rich region with a high potential to contribute to the re-carbonisation of the earth's biosphere. The protection of forests and the prevention of land conversion is an important part of that process, however, carbon pricing may raise the opportunity costs of land use for crops unless calculated with a focus on agro-forestry and soil carbon enrichment. Given these trade-offs and that carbon markets at present do not offer the most effective way to channel financing to smallholder farmers, alternative sources of climate finance need to be explored in the meantime.

ADAPTATION FOR SMALLHOLDER AGRICULTURE PROGRAMME

One of the largest adaptation programmes dedicated to improving smallholder farmers' resilience to climate change is the International Fund for Agricultural Development (IFAD) Adaptation for Smallholder Agriculture Programme (ASAP). Since 2012 more than US$300 million have been channelled to at least eight million smallholder farmers. The programme works in more than 30 developing countries. ASAP is scaling-up successful multiple-benefit approaches to increase agricultural output whilst simultaneously reducing vulnerability to climate-related risks and diversifying livelihoods. ASAP-supported initiatives such as mixed-crop and livestock systems, crop rotation and a combination of agroforestry and communal ponds, can improve soil quality, increase the availability of water during dry periods, and provide additional income.[74]

OTHER SOURCES OF CLIMATE FINANCE FOR SMALLHOLDERS

Often it is funds and projects outside the larger multilateral funding mechanisms that are most effective in channelling funds to smallholder farmers in pursuit of adaptation and mitigation strategies for improving food security. Although smaller in scale, and perhaps for that reason, they tend to be more sensitive to local conditions and to the needs of smallholder farmers.

In Kenya, smallholder farmers benefit from carbon credits generated by improving farming techniques issued under the sustainable agricultural land management (SALM) carbon accounting methodology. The Kenya Agricultural Carbon Project (KACP) involves 60,000 farmers on 45,000 hectares and supports farming that is more productive, sustainable and climate-friendly. For example, they are using a wide range of methods to increase the organic matter in soils. In the long term, this should improve the soil's water absorption, nutrient supply and biodiversity, and help prevent erosion. Better soils raise farm yields, improving food security and making agriculture more resilient to climate change. In January 2014 the project issued its first carbon credits for sequestering carbon in soil. The carbon credits represent a reduction of 24,788 tonnes of CO_2, equivalent to annual emissions from 5,164 vehicles. Results so far show that SALM can help increase farmers' yields between 15% and 20%. These productivity gains from greater soil fertility help counteract the effects of climate change, whilst sequestering more carbon in the soil, thereby also reducing GHG emissions.[75]

THE CLIMATE ADAPTATION FUND PILOT PROGRAMME IN ISIOLO COUNTY, KENYA

In 2012 the government of Kenya launched a new fund to help communities in the north of the country adapt to climate change. In its first year the Climate Adaptation Fund disbursed US$780,000 in Isiolo County. Livelihood and local resilience assessments identified the drivers that improved or undermined the ability of different groups to manage challenges such as climate variability, changing market conditions, disease or insecurity. Local communities also helped to identify solutions that would strengthen their adaptive capacities. The findings were used to prioritise investments to promote climate resilient growth and adaptive livelihoods. Climate information was also disseminated through a series of seasonal forecast workshops hosted by the Kenyan Meteorological Department (KMD) and a community radio station that broadcast seasonal climate information country-wide in local languages.[76]

TRACKING SUCCESS

As countries start making large investments in climate change adaptation, robust assessments of the expected and actual returns are needed in order to plan, implement and track the interventions in which they are investing. The International Institute for Environment and Development (IIED) has worked with partners to develop and pilot a framework.[77] Tracking Adaptation and Measuring Development (TAMD) evaluates adaptation success as a combination of how widely and how well countries or institutions manage climate risks and how successful adaptation interventions are at reducing climate vulnerability and keeping development on course. The aim is to generate bespoke frameworks for individual countries and specific contexts. Pilots began in Kenya, Mozambique, Nepal, and Pakistan in 2012 and in Ethiopia, Cambodia, Uganda and Tanzania in 2014.

ENABLING ENVIRONMENT

THERE ARE A NUMBER OF BARRIERS TO IMPLEMENTING AMBITIOUS ADAPTATION AND MITIGATION STRATEGIES AND ACCESSING CLIMATE FINANCE. LIMITED AWARENESS OF THE PROBLEM OR THE POTENTIAL SOLUTIONS CAN BE AS STIFLING AS THE LACK OF TOOLS OR FUNDING. THE INSTITUTIONAL BARRIERS RANGE FROM INADEQUATE STAFFING AND INSUFFICIENT TRAINING AND EDUCATION, TO A LACK OF WEATHER INFORMATION OR WELL-FUNCTIONING MARKETS. THESE BARRIERS CAN BE OVERCOME WITH PLANNING, COORDINATION, INSTITUTION-BUILDING AND STRONGER POLITICAL LEADERSHIP.

Strong political leadership, including effective regulatory regimes and regional cooperation, is key to ensure the resilience and productivity of Africa's farmers under climate change.[78] Africa could become a leader in the climate debate and action post-2015 by pursuing low-carbon development pathways.[79]

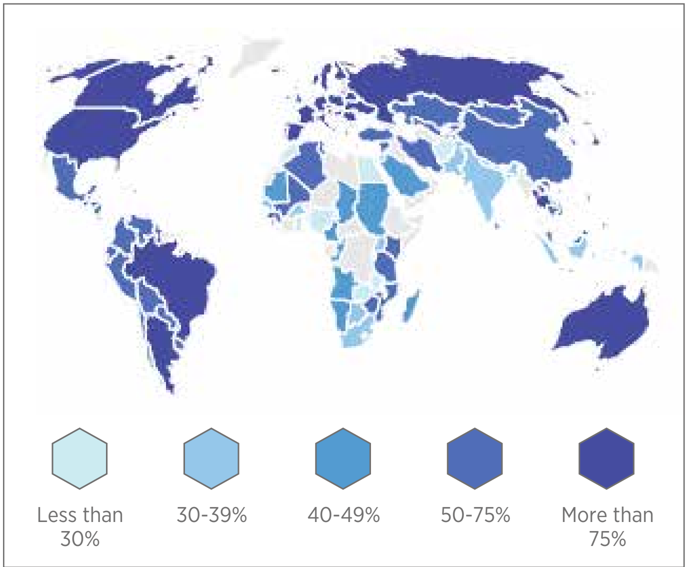
As a first step, governments should integrate climate change planning across government departments and ministries, whilst food security and agricultural development policies should complement and reinforce national climate change adaptation and mitigation goals. The integration of climate change strategies into national agricultural development plans under the Comprehensive Africa Agriculture Development Programme (CAADP), serves as a role model for developing countries. Regional initiatives such as the Africa Climate-Smart Agriculture Alliance (ACSAA) are strong indicators of commitment and political will across Africa to increase the continent's resilience to the adverse impacts of climate change, whilst harnessing the opportunities for mitigation co-benefits through sustainable agricultural practices.

However, managing climate responses, including the financing of climate adaptation and mitigation, cannot be left to the public sector alone. Building resilience requires shared action and responsibility by the public and private sectors at local, national and international levels. The exclusion of local communities from this process often prevents their capacity to adapt.

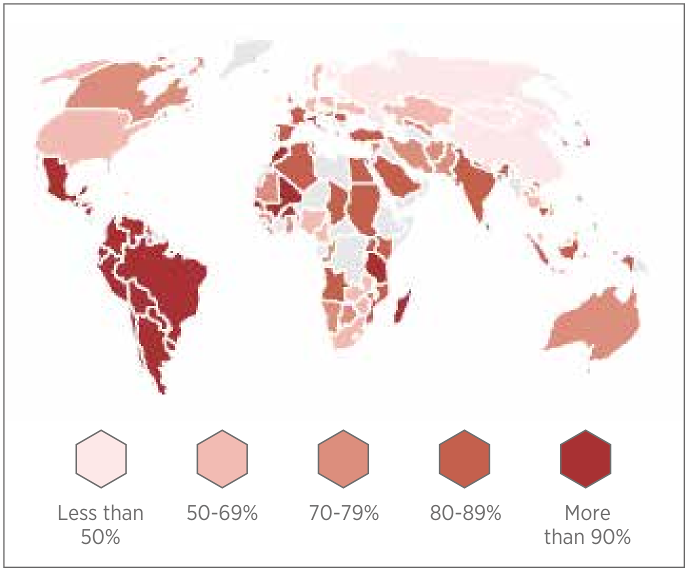
Designing and implementing adaptation and mitigation strategies that benefit smallholder farmers requires strong political leadership, functioning markets and regulatory instruments.

EDUCATION AND RESEARCH

Substantial investments in advanced capacity building, education and research are crucial for strengthening Africa's voice in international climate policy design and implementation. Education is the most important factor affecting climate change awareness, particularly in developing countries.[80] Recent opinion polls suggest that the majority of people in Asia, Africa and the Middle East had never heard of climate change. In Egypt this figure was 75% and in Burundi 78%, much higher than in developed countries. However, among those who had heard about climate change, it was perceived as a greater threat to themselves and their families than in developed countries. Increasing awareness of climate change should therefore be a major priority for African governments.



Percent of people aware of climate change by country



Percent of people who are aware of climate change who perceive it to be a serious threat[81]

Equally important is the strengthening of the research infrastructure and capacity across Africa to ensure the next generation of African scientists and policy makers are equipped with the necessary skills and technical knowledge to put the continent on a climate-resilient low carbon development pathway. Critical are the premier universities in Africa such as Makerere University in Uganda and the University of Ghana, which runs a postgraduate training programme in crop improvement[82] and the national agricultural research institutions in each country, such as the National Agricultural Research Organisation (NARO) in Uganda and the Kenya Agricultural Research Institute (KARI), both of which are working on the breeding of drought-tolerant crops.

The West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) is a research programme for doctoral students designed to enhance the resilience of agricultural systems to climate change.[83] WASCAL is funded by the German Federal Ministry of Education and Research (BMBF) and implemented in a collaborative effort by West African and German partners. Yet, programmes such as WASCAL only address part of the challenges. Scaling up investments and ensuring that African governments and communities can take advantage of climate finance opportunities requires the presence of regulatory regimes, tax laws and defined property rights systems.

REGULATORY REGIMES

For smallholders to invest capital and time in sustainable agricultural practices that are often unfamiliar, they need to be given incentives and rewards that will help them change many of their existing practices. African governments similarly need to make the best use of available climate finance, laws and policies that are designed and aligned to encourage better farming practices.

Effective policies must identify the most important and relevant barriers and regulate rights to land and water, provide access to markets and strengthen extension systems.[84] A critical barrier to uptake of new technologies and practices on the farm is weak land tenure and security. With well-defined land and property rights farmers have a clear incentive to manage their land in a sustainable and productive way.

Regulatory regimes, similar to those around Reducing Emissions from Deforestation and Forest Degradation (REDD+) - an effort to create incentives for developing countries to reduce emissions from forest lands - are essential to guarantee benefits to smallholder farmers and to ensure that they are rewarded for preserving and restoring forests, generating biomass, sequestering soil carbon and preserving water resources. Such appropriate regimes need to be implemented across Africa.

REDD+ REGULATORY REGIMES

Implementing REDD+ involves a combination of policy instruments. The best policies for this are chosen following sound planning and active support from several interest groups, including national and local governments and the private sector. Policy can include regulations such as new laws, clarity on land tenure and binding safeguards. In 2004, the Brazilian government launched the “Action Plan for Prevention and Control of Deforestation in the Legal Amazon.” Brazil set up a combined effort of improved satellite monitoring, increased law enforcement, and created protected areas. In 2008, reacting to a surge in deforestation, the government imposed restrictions on bank credits. These actions brought about a significant drop in deforestation rates, from 27,000 km^2 in 2004 to 4,700 km^2 in 2011, although this has recently been reversed.[85,86]

MARKETS

Well-functioning and inclusive regional markets are crucial to adapting to climate change. They minimise the effects of stresses and shocks when characterised by sound institutional arrangements, price discovery transparency and low transaction costs. These result in a degree of price stability that benefits both producers and consumers.[87] Access to these markets enables farmers to respond to regional demand with higher production, take appropriate risks and increase their incomes, whilst ensuring food is available at affordable prices for consumers. The ability to engage in these markets also builds resilience by providing access to alternative food supplies during droughts or floods when some countries cannot produce adequate amounts of food or transfer food from a surplus to a deficit region.

Whilst regional markets can increase farmers' and countries' resilience to climatic extremes and reduce food insecurity during food crises, smallholder farmers face several challenges to their participation. Road infrastructure is often poor or transport networks are weak presenting physical barriers that can be very expensive to bypass. Transport costs – for road, rail, sea, and air – are notably higher in Africa than in other areas of the world.[88] Uncertain and sometimes conflicting regional trade agreements in Africa, high import or export tariffs, or insufficient institutional capacity to minimise corruption leads to long and expensive border crossings further isolating farmers from markets and reducing competitiveness.

Regional and national food crises also result in unplanned migration from rural to urban areas as well as cross-border migration within Africa triggering displacement and conflict, often resulting in further environmental degradation. Globally, at least 32 million people were displaced by climate-related sudden-onset disasters in 2012 alone.[89] Under climate change, this figure is likely to increase sharply. Addressing these challenges will require increased investments and strong political cooperation and leadership across countries and for Africa as a whole.

POLITICAL LEADERSHIP

For Africa to turn CSA into a booming industry requires the creation of a knowledge economy that builds human and institutional capacities, supports innovation and research, and is driven by appropriate economic policies, financial incentives and investments in hard infrastructure.

Ethiopia's Climate Resilient Green Economy (CRGE) – an initiative that combines aspirations of developing a green economy and climate resilience – offers a good example of what can be accomplished with political leadership and vision. The CRGE was developed to insulate the country from the impacts of climate change by identifying environmentally sustainable economic opportunities that could accelerate Ethiopia's development and to attain middle-income status by 2025.

The CRGE is based on four pillars: agriculture, forestry, power and transport, and industrial sectors and infrastructure. Under the agriculture pillar, crop and livestock production practices are to be improved to increase crop yields, achieve food security and improve the incomes of farmers, whilst reducing GHG emissions. The green growth pathway envisages limiting national GHG emissions to 150 million tonnes of CO_{2e} ($MtCO_{2e}$) instead of 400 $MtCO_{2e}$ in 2030 under a business as usual scenario. The CRGE strategy adopts a sectoral approach across six government ministries with more than 60 initiatives, requiring an estimated US$150 billion to deliver on these goals over a period of 20 years.

CONCLUSION

AGRICULTURAL PRODUCTION AND FARMER LIVELIHOODS ARE UNDER THREAT FROM CLIMATE CHANGE. AT THE SAME TIME FARMERS HAVE THE POTENTIAL TO HELP REDUCE GHG EMISSIONS. APPROPRIATE INCENTIVES AND A SUPPORTIVE ENABLING ENVIRONMENT FOR SMALLHOLDERS ARE CRUCIAL TO LIMIT GLOBAL TEMPERATURE RISE TO 2°C ABOVE PRE-INDUSTRIAL LEVELS.

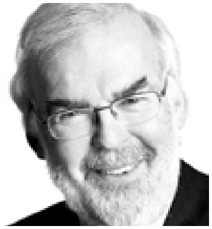
Intensifying climatic stresses and shocks will put the lives and livelihoods of Africa's smallholders at greater risk, increasing their vulnerability to drought, famine and disease. Adaptation actions that both reduce the risks posed by climate change and enhance the resilience of the agricultural sector and farmer livelihoods are hence ever more important. Given the right options and incentives, smallholder farmers can drive sustainable agricultural development that builds resilience but also contributes significantly to a reduction in GHG emissions.

Across Africa climate change could also spur countries to invest in renewable energy technologies, thereby creating new markets and opportunities for agricultural producers. Africa could become a leader in the climate debate and action post-2015 by pursuing low-carbon development pathways. However, to design and implement the supportive adaptation and mitigation strategies, increased investments from international organisations, governments and the private sector as well as strong political leadership are urgently required.

THE MONTPELLIER PANEL

Gordon Conway
Professor of International Development, Imperial College London and Director of Agriculture for Impact (Chair)

Camilla Toulmin
Former Director, International Institute for Environment and Development (IIED) (Vice Chair)

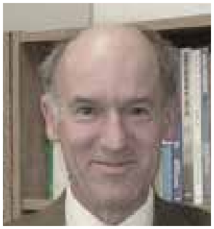


Tom Arnold
Director General, Institute for International and European Affairs and Special Hunger Representative, Concern Worldwide

Ousmane Badiane
Africa Director, International Food Policy Research Institute (IFPRI)

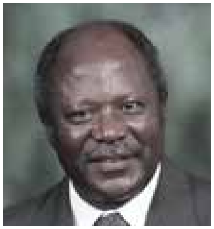
Joachim von Braun
Director, Center for Development Research (ZEF), University of Bonn

Henri Carsalade
Africa Rice Board Member and Chairman of Agropolis Foundation Board of Directors



Peter Hazell
Visiting Professor, Imperial College London

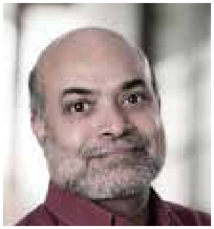
Jane Karuku
Former President, Alliance for a Green Revolution in Africa (AGRA)



Namanga Ngongi
Former President, Alliance for a Green Revolution in Africa (AGRA)

Oumar Niangado
Delegate for West Africa, Syngenta Foundation

Ruth Oniang'o
Editor in Chief and Founder of the African Journal of Food and Agriculture, Nutrition and Development (AJFAND)



Prabhu Pingali
Professor and Director, Tata-Cornell Agriculture and Nutrition Initiative, Cornell University

David Radcliffe
Former Senior Advisor, Agricultural Research for Development, DG Development and Cooperation, European Commission

Lindiwe Majele Sibanda
Chief Executive Officer, Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN)

Ramadjita Tabo
Director for West and Central Africa, International Crops Research Institute of the Semi-Arid Tropics (ICRISAT)

REFERENCES

1 The Food and Agriculture Organization of the United Nations, (2009), Climate Change in Africa: The threat to agriculture

2 Africa Progress Panel, (2015) Power People Planet: Seizing Africa's energy and climate opportunities

3 World Resources Institute, CAIT - Country Greenhouse Gas Emissions Data, accessed 02.07.2015 http://www.wri.org/resources/data-sets/cait-country-greenhouse-gas-emissions-data

4 United Kingdom Department for International Development, (2011), UK International Climate Fund, accessed 16.07.2015 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48217/3389-uk-international-climate-fund-brochure.pdf

5 Behrman J.A., (2014), Gender, Climate Change, and Group-Based Approaches to Adaptation, IFPRI Policy Paper

6 Brooks, N. (2004), Drought in the African Sahel: Long term perspectives and future prospects. Tyndall Centre for Climate Change Research, Working Paper 61

7 NOAA NCDC Global Historical Climatology Network, https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn

8 Dong, B. and Sutton, R., (2015), Dominant role of greenhouse-gas forcing in the recovery of Sahel rainfall. Nature Climate Change

9 Conway, G. (2009), The science of climate change in Africa: impacts and adaptation, Grantham Institute for Climate Change Discussion paper No 1 and IPCC 2014 op cit

10 IPCC. (2014), Africa, Intergovernmental Panel on Climate Change, WG11AR5, Ch 22 Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart, 2014: Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field,D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.

11 IPCC, (2014): Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

12 International Food Policy Research Institute, (2009), Impact of Climate Change on Agriculture - Factsheet on Sub-Saharan Africa

13 Townsend, R.F., (2015), Ending Poverty and Hunger by 2030: An Agenda for the Global Food System, The World Bank

14 Lobell, D.B. et al. ,(2011), Nonlinear heat effects on African maize as evidenced by historical yield trials, Nature Climate Change Vol. 1

15 Lobell, D.B. et al., (2011), Nonlinear heat effects on African maize as evidenced by historical yield trials, Nature Climate Change Vol. 1

16 Blanc, E., (2012), The Impact of Climate Change on Crop Yields in Sub-Saharan Africa, American Journal of Climate Change, 1, 1-13

17 Osman-Elasha, B.,(2015),Africa's climate challenge, in: Climate 2020: Facing the future, UNA-UK

18 Chavez, E. et al., (2015), An end-to-end assessment of extreme weather impacts on food security, Nature Climate Change Vol.5

19 FAO, IFAD and WFP, (2014), The State of Food Insecurity in the World

20 IPCC, (2014), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

21 Choularton, R., (2015), Ensuring food security, in: Climate 2020: Facing the future, UNA-UK

22 Ringler C. et al., (2011), Climate Change Impacts on Food Security in Sub-Saharan Africa, IFPRI Research Brief

23 Based on: Wheeler, T. and von Braun, J., (2013), Climate Change Impacts on Global Food Security, Science, Vol. 341: 508-513

24 Myers, S.S. et al.,(2014) Increasing CO2 threatens human nutrition. Nature, 510, 139-142

25 Myers, S.S. et al.,(2014) Increasing CO2 threatens human nutrition. Nature, 510, 139-142

26 Myers, S.S. et al., (2015), Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency: a modeling study. Lancet Global Health, online July 15, 2015

27 Myers, S.S. et al.,(2014) Increasing CO2 threatens human nutrition. Nature, 510, 139-142

28 Resilience to extreme weather, (2014), The Royal Society Science Policy Centre report

29 The Montpellier Panel, (2013), Sustainable Intensification: A New Paradigm for African Agriculture

30 Agriculture for Impact, (2015), Sustainable Intensification Database, http://ag4impact.org/database/

31 Dahou, K. et al. (2012), Climate challenges to Africa, a call for action, OECD Journal: General Papers, Vol. 2010/4

32 Behrman J.A. (2014), Gender, Climate Change, and Group-Based Approaches to Adaptation, IFPRI Policy Paper

33 IPCC (2012) Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (ed. Field, C B, Barros, V, Stocker, T F, Qin, D, Dokken, D J, Ebi, K L, Mastrandrea, M D, Mach, K J, Plattner, G-K, Allen, S K, Tignor, M & Midgley P M). Cambridge and New York: Cambridge University Press.

34 Resilience to extreme weather, (2014), The Royal Society Science Policy Centre report

35 UN World Food Programme and Oxfam America, (2015), R4 Rural Resilience Initiative, 2014 Annual Report

36 Montpellier Panel, (2014), No Ordinary Matter: Conserving, Restoring and Enhancing Africa's Soils

37 African Agricultural Technology Foundation (AATF), Drought tolerant maize hybrid to be ready end of the year, http://wema.aatf-africa.org/fr/node/384 accessed 15.07.2015

38 Liangzhi, Y. et al., (2010), What is the irrigation potential for Africa?, IFPRI

39 The Montpellier Panel, (2013), Sustainable Intensification: A New Paradigm for African Agriculture

40 Montpellier Panel, (2014), No Ordinary Matter: Conserving, Restoring and Enhancing Africa's Soils

41 Glatzel, K., Wright, H. and Makuch, Z., (2012), Technology Innovation and the Law – the example of climate change adaptation technologies, In: Makuch, K.E. and Pereira, R., (2012), Environmental and Energy Law, Wiley-Blackwell, London

42 Ngigi, S.N., (2001), Low-cost irrigation for poverty reduction: An evaluation of low-head drip irrigation technologies in Kenya, International Water Management Institute

43 Simms, A. and Reid, H., (2005), Africa - Up in smoke? The second report from the Working Group on Climate Change and Development, IIED

44 Osbahr, H. et al. (2008), Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique, Geoforum 39

45 United Nations Development Programme, Farmerline joins the Business Call to Action with commitment to provide mobile communication services to rural farmers, accessed on 28.04.2015: http://www.undp.org/content/undp/en/home/presscenter/pressreleases/2014/10/15/farmerline-joins-the-business-call-to-action-with-commitment-toprovide-mobile-communication-services-to-rural-farmers.html

46 Digital Green, http://www.digitalgreen.org/, accessed 10.08.2015

47 The Montpellier Panel (2014), No Ordinary Matter: conserving, restoring and enhancing Africa's soils

48 Food and Agriculture Organization of the United Nations, Economics and Policy Innovations for Climate-Smart Agriculture, accessed 14.07.2015 http://www.fao.org/climatechange/epic/home/en/

49 Food and Agriculture Organization of the United Nations, (2014), Mid Term Evaluation of Climate Smart Agriculture: Capturing the Synergies between Mitigation, Adaptation and Food Security in Malawi, Vietnam and Zambia – GCP /INT/139/EC

50 Toulmin, C., (2015), Who should pay? The case for a carbon tax. In: Climate 2020: Facing the future, UNA-UK

51 IPCC, (2007): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

52 IPCC, (2007): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

53 Focus on Land in Africa, (2012), Rights to trees and livelihoods in Niger

54 Neate, P. (2013), Climate-smart agriculture: Success Stories from Farming Communities around the World, CGIAR and Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA)

55 The Montpellier Panel, (2014), No Ordinary Matter: conserving, restoring and enhancing Africa's soils

56 Conway, G., (2012), One Billion Hungry: Can We Feed The World?, Cornell University Press

57 Conway, G., (2012), One Billion Hungry: Can We Feed The World?, Cornell University Press

58 Chakrabarti, S., (2015), The Mitigation Advantage: Maximizing the co-benefits of investing in smallholder adaptation initiatives, International Fund for Agricultural Development (IFAD)

59 World Bank, (2010), Economics of adaptation to climate change –Synthesis report. Washington DC

60 United Nations Environment Programme, (2015), Africa's Adaptation Gap 2

61 World Bank, (2010), Economics of adaptation to climate change –Synthesis report. Washington DC

62 Barnard et al., (2014), Climate Finance Regional Briefing: Sub-Saharan Africa, Overseas Development Institute and Heinrich Böll Stiftung North America

63 World Bank, (2010), Economics of adaptation to climate change –Synthesis report. Washington DC

64 United Nations Environment Programme, (2015), Africa's Adaptation Gap 2

65 Africa Progress Panel, (2015) Power People Planet: Seizing Africa's energy and climate opportunities

66 Clean Technology Fund Investment Plan for South Africa, https://www.climateinvestmentfunds.org/cifnet/sites/default/files/South%20Africa%20CTF%20Investment%20Plan%20-%20Endorsed.pdf

67 Clean Technology Fund Investment Plan for Nigeria, https://www.climateinvestmentfunds.org/cifnet/sites/default/files/Nigeria%20CTF%20Investment%20Plan%20-%20Endorsed_1.pdf

68 Green Climate Fund Pledge Tracker, http://news.gcfund.org/wp-content/uploads/2015/04/Status-of-Pledges-2015.7.23.pdf, accessed 23.07.2015

69 The Climate Investment Funds: http://www.climateinvestmentfunds.org/cif/node/11900

70 The Green Climate Fund: http://www.gcfund.org/about/the-fund.html

71 Bryan et al., (2010), Global carbon markets: Opportunities for sub-Saharan Africa in agriculture and forestry, Climate and Development, 2:4, 309-331

72 Gonzalez, G. (2013), Africa looms large on CDM cap, LINK, accessed 10.08.2015 http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=9827

73 Desanker, P.V., (undated), The Kyoto Protocol and the CDM in Africa: a good idea but..., Food and Agricultural Organization of the United Nations, accessed 15.07.2015 http://www.fao.org/docrep/009/a0413e/a0413E05.htm

74 International Fund for Agricultural Development (IFAD), Adaptation for Smallholder Agriculture Programme (ASAP), accessed 15.07.2015, http://www.ifad.org/climate/asap/index_full.htm

75 The World Bank, (2014), Kenyans Earn First Ever Carbon Credits From Sustainable Farming, accessed 15.07.2015 http://www.worldbank.org/en/news/press-release/2014/01/21/kenyans-earn-first-ever-carbon-credits-from-sustainable-farming

76 Isiolo County Adaptation Fund: Activities, Costs and Impacts after the 1st nvestment Round – Project Report 2014, IIED

77 Anderson, S., (2012), TAMD: A framework for assessing climate adaptation and development effects, International Institute for Environment and Development

78 Toulmin, C. et al., (2015), Investing in institutional 'software' to build climate resilience, Angle Journal

79 United Nations Association UK, (2015), Climate 2020: facing the future

80 Lee, M.T. et al. (2015), Predictors of public climate change awareness and risk perception around the world, Nature Climate Change

81 Lee, M.T. et al. (2015), Predictors of public climate change awareness and risk perception around the world, Nature Climate Change

82 The West Africa Centre for Crop Improvement

83 The West African Science Service Center on Climate Change and Adapted Land Use, http://www.wascal.org/, accessed 30.07.2015

84 Streck C., et al., (2012), Incentives and benefits for climate change mitigation for smallholder farmers CCAFS Report no. 7, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

85 Links between a Green Economy and REDD+, UN-REDD Programme, http://www.unredd.net/index.php?option=com_unsubjects&view=unsubject&id=2&Itemid=493, accessed 22.07.2915

86 Ortiz, F. (2014), Experts question slowing Amazon deforestation trend, SciDevNet: http://www.scidev.net/global/forestry/news/slowing-amazon-deforestation-trend.html

87 Montpellier Panel, (2012), Growth with Resilience: Opportunities in African Agriculture

88 Wiggins, S. and Keats, S., (2013), Leaping & Learning: Linking smallholders to markets, Agriculture for Impact and Overseas Development Institute

89 Yonetani, M. (2013), Global Estimates 2012: People displaced by disasters, IMDC

Photo credits:

Cover: Neil Palmer/CIAT
P2: Marco Simola/CIFOR, A Faidherbia tree
P3: Agriculture for Imapct, Arne Hoel/World Bank, Neil Palmer/CIAT, Neil Palmer/CIAT, Ollivier Girard/CIFOR, CIFOR
P4: Agriculture for imapct Anna Fawcus, Afp-Reuters-Gettyimages&Ap, Fatoumata Diabate/Oxfam, Bioversity International/J.Van de Gevel, Petr Kosina/CIMMYT
P:6 John Isaac/UN Photo
P:8 Ollivier Girard/CIFOR
P:10 Neil Palmer/CIAT
P:13 Devan Wardwell/Abt Associates
P:16 Kelly Ramundo/USAID
P:17 Brendan Cox/Oxfam
P:18 A. Wangalachi/CIMMYT
P:19 CIAT
P:20 Alba Saray Pérez Terán/ CIFOR
P:21 Trevor Samson/World Bank 2010
P:25 Fatoumata Diabate/Oxfam
P:26 Neil Palmer/CIAT
P:28 A.Rogers/UNCDF
P:32 Georgina Smith/CIAT
P:36 IFPRI
P:37 Bill & Melinda Gates Foundation, EU ENPI Info centre

AGRICULTURE FOR IMPACT
GROWING OPPORTUNITIES FOR AFRICA'S DEVELOPMENT

AGRICULTURE FOR IMPACT

Imperial College London
15 Princes Gardens
London SW7 1NA

Phone: +44 (0) 20 7594 9311

Website: www.ag4impact.org

Twitter: @ag4impact