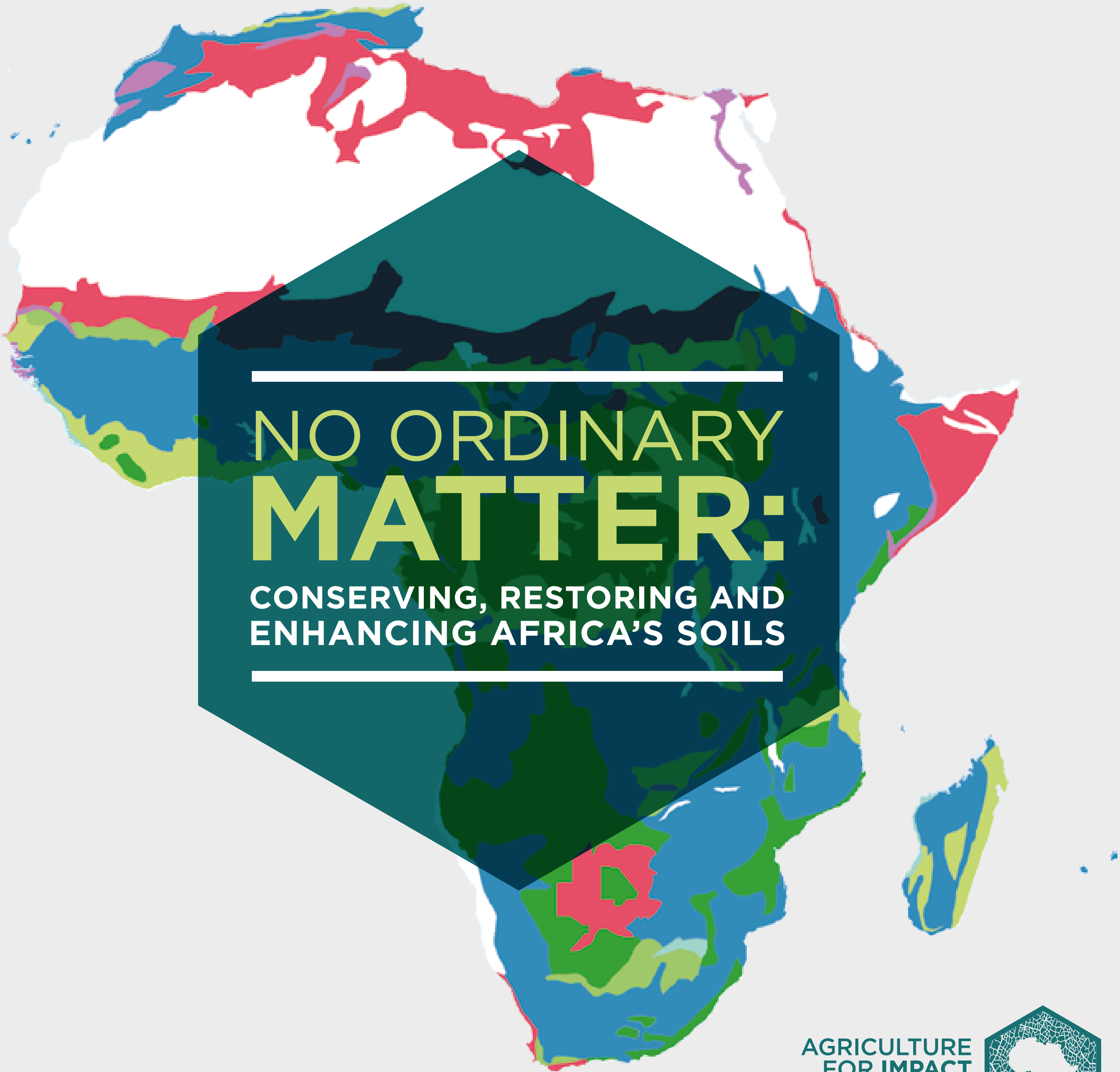
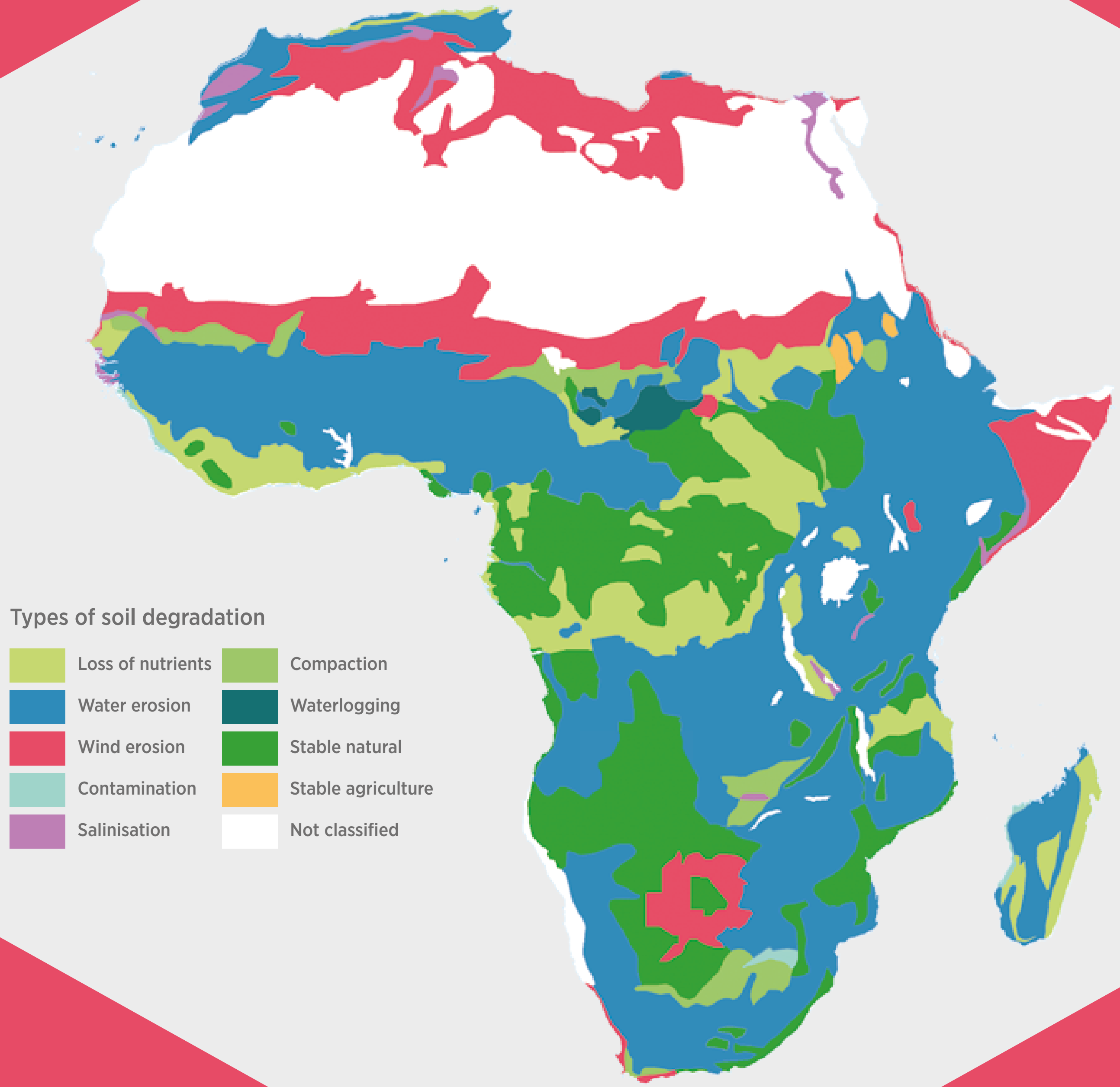
MONTPELLIER PANEL DECEMBER 2014



NO ORDINARY MATTER:

CONSERVING, RESTORING AND ENHANCING AFRICA'S SOILS

AGRICULTURE FOR IMPACT
GROWING OPPORTUNITIES FOR AFRICA'S DEVELOPMENT


Types of soil degradation
Loss of nutrients
Compaction
Water erosion
Waterlogging
Wind erosion
Stable natural
Contamination
Stable agriculture
Salinisation
Not classified

NO ORDINARY MATTER:

CONSERVING, RESTORING AND ENHANCING AFRICA'S SOILS

A Montpellier Panel Report, December 2014

This report was authored by Agriculture for Impact with advice and inputs from members of the Panel. The primary author Dr Katrin Glatzel was supported by Professor Sir Gordon Conway, Emily Alpert and Stephanie Brittain. We also acknowledge valuable inputs from Professor Rattan Lal of Ohio State University. The report was designed by Robb Whiteman and Hoevel & Associates.

SUMMARY

SOILS ARE THE ESSENCE OF LIFE, SUSTAINING HUMANS, PLANTS AND ANIMALS FOR PRESENT AND FUTURE GENERATIONS. AS THE SOURCE OF THE FOOD WE EAT AND HOME AND HABITAT FOR MUCH OF THE PLANET'S FLORA AND FAUNA, SOIL IS A PRECIOUS RESOURCE.

Soils' varying properties, diverse qualities and characteristics directly influence the quality and amount of food that farmers grow. In effect, healthy and fertile soils are fundamental in the effort to reduce food insecurity, create viable rural livelihoods and sustainably manage ecosystems.

The contribution of soil to alleviating many of today's pressing challenges, however, is overlooked. Undervalued, soils have become politically and physically neglected, triggering land degradation. Affecting nearly one-third of the earth's land area, land degradation reduces the productive capacity of agricultural land by eroding topsoil and depleting nutrients[1] resulting in enormous environmental, social and economic costs. In sub-Saharan Africa (SSA) an estimated 180 million people are affected,[2] while the economic loss due to land degradation is estimated at $68 billion per year.[3,4]

Most critically, land degradation reduces soil fertility leading to lower yields, and increases in greenhouse gas (GHG) emissions. In Africa, the impacts are substantial: 65% of of arable land, 30% of grazing land and 20% of forests are already damaged.[5] The burden is disproportionately carried by smallholder farmers because natural soil characteristics, tenuous land security and limited access to markets and financial resources prompt farmers to make short-term trade-offs that reduce long-term gains.

In many cases the limited use of fertiliser and poor land management practices are to blame. Rectifying these is required in order to achieve sustainable yields over time. Yet, African farmers need to strike the right balance between adequate and affordable nutrient management and minimising environmental impacts. Central to reversing land degradation and enhancing depleted soils, farmers require incentives for investing in land; these remain unattractive at present.

With more secure land rights, improved education and training, farmers could realise the productive, environmental and social rewards that come from long-term investment and stewardship in land. Because Africa's soils are as diverse and varied as farmers' individual knowledge, resources and endowments, these must be recognised, enhanced and treated accordingly. Integrated Soil Management (ISM) offers the ability to sustainably intensify production and maximise social, economic and environmental benefits.

Globally, soils are under duress and their conservation, restoration and enhancement should be elevated as top priorities on global and national agendas. Increased funding for sustainable land management must be mobilised with greater transparency not only to maximise effectiveness, but to ensure that smallholder farmers receive the full benefits. Climate smart soil management will ultimately help agricultural systems better adapt and build resilience to climate change while minimising GHG emissions and restoring lost carbon to the soil.

WE, THE MEMBERS OF THE MONTPELLIER PANEL THEREFORE BELIEVE THAT soil is the cornerstone of food security and agricultural development and its care, restoration, enhancement and conservation should intuitively become a major global priority. Neglected soils lose fertility that increasingly lowers yields over time. Smallholder farmers, especially those that farm inherently poor soils and lack the resources to invest in their lands, disproportionately carry the greatest burden. Renewed attention and investments in soils and sustainable land management, however, can reverse the process of degradation. Embracing integrated soil management that builds on local and natural resources, with the appropriate use of targeted inputs and management practices, will provide the care and attention that Africa's soils need for long term sustainable and productive use.

RECOMMENDATIONS

1. Strengthen political support for sustainable land management.

Along with food, water and energy security, sustainable land management should be a focus area within the post-2015 global development agenda that commits and builds on the Rio+20 target of "Zero Net Land Degradation."

2. Increase financial support for investment in land and soil management.

Donors and governments must commit resources dedicated to sustainable land and soil management practices. Resources for more research must be mobilised, while institutions and knowledge to address land degradation must be strengthened.

3. Improve transparency for land and soil management.

Existing contributions to land and soil management are not easily discerned. Donors and governments should clearly identify their contributions to these priorities in national investment plans and food security strategies, coupled with ongoing monitoring of the effectiveness of their investments.

4. Attribute a value to land degradation.

Quantifying the costs of land degradation and the benefits generated by sustainable land management practices will reinforce attention to treat land degradation as a serious global challenge.

5. Start a 'Big Data' Revolution on soils.

There are huge gaps in data availability, especially in Africa. Regularly updated data on soil types, locations, qualities and degradation must be significantly enhanced through the use of advanced remote-sensing systems, dense networks of local weather information and "citizen science." This information must be made available in a timely manner to allow for the targeted and selective use of inputs.

6. Create incentives, especially secure land rights.

Insecure land rights are a fundamental disincentive to invest in the care and management of farming land. Farmers also need better access to markets, extension services and training to improve soil health and be provided with incentives, such as carbon credits, to adapt to and to mitigate climate change.

7. Build on existing knowledge and resources.

There is a vast amount of local knowledge and information on soil science and land degradation in Africa. It is essential that new research is built on this existing knowledge and that new findings are shared amongst actors.

8. Build soil science capacity in Africa.

There is a lack of soil science capacity in Africa. This capacity needs to be enhanced by strengthening soil research centres in Africa and collaboration with European and other international scientists and research centres.

9. Embrace integrated soil management.

A combination of remedies is needed to restore, conserve and enhance soils. ISM must become the cornerstone of sustainable land management in the 21st century, integrating organic farming methods, conservation agriculture, ecological approaches and selective and targeted use of inputs.

10. Foster climate smart soil research and application.

Farmers should be provided with the knowledge and resources on how ISM can help them better adapt to the adverse effects of climate change and reduce greenhouse gas emissions, supported by publicly funded incentives.

AFRICA'S SOILS

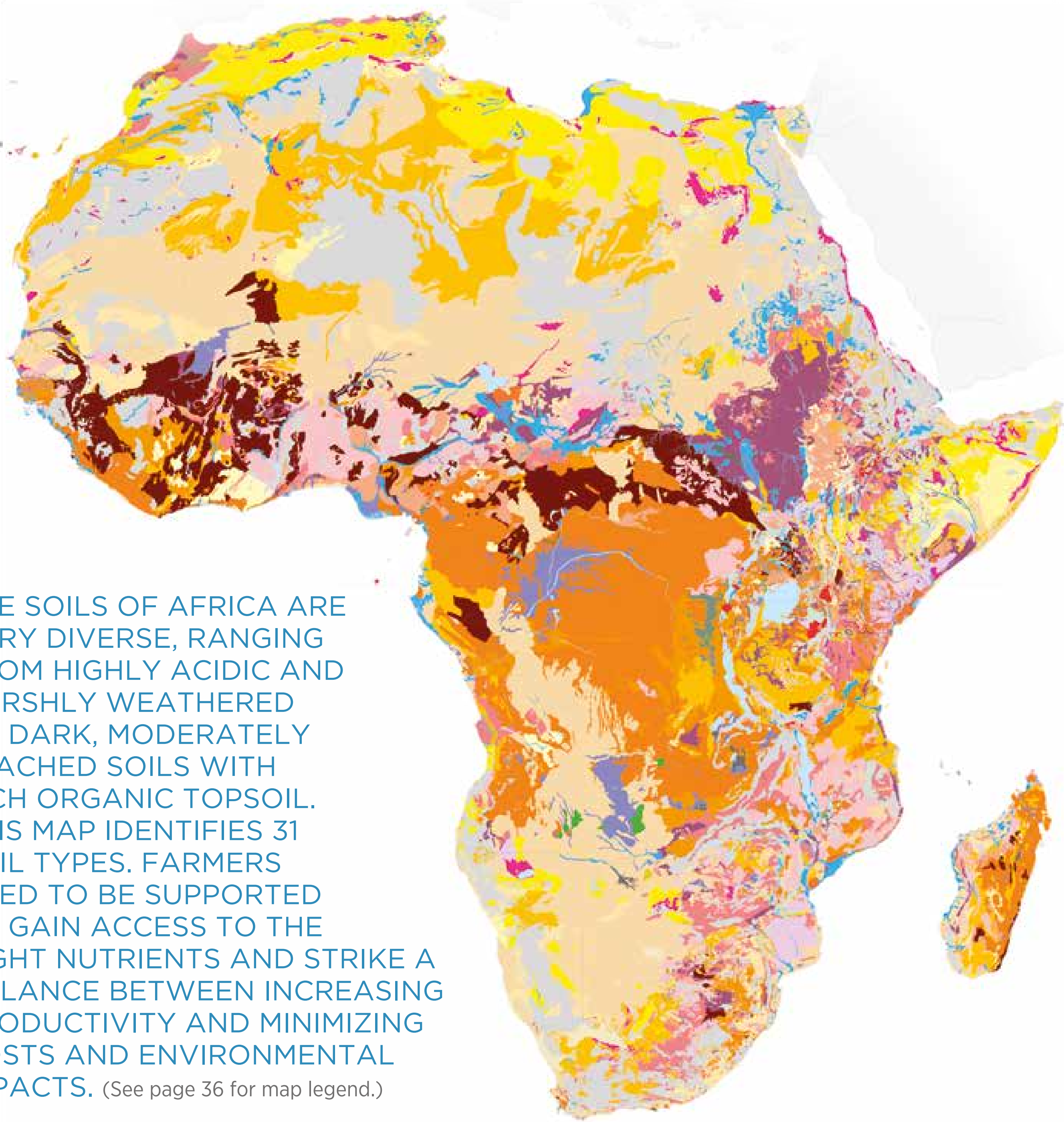
SOIL STRUCTURE AND QUALITY ARE A COMBINATION OF NATURAL CHARACTERISTICS AND ACQUIRED FEATURES THAT ARE THE RESULT OF INVESTMENTS BY LAND USERS OVER TIME.

Most farm landscapes contain a variety of soils that vary depending on their position, slope, vulnerability to wind and water erosion, composition, suitability for particular crops and rainfall conditions. These inherent qualities affect the fertility and functions of the soil. Soils will underperform if not managed according to their needs.

Much of Africa's land surface is old and weathered giving rise to soils of low inherent fertility. In the more humid lowland areas, soils are typically highly weathered, acidic and nutrient deficient. Nutrients are strongly concentrated in the topsoil, where they are subject to losses by erosion. Other common problems include aluminium toxicity and poor absorption of phosphorus, while plinthite, an iron-rich and hummus-poor clay common in weathered areas, impedes root growth. In contrast, soils in the arid and semi-arid areas are susceptible to salt accumulation and may also face difficulties retaining phosphorus, in this case due to alkaline conditions.

Africa's arable lands are located primarily in climate zones that vary from humid to semi-arid. The highland areas of Africa are often the most fertile, supporting very large rural populations under low input conditions, for example in Rwanda and southern Ethiopia. Due to lower rates of weathering and to more recent volcanic activity that adds valuable nutrients, soils here are typically well structured, highly fertile, with good water holding capacity, and responsive to fertilisers and supplementary irrigation.

Low fertility soils typical in other regions, however, can be improved. The sustainable management of soils needs to account for soil properties and the differences in soil types. Soil mapping is a prerequisite, but soil maps vary greatly in terms of scale and accuracy and current capacity for carrying out soil surveys and land evaluations is low. A relatively new assessment by the United Nations Food and Agricultural Organization's (FAO) Global Land Degradation Assessment (GLADA) using remote sensing found that Africa south of the equator is particularly affected by land degradation. However, regularly updating this information and communicating these findings in a timely manner to farmers remains a significant challenge.[6]



THE SOILS OF AFRICA ARE VERY DIVERSE, RANGING FROM HIGHLY ACIDIC AND HARSHLY WEATHERED TO DARK, MODERATELY LEACHED SOILS WITH RICH ORGANIC TOPSOIL. THIS MAP IDENTIFIES 31 SOIL TYPES. FARMERS NEED TO BE SUPPORTED TO GAIN ACCESS TO THE RIGHT NUTRIENTS AND STRIKE A BALANCE BETWEEN INCREASING PRODUCTIVITY AND MINIMIZING COSTS AND ENVIRONMENTAL IMPACTS. (See page 36 for map legend.)

SOIL, A GLOBAL PRIORITY?

"PRESERVING THE EARTH'S LANDS AND SOILS IS FUNDAMENTAL IF WE ARE TO PROVIDE SUFFICIENT FOOD, CLEAN WATER, HEALTHY RECREATIONAL SPACES, AND LOWER GREENHOUSE GAS EMISSIONS. WE NEED TO USE LAND AND SOIL RESOURCES MORE SUSTAINABLY, SET A MEASURABLE PATH TOWARDS PREVENTING DEGRADATION AND STRENGTHEN EXISTING GLOBAL GOVERNANCE TO TACKLE LAND AND SOIL DEGRADATION." - EUROPEAN COMMISSION, DG ENVIRONMENT, 2012.

To raise awareness about the importance of sustainable soil management as a source of healthier food systems, better ecosystem services and improved adaptation to climate change, the UN declared 2015 to be the International Year of Soils. As part of discussions on the post Rio+20 sustainable development goals, the United Nations Convention to Combat Desertification (UNCCD) proposed a target of zero-net land degradation.

These efforts are welcome, but insufficient to handle the scale of the challenge. Globally, soils are under duress and their conservation, restoration and enhancement should be elevated to top priorities on global and national agendas. In Africa, sustainable land management must become a cornerstone of the Comprehensive African Agriculture Development Programme (CAADP) investment plans and, more broadly, donors should incentivise these efforts with renewed and invigorated funding.

TAKING STOCK

Governments have been active in combatting desertification through the UNCCD's initiative. However, this is neither translated into funding initiatives nor reflected in donors' agricultural development and poverty reduction strategies, suggesting there is an urgent need to take stock of existing contributions aimed at preventing further land degradation and restoring depleted soils. This will provide a starting point for identifying gaps, overlapping efforts and monitoring progress.

European and other donors fund soil programs through institutions such as the International Centre for Tropical Agriculture (CIAT), the International Fertilizer Development Centre (IFDC) and the Alliance for a Green Revolution in Africa (AGRA). However, there is an overall need for land and soil

AGRA Soil Health Programme

In 2008, with funding from the Bill & Melinda Gates Foundation and the Rockefeller Foundation, AGRA established its Soil Health Programme (SHP). The SHP is focused on helping smallholder farmers acquire the skills and inputs they need to revive their lands, boost their yields and increase food and economic security for Africa as a whole. Since 2009 AGRA has trained almost two million farmers in 13 countries in what they call Integrated Soil Fertility Management (ISFM) and has reached out to another 3.5 million farmers through radio and other communication channels to promote ISFM practices, such as fertiliser microdosing. In Tanzania, Malawi and Ghana, farmers participating in AGRA's soil health initiatives are doubling and even tripling yields of maize, pigeon pea and soybean.

management programmes in Africa to be aligned with CAADP investment plans and accompanied by easily identifiable financial commitments against which efforts can be monitored and evaluated.

CAADP PLANS DO NOT PRIORITISE SOILS

Although most CAADP investment plans identify soil and land degradation as areas for investment, the majority of the plans do not prioritise land management. The evidence of specific funding commitments for these services is also very sparse. Of the 19 CAADP investment plans available online, 14 include proposals for addressing land degradation or its causes, but land degradation is not prioritised or reflected in the form of concrete financial commitments and projects. Although soil was not a top priority when the CAADP plans were drawn up initially, CAADP country investment plans should be amended and clearer commitments to improving soil quality and combatting degradation identified.

CAADP INVESTMENT PLANS

MALI

Mali's investment plan focuses on desertification through the preservation and decentralised management of its natural resources and wildlife programme. The cost of this programme is budgeted at $255 million between 2009 and 2015, but the funds dedicated to soil protection are not itemised. Desertification is also a key theme in Mali's national development strategy where drylands development is linked to good governance and prudent use of natural resources with an estimated cost of $60 million from 2009 until 2015.

NIGERIA

The Nigerian agriculture investment plan sets relatively specific targets related to soil and land degradation; for example, to increase the size of irrigated land from 1% to 10% by 2015 and to increase the land planted with diversified biomass from the current 3.5% to 7% by 2015. The plan also identifies a funding gap of about $33 million for a soil fertility management project and a funding gap of $6 million for the promotion of conservation agriculture and the reclamation of 'problem' soils.

ETHIOPIA

Ethiopia has one of the highest rates of soil nutrient depletion in SSA, therefore soil is a recurrent theme and falls under different sections within the national investment plan (e.g. sustainable land management, natural resource management and climate change). Under Ethiopia's five year growth and transformation plan, there is a dedicated sustainable land management project that focuses on the conservation of soil and water in arid zones. An estimated $8 billion is still required over the next ten years, in particular for irrigation development.

DONOR STRATEGIES PAY SCANT ATTENTION

Identifying funding from donors for soil management and other related contributions to combatting land degradation is even more complicated. Similar to CAADP investment plans, most donor development strategies only pay scant attention to these issues.

Although donors are engaged in combatting land degradation and desertification through international initiatives such as the UNCCD, transparency for these efforts is limited. A new programme, Action Against Desertification,[7] launched by the European Union (EU), the FAO and the African, Caribbean and Pacific (ACP) Group of States in October 2014 commits €41 million over a 4.5 year period to improve sustainable land management and restore dry and degraded lands in ACP countries. While this is an important step towards scaling-up efforts, information on what share of these funds is dedicated towards combatting land degradation in Africa or how they will be allocated is not yet available.

Based on publicly available donor development strategies from the G7 countries,[8] the European Commission, Australia and China, improving soil quality and reversing the impacts of degradation are evident but not prominent areas of concern. These issues are most evident in France, Germany and the United States' development strategies, but more broadly, all donors must consider whether their efforts to reduce food insecurity and generate economic growth, particularly in rural areas, risk falling well beneath their potential if greater political attention and development resources are not channelled into land and resource management.

DONOR STRATEGIES

UNITED STATES

The US recognises environmental degradation, climate change, water scarcity and competition for energy resources as threats to food supplies that must be addressed. Degradation is also recognised as a factor increasing vulnerability and is treated as a cross-cutting issue that should be integrated into developing countries' strategic plans. When supporting developing countries, the United States Agency for International Development (USAID) commits to provide assistance to "foster soil conservation practices that improve productivity of degraded soils by supporting farming practices that build soil carbon, improve the efficiency of fertilizer and water inputs, increase drought resistance, reduce GHGs, and minimize adverse environmental impacts to soil, water and forest resources."

GERMANY

Germany is one of the largest donors to combat desertification and has supported and implemented, mainly through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and KfW Development Bank, 344 projects in Africa in 2010 and 2011. In total €549 million were spent or newly committed to combat desertification globally; roughly half of this is allocated to Africa. Clear priority areas include agriculture and rural development, accounting for three quarters of all supported projects and almost half of new commitments. Under a forthcoming initiative "One World – No Hunger," Germany has committed to a global initiative for the protection of soil and the rehabilitation of depleted soils from the end of 2014.

FINANCIAL COMMITMENTS ARE UNCLEAR

For most donors clear financial commitments to these priorities are difficult to identify. Presently, the only available dataset that provides any insight is the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) Rio Marker for desertification. According to the OECD, desertification is defined as "mitigating the effects of drought in arid, semi-arid and dry sub-humid areas through the prevention and/or reduction of land degradation, rehabilitation of partly degraded land, or reclamation of desertified land."

THERE IS AN URGENT NEED FOR DONORS TO WORK WITH THE OECD TO DEVELOP A CLEAR AND TRANSPARENT PROCESS FOR MONITORING AID TO SOIL AND LAND MANAGEMENT.

The Marker measures whether or not desertification was a principal or a significant objective of a development project. From 2002 to 2012 an estimated $5.5 billion or less than 1% of all development aid was prioritised to combatting desertification as a principal objective. However, another $15.8 billion or fewer than 2% of Official Development Assistance (ODA) made a 'significant' contribution to address the challenge. About one-third of principal funds were directed to combatting desertification in Africa. When considered as a component of ODA to agriculture, the figures drop to just $632 million or less than 2% of ODA to agriculture over the same period.[9]

FRANCE

Agricultural development, natural resource management and climate change adaptation and mitigation are high priorities for the French government as indicated in the recent Project Law on Development adopted in June 2014. France is the third largest European government donor to agriculture and rural development, allocating $742 million in 2012. Agence Française de Développement (AFD), France's main aid agency spent €479 million to protect the environment and manage natural resources. This builds on previous efforts to combat land degradation and desertification. Between 2006 and 2009, €100 million per year was allocated to combat land degradation. Over the 2010-2011 period, France devoted €138 million annually to desertification and land degradation projects, mainly in Africa and the Mediterranean, through funding from AFD and the French Global Environment Facility.

Moreover, the marker system is not precise enough to calculate exactly how much aid was dedicated to combatting desertification. The system information is not sufficient for estimating needs, resource gaps or monitoring progress. Further, desertification is land degradation in drylands and thus ignores efforts to prevent or address land degradation in other climates, such as in humid areas that new data suggests is an even greater problem.[10] There is an urgent need for donors to work with the OECD to develop a clear and transparent process for monitoring aid to soil and land management.

CONSERVING, RESTORING AND ENHANCING SOILS

HEALTHY AND FERTILE SOILS ARE THE CORNERSTONE OF FOOD SECURITY AND RURAL LIVELIHOODS. CONSERVING, RESTORING AND ENHANCING SOILS THROUGH SUSTAINABLE MANAGEMENT PRACTICES COULD UNLEASH AFRICA'S AGRICULTURAL TRANSFORMATION TOWARDS A FOOD SECURE ECONOMY WITH VIBRANT RURAL LIVELIHOODS.

Reaching this goal will require substantial investments in ISM within the framework of Sustainable Intensification.[11] ISM for the 21st century must go beyond purely organic or conventional approaches. It must target and selectively use inputs, integrate conservation practices and produce climate smart soil that both adapts to and mitigates climate change, thus ultimately intensifying agricultural production in a sustainable manner.

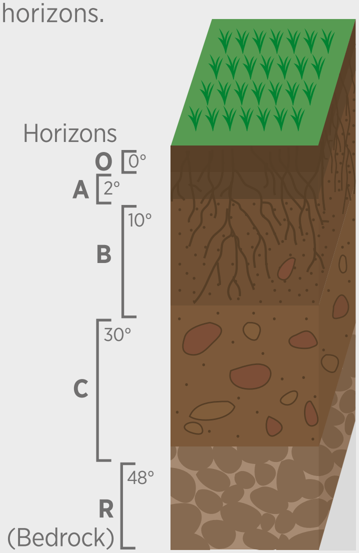
A healthy soil is strong in structure with an optimal mix of small and large particle sizes, providing good permeability and water holding capacity. It is highly fertile with rich humus and sufficient plant nutrients for high yields. It is also rich in soil biota and contains no pollutants.

LAND DEGRADATION IN AFRICA

Land degradation and soil fertility decline in Africa are deeply complex with intertwining and cyclical causes. They range from poor inherent soil qualities to population pressure to insecure land tenure and climate change, amongst other factors. These pressures influence farmers' decisions and often investments in better land management practices are sacrificed for short-term needs. Without stemming the causes, farmers will continue to make the same choices, even at the expense of their future well-being. Left unaddressed, the cycle of poor land management will result in higher barriers to agricultural development for smallholder farmers and wider economic growth for Africa.

SOIL HORIZONS

Humus is decomposed organic matter (stems, leaves, roots, seeds etc.) that cannot breakdown further; it is black or dark brown in colour and contains organic carbon. It may be at the surface (O) or be buried. A, B, C are the surface, subsoil and substratum horizons.



DRIVERS OF LAND DEGRADATION

POOR LAND MANAGEMENT

Most African farms are rain-fed, dependent on increasingly erratic rainfall amounts and patterns; fertiliser, if available, is expensive; and farm labour, at critical times, is in short supply. Struggling to compete with these challenges, African farmers have steadily abandoned traditional practices that restore soil nutrients.

POPULATION PRESSURE

The population of SSA is growing and is projected to exceed two billion shortly after 2050[12] up from just 896 million in 2010. At the same time arable land per capita is declining precipitously thereby intensifying competition for land for food, rangeland, shelter and other uses.

INSECURE LAND TENURE

Africa's lands are held under both statutory (individual) and the more widespread customary (collective) property ownership systems. Customary systems are often loosely defined and especially disadvantage women. When the terms are unclear, landholdings are small or fragmented and the ability to mortgage or transfer land is restricted, the incentives to invest in land are unattractive.

POOR ACCESS TO MARKETS AND SERVICES

Where markets are poorly developed or missing, farmers are more likely to make decisions determined by their basic subsistence needs, and make little use of modern inputs such as improved seed varieties, fertilisers or crop protection products[13] that could otherwise create the time and resources needed for better land management practices.

CLIMATE CHANGE

Harsh growing conditions already experienced in many parts of Africa, are likely to exacerbate under climate change and force large areas of cropland out of production.[14] Climate change will bring about higher levels of long-term stress, including desertification, and a greater incidence and severity of extreme weather events.

LAND DEGRADATION
the persistent reduction or loss of land ecosystem services, notably the primary production service.[15]

ECOSYSTEM SERVICES
include providing biodiversity, maintaining hydrological and nutrient cycles.

SOIL EROSION
the loss of soil through water or wind and a major cause of degradation.

SOIL DEGRADATION
the processes by which soil declines in quality and is thus made less fit for a specific purpose, such as crop production.

DESERTIFICATION
land degradation in arid, semi-arid and sub-humid areas.

SOIL FERTILITY DECLINE
defined either as the loss of key nutrients or as the decline in the capacity of soil to support high biological production.

ESTIMATING LAND DEGRADATION

Land degradation broadly refers to a decline in the capacity of the land to supply human needs, whether of food or other services. Given such a wide definition it is not surprising that there is much controversy about its nature and extent.

Estimates of land degradation also vary widely, while early estimates were largely subjective, in recent years the advances in remote-sensing and satellite technologies have enabled efforts such as the Global Inventory Modelling and Mapping Studies to measure vegetative growth at a resolution of eight km^2. This has been used, with various weights and corrections for local conditions, by the team at the Center for Development Research (ZEF) at the University of Bonn to provide a worldwide measure of land degradation 'hotspots'. The loss of biomass production is used as an indirect measure of the decline in health of ecosystem services, in particular primary productivity (e.g. plant growth). Initial results show that land degradation 'hotspots' stretch to about 29% of the total global land area.[16] For SSA land degradation hotspots affect about 26% of land.[17]

While national level data is limited, it is striking where available. For example in Ethiopia, over one-quarter of land is degraded which affects about 20 million people, almost a third of the total population. Another study found that nearly one-third of South Africa and 40% of all cropland suffers from land degradation. Nearly 17 million people or 40% of South Africans depend on these degraded areas for their livelihoods.[18]

LAND DEGRADATION IN ETHIOPIA[19]

Total land area: 1.13million km^2

Average fertiliser use: 17 kg/ha

Degraded land area: 26%

People affected: 21 million, equal to 29% of the population

Hotspot characteristics: high population pressure on land and forests, farming on steep slopes and frequent food crises caused by unreliable rainfall

Loss of topsoil: one billion tons annually

Soil productivity losses: at least 20% over the last century in large parts of the country

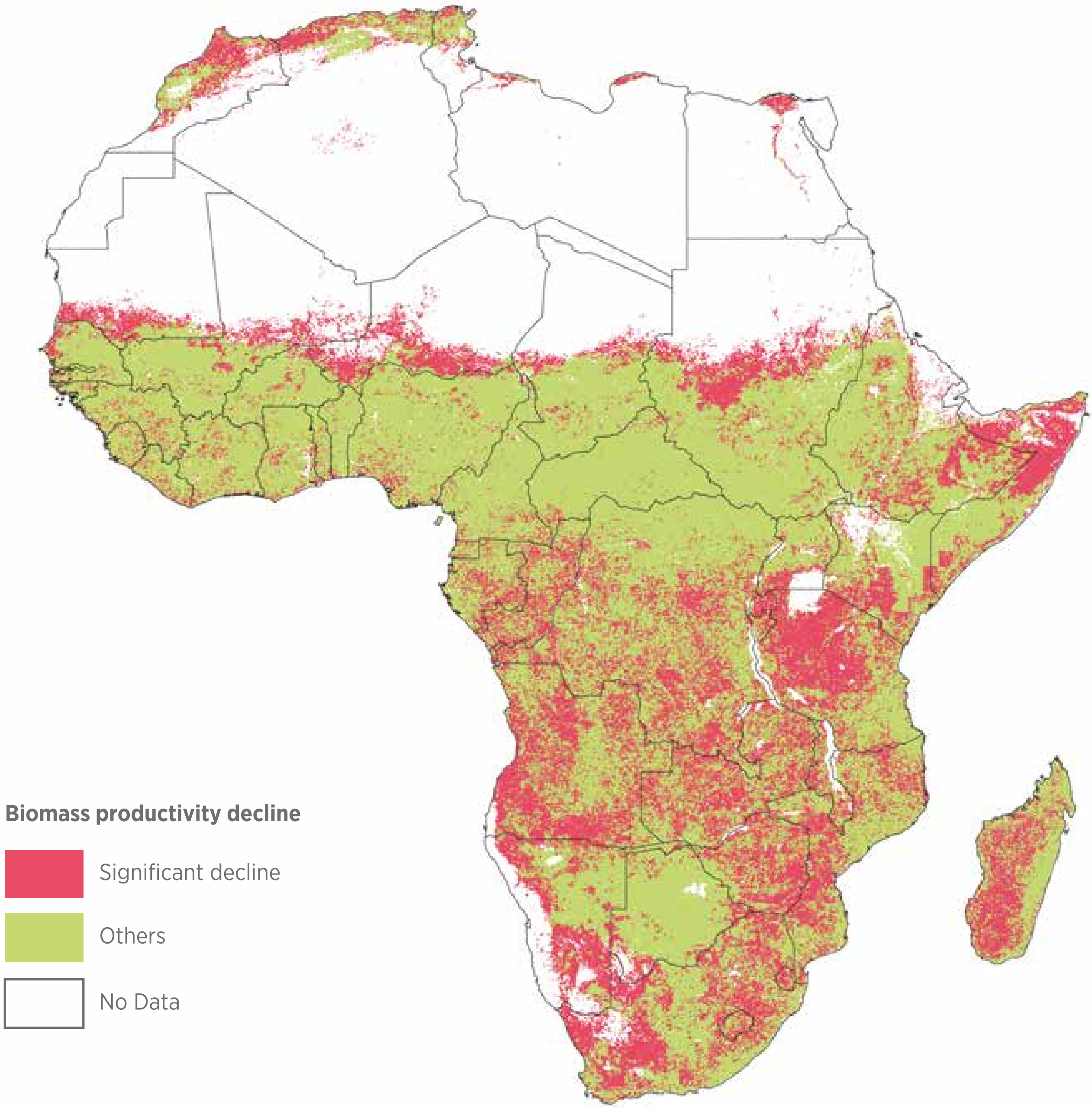
ANNUAL COSTS

Soil erosion and nutrient loss from farming and grazing: $106 million

Deforestation: $23 million

Loss of livestock capacity: $10 million

Total: $139 million or equivalent to 4% of GDP


Biomass productivity decline
Significant decline
Others
No Data

CALCULATING THE COSTS OF LAND DEGRADATION

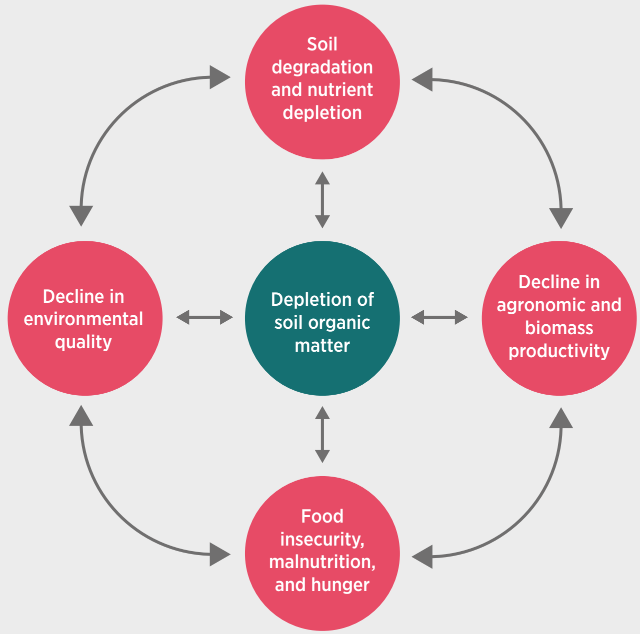
Land degradation reduces the productive capacity of agricultural land by eroding topsoil, and leaching and depleting nutrients[20] resulting in enormous environmental, social and economic costs. In SSA the economic loss is estimated at $68 billion per year,[21,22] affecting an estimated 180 million people.[23] In some areas of Africa, agricultural productivity declined by half between 1981 and 2003 as a result of soil erosion and desertification processes.[24]

IMPROVED LAND MANAGEMENT COULD DELIVER UP TO $1.4 TRILLION GLOBALLY IN INCREASED CROP PRODUCTION OR 35 TIMES THE VALUE OF ESTIMATED LOSSES.

Also alarming are the losses at national level. In Ethiopia, the annual losses from land degradation reach an estimated 4% of GDP; in Malawi the costs could be as high as 11% of GDP.[25] Considering the stress these losses place on already strained government budgets, it is important to recognise the gains that could be made from adopting sustainable land management practices on a wide scale. In order to focus attention and to treat land degradation as a serious global challenge, efforts to quantify the economic value of land and costs of degradation must be enhanced.[26]

Comparatively, the benefits of improved land management could be significant. The Economic Land Degradation Initiative calculates that improved land management could deliver up to $1.4 trillion globally in increased crop production or 35 times the value of estimated losses.

The Vicious Cycle of Soil Degradation:



Adapted from Lal, 2004

IS THE ANSWER ORGANIC FARMING?

In principle, organic farming has the capacity to reverse soil degradation and to provide a long-term basis for crop and livestock productivity. At present, most farming systems in Africa are organic and low input by default. Farmers do not have sufficient access to inputs or organic matter. If yields are very low so is the quantity of leaf, stem and other residue that could be incorporated in the soil. Likewise, the manure from malnourished livestock is less nutritive. Such material as is available may be preferentially used for feeding livestock or for cooking fuel.

Transforming farms to become fully organic may be valuable in drought affected areas, improving yields where the soils have been severely degraded.[27] There is also a significant demand for organic export crops from Africa, such as coffee and cocoa. However, yields are typically about 20% lower on organic than conventional farms. This is a challenge for farmers when production is below subsistence or prices drop dramatically.[28] Importantly, it questions whether yields produced through organic agriculture can be intensified at scale in order to ensure food security for Africa as a whole.

ORGANIC AGRICULTURE relies on natural or non-synthetic resources to provide nutrients to the soil and control pests, diseases and weeds. By ‘mimicking nature’ and making use of natural ecological processes such as building up soil organic matter and biota, recycling and composting crop residues and integrating the nitrogen fixing properties of legumes, organic agriculture seeks to improve soil fertility while exerting minimal environmental impact.

By contrast, conventional farming relies heavily on synthetic fertilisers and pesticides and can be extremely productive.[28] In Asia grain yields can average 3-5 tons per hectare and in developed countries over 10 tons, but in Africa yields for crops such as maize are often only 1 ton or less per hectare. However, if the inputs are used imprudently, there can be serious consequences. Modern agricultural practices, when left unchecked or relied upon too heavily, can contribute to soil erosion through agrochemical run-off. This also contaminates waterways causing adverse impacts on aquatic ecosystems. Soils often do not adequately absorb nutrients when fertilisers are haphazardly applied, for example "broadcast" on crops. Excessive fertiliser use, apart from being wasteful, may result in high emissions of GHGs. Thus poorly targeted and excessive fertiliser use is costly and inefficient.

THE ANSWER LIES IN COMBINING ORGANIC APPROACHES WITH A PRUDENT USE OF NECESSARY INPUTS. ON AFRICA'S DEPLETED SOILS, PRODUCTION CANNOT BE INCREASED AND MAINTAINED WITHOUT BRINGING NUTRIENTS IN FROM THE OUTSIDE, EITHER THROUGH LIVESTOCK MANURE, MINERAL FERTILISER OR CULTIVATION OF LEGUMES.

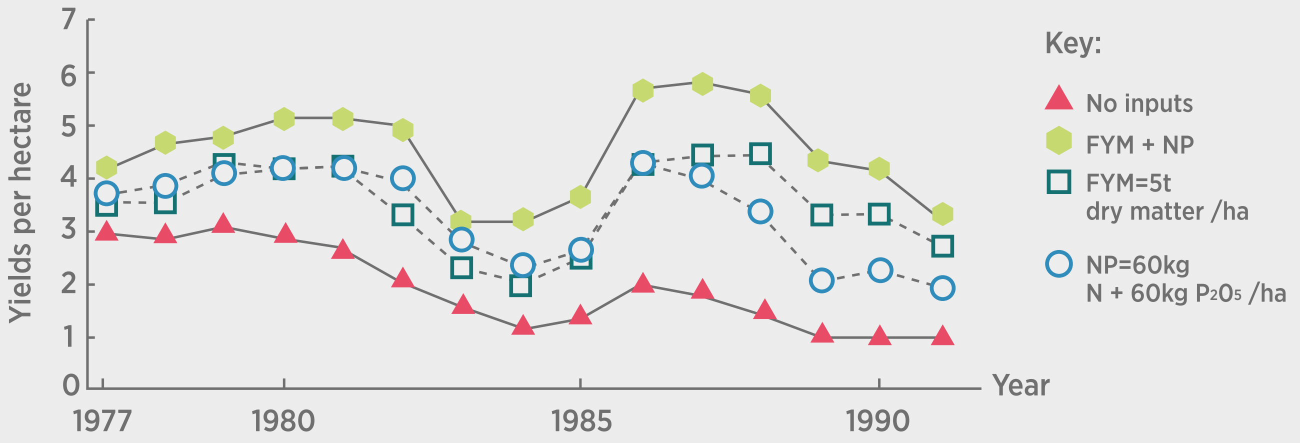
Long term experiments and detailed analysis of soil processes have shown why the addition of nutrients is so important, not only for higher yields but also for yield sustainability.

LONG-TERM AFRICAN CROP TRIALS[30]

21 long-term arable cropping trials in different environments across SSA took place between 1948 and 1988; the trials exhibited the following shared characteristics:

1. Yield decline, often with a relatively rapid fall to a low level equilibrium.
2. A significant decline in soil organic matter when land was cultivated, between greater than 5% per annum loss on sandy soils to around 2% on better textured soils.
3. Yield declines from prolonged treatments with organic matter alone (animal manure, green manure, crop residues), although yields held up better than when treated with inorganic fertilisers alone.
4. Rotational treatments, including sequences with legumes and fallow periods had lower declines than monocultures, and lower rates of soil organic matter loss.
5. The best results invariably were those treatments that combine inorganic and organic inputs.

Long-term crop trials on long-term maize yields in Kabete, Kenya[31]



FYM = Farmyard Manure **NP** = Nitrogen and Phosphorus **P_2O_5** = Phosphorous Pentoxide

RESTORING SOIL ORGANIC CARBON HOLDS THE KEY

Organic matter and inorganic fertilisers are combined to improve the quality of the humus and its soil organic carbon (SOC). Humus fosters the storage of water and nutrients available to the plant, the activity and diversity of soil biota, soil structure and tilth, susceptibility of soil to erosion, and a soil's resilience against a changing and uncertain climate. The quality and amount of humus and its SOC is thus a key determinant of soil quality and crop productivity.

When the concentration of SOC falls below a certain threshold, key soil properties are adversely affected inhibiting plant growth. While the threshold level varies among soil types, climate and land use, in general it is 1.1 to 1.5% for soils in the tropics. For some severely eroded and degraded soils in SSA, the SOC concentration is just 0.5%, or even as low as 0.05%. In these cases, the SOC must be raised considerably and doing so can increase yields dramatically.

Increasing the amount of humus and SOC in the soil requires adding nitrogen (N) and other plant nutrients, such as phosphate (P) and sulphur (S) in order for the transformation of biomass carbon into SOC to occur. To increase the SOC pool by 1 ton per hectare requires 75-80kg of N, 15-20kg of P and 12-15kg of S, in addition to the amounts directly required for growth of the crop. The nutrients may come from inorganic fertiliser, manure or legumes. If they are not present or supplied, accumulation of humus will not occur even with liberal applications of crop residues.[32]

A high SOC is desirable because it makes nitrogen more readily available to plants and does so on a sustainable basis. Thus, restoring the concentration of SOC to above the threshold level is a critical determinant of plant health and productivity, and therefore essential to addressing global food and nutritional security.

INTEGRATED SOIL MANAGEMENT

In the 1950s and 1960s when it became apparent that the overuse of pesticides was polluting and making problems worse, the concept of Integrated Pest Management (IPM) was created and applied in a number of different environments. IPM focused on utilising practices of biological and ecological control, coupled with targeted and highly selective use of pesticides aimed at the minimum needed to control the pest or disease. Over the years IPM has become the cornerstone of control for many pest problems.

We now face a similar challenge in managing soils. Conventional means of soil management often cause more harm than good, while organic approaches are sometimes too demanding of labour, reliant on scarce or unavailable inputs, and insufficient to produce the yields required to achieve local or global food security. The solution is to combine the best of organic and conventional approaches in a way that is environmentally appropriate and sustainable.

As defined by CGIAR,[33] ISM is "a set of soil fertility management practices that necessarily include the use of fertiliser, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximising agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic principles."[34] In practice this requires harnessing the skill and knowledge available in traditional farming, together with ecological approaches and precision farming using modern inputs.

TRADITIONAL AND ECOLOGICAL APPROACHES

In many environments the principles of conservation farming are appropriate - minimal soil disturbance, permanent soil cover and crop rotations. Commonly farmers till the soil before seeding in order to loosen and aerate the soil and to destroy weeds. This can break up heavy clay soils, but for soils prone to erosion or drought, as are common in SSA, tilling can harm soil structure and increase water loss. Reduced or no tillage creates savings on labour and machinery, protects vulnerable soils, improves soil structure and fertility and encourages populations of beneficial soil biota. Traditional and ecological approaches such as intercropping with nitrogen enriching legumes, mixing crops with livestock and trees, conserving water by building bunds and terraces, digging planting pits and erecting windbreaks to minimise wind erosion also improve soil fertility and increase yields with minimal environmental impact.

THE SOLUTION IS TO COMBINE THE BEST OF ORGANIC AND CONVENTIONAL APPROACHES IN A WAY THAT IS ENVIRONMENTALLY APPROPRIATE AND SUSTAINABLE.

EXAMPLES OF TRADITIONAL AND ECOLOGICAL APPROACHES[35]

WATER HARVESTING

Nutrients will only be used efficiently if a crop has sufficient water. In areas that are prone to drought, the amount of rainfall captured and made available to crops can be increased. Extra water can be harvested by installing structures that decrease runoff (e.g. the Zaï planting pit system used in the Sahel or the use of planting basins in southern Africa), or by maintaining organic mulch on the soil surface to promote infiltration and reduce evaporation from the soil surface.

EROSION CONTROL

Soil erosion can be a serious problem, especially on fields with steep slopes, but also on slightly sloping fields with coarse-textured top soil. Soil organic matter and nutrients are lost in eroded soil, which may substantially reduce the agronomic efficiency of applied inputs. Several measures can assist in controlling erosion, including planting of live barriers such as grass strips, construction of terraces and stone bunds or applying surface mulch.

INTERCROPPING

When two or more crops are grown together, either as mixtures or rotations, nutrients mined by one crop can be replaced by another. This is especially true when one is a nitrogen-fixing legume such as beans, peas, clover, alfalfa or groundnuts. Annual herbaceous crops that discard their leaves and stems at the end of the growing season can also be interspersed with perennial trees or shrubs to return nutrients to the soil. The trees may also provide shade and mulch, creating a micro-environment while the ground cover of crops reduces weeds and prevents erosion.

PRECISION FARMING

Central to Sustainable Intensification and ISM is the selective choice of inputs, whether organic or inorganic, and their targeted use. This applies to fertilisers and biological nutrient absorption and also to water. In SSA, less than 3% of total cropland is under sustainable land and water management practices. However, by combining conservation farming practices with the microdosing of fertilisers, farmers can implement ISM.[36]

Microdosing Fertilisers

In 2008 SSA, excluding South Africa, consumed just 1% of global fertiliser supply.[37] The African Union-led Abuja Declaration of 2006 calls for strategic investment to increase the availability and use of fertiliser alongside other inputs.[38] The goal to raise fertiliser use to 50kg per hectare may be excessive in some situations and it would be better to tailor fertiliser application to soil conditions and crop requirements. While no region of the world has been able to increase agricultural growth rates and reduce hunger without increasing fertiliser use, Africa's farmers must complement existing knowledge and resources – livestock manure and intercropping with nitrogen-fixing legumes or covering farmland with crop residues – with increased but targeted and selected use of fertilisers to return nutrients to the soil and ensure their uptake.

Just as developed country farmers practice precision farming through global positioning systems (GPS) and digital soil mapping, African farmers too need to know exactly what nutrients are needed and where. Improvements in extension services, but also local soil testing facilities would enable farmers to better understand their soil types, tendencies and nutrient deficiencies in order to minimise the amount of fertilisers they need to purchase and use. For example, under the guidance of Ethiopia's Agricultural Transformation Agency (ATA), farmers growing hybrid maize were able to achieve 6-8 tons per hectare – reaching the European average – when they applied an appropriate balance of NPK (Nitrogen, Phosphorus and Potassium) coupled with Boron that was determined to be deficient in the region.

Microdosing replenishes soils and incomes

Placing small doses of fertiliser – about 4–6 grams for 2–4 plants – at the roots of a young plant or in the seed planting pit boosts the root system so that it is capable of capturing more water and coping with stresses. Through support from the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT), more than 300,000 farmers in Mali, Burkina Faso and Niger have learned the technique for microdosing. A combination of 30% to 100% higher yields for sorghum and millet, improved seeds, access to finance, storage systems and markets, has resulted in incomes growing between 50% and 130%. After the rain-fed cropping season, left-over fertiliser can then be used for vegetable production, giving farmers a source of additional nutrition and income.

Across Africa, mineral fertiliser is often very expensive relative to crop prices and fertiliser costs in other areas of the world. As a result, average rates of fertiliser use are just 10kg per hectare compared to a worldwide average of about 130kg per hectare.[39] Even when fertilisers are accessible and affordable in small quantities, farmers still require assistance to know the right mixture of nutrients to apply and how they can be combined with manure and other natural resources, such as lime and phosphorus, to maximise productivity.

African farmers need to use more inorganic fertiliser to give the right nutrients to their crops and achieve higher yields, but they also 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.

AFRICAN FARMERS NEED TO USE MORE INORGANIC FERTILISER TO GIVE THE RIGHT NUTRIENTS TO THEIR CROPS AND ACHIEVE HIGHER YIELDS, BUT THEY ALSO NEED TO STRIKE THE RIGHT BALANCE BETWEEN THIS GOAL AND MINIMISING COSTS AND ENVIRONMENTAL IMPACTS.

Enhancing Nitrogen Fixation and Uptake

Biological nutrient fixation and recycling through green manures, composts and animal manure represent important ways in which over-reliance on synthetic nutrients and losses to water in the soil can be minimised.

N2AFRICA is a large scale, science-based project that works with smallholder farmers in Africa to improve the nitrogen uptake through legume cropping combined with selected rhizobium inoculation. The legume varieties are chosen through on-farm participatory field testing. In the first phase, N2Africa reached more than 230,000 farmers who adopted improved combinations of grain legume varieties, bacterial inoculants and phosphate based fertilisers. The second phase that began in January 2014 will continue to research and distribute major grain legumes while working to build local legume expertise. By 2019, the project aims to reach more than 550,000 farmers with tailored and adapted legume technologies, establish new value chains for input supplies and output markets, empower women to benefit from legume production, and training and extension.

Faidherbia is a leguminous tree that has the curious habit of shedding its leaves in the wet season. Between the nutrients provided from the leaves and the light allowed to pass through them, it is possible to plant and grow maize under Faidherbia trees without fertilisers, and still achieve maize yields that can exceed three tons per hectare.

Leguminous plants, such as peas, clover and alfalfa, take in nitrogen from the atmosphere by utilising symbiotic bacteria called rhizobia contained in nodules in their root systems. The nitrogen is first used to help the plants grow and when the plant dies, the nitrogen is released into the soil for other plants to use. For many years, scientists have been trying to get cereal crops – maize, rice, wheat – to develop similar nodule systems. It looked like an unthinkable goal, but recent research has uncovered the evolutionary pathways, whereby legumes acquire nitrogen fixing nodules. Replicating these pathways in cereals now seems feasible – perhaps in the next 10 – 20 years.[40]

CLIMATE SMART SOIL MANAGEMENT WILL HELP PROTECT AND STRENGTHEN AFRICA'S SOILS AND ITS FARMERS TO WITHSTAND CLIMATIC CHANGES AND SHOCKS.

Microdosing Water

Agriculture accounts for around 70% of annual global water use, most of which is consumed for irrigation.[41] In hot, dry regions, much larger amounts of water are needed to produce the same yields than in less stressed regions.[42] Although irrigated areas account for less than 20% of the world's cropped land, they produce nearly half of all food globally.[43] Finding ways of saving water or using 'less drop per crop' must become a mainstay of agricultural production.

Water-saving agriculture includes a variety of technical approaches. Drip irrigation is widely used in developed countries to ensure the right amount of water is placed close to the growing plant at the right time. Similarly, laying cheap perforated plastic hoses alongside crop beds, especially for horticultural crops, is cost efficient for developing countries. Regulated deficit irrigation schemes restrict water applications to the most drought sensitive time of a crop's growth cycle. Rainfall is relied upon for additional water needs. Combining deficit irrigation with methods such as covering fields with leftover crop residues or mulch helps the soil to retain moisture.

Better weather data can also help farmers use less water. For example, wheat yields in Western Australia increased nearly three-fold over 70 years between 1930 and 2000 even as rainfall decreased.[44] This was achieved largely by altering planting dates to ensure the ground is still covered while there is water available in the soil to maximise retention.

While ISM offers a pathway for sustainable soil and land management for the 21st century, climate change poses a significant challenge, with particularly severe consequences for African agriculture. Climate smart soil management will help protect and strengthen Africa's soils and its farmers to withstand climatic changes and shocks.

"WE NEED A BLUE REVOLUTION IN AGRICULTURE THAT FOCUSES ON INCREASING PRODUCTIVITY PER UNIT OF WATER—MORE CROP PER DROP" - KOFI ANNAN, FORMER UN SECRETARY GENERAL, 2000

CLIMATE SMART SOIL

“IT IS LIKELY THAT LAND TEMPERATURES OVER AFRICA WILL RISE FASTER THAN THE GLOBAL LAND AVERAGE, PARTICULARLY IN THE MORE ARID REGIONS” - IPCC, 2014[45]

The most serious consequences of climate change for African agriculture will arise from higher temperatures. An average increase of more than 2°C by the end of this century compared with pre-industrial levels or a rise of even 3°-6°C predicted under some scenarios will result in lower average rainfall and shorter wet seasons in many semi-arid regions. Agriculture will also suffer from a greater incidence and severity of extreme events such as drought and flooding.

Governments, farmers and the private sector must protect and reinforce our soils to withstand these shocks. Climate smart soil helps agricultural systems become better adapted and resilient to the adverse effects of climate change, while minimising the emission of GHGs and restoring the lost carbon to the soil.

In many parts of Africa the effects of global warming are already becoming apparent and smallholder farmers are suffering. For them, adaptation is a growing priority. Part of the answer lies in building more resilient soils through the adoption of ISM practices that restore and improve the structure and the functioning of degraded soils. This includes the soil’s capacity to store water and nutrients, which will provide a sound basis for adaptation. At the same time, ISM can contribute to mitigating climate change by sequestering carbon in the soil, and reducing GHG emissions and the use of fossil fuels through the prudent use of fertiliser. In addition to being provided with the knowledge and understanding of how ISM can help them adapt to climatic changes, farmers also need incentives, such as carbon credits, to mitigate climate change.

CLIMATE SMART AGRICULTURE[46]

- Provides adaptation and resilience to shocks
- Generates adaptation and mitigation as co-benefits
- Is a location-specific and knowledge-intensive approach
- Provides integrated options that create synergies and reduce trade-offs
- Identifies barriers to adoption and provides appropriate solutions
- Strengthens livelihoods by improving access to services, knowledge and resources
- Integrates climate financing with traditional sources of agricultural investment

Adaptation through Soil Management

Soil capital - consisting of physical and organic matter, nutrients, moisture and living organisms - will change over time and is unevenly distributed across farms and in the soil profile. Therefore, adaptation inevitably depends on caring for and managing the local soil environment.

First, soils have a role in reducing the adverse impacts of high temperatures. Soil temperatures exceeding 30°C are common in tropical soils, significantly reducing yields of crops such as maize and soybean. However, crop residue mulches applied on no-tilled fields can reduce soil temperatures by 4°–6°C.[47]

Second, a more important contribution to adaptation, is increasing the moisture in the soil – the so called 'green water' - in contrast to the blue water of lakes, rivers and deep aquifers. Enhancing soil moisture availability can be achieved in various ways, for example by plugging gullies to retain water, by creating contoured terraces with stones and plants such as vetiver grass, or by using machines to create ridge and furrow systems for planting sorghum.

CLIMATE SMART SOIL HELPS AGRICULTURAL SYSTEMS BECOME BETTER ADAPTED AND RESILIENT TO THE ADVERSE EFFECTS OF CLIMATE CHANGE, WHILE MINIMISING THE EMISSION OF GHGS AND RESTORING THE LOST CARBON TO THE SOIL.

A RIDGE AND FURROW MACHINE IN SUDAN

Planting sorghum at the bottom of a furrow helps to conserve soil moisture in areas of low and unreliable rainfall. A tractor drawn machine developed in Sudan creates ridges and sows seeds in the furrow at the same time. A recent invention, the ridge and furrow machine is set to boost productivity and yields of sorghum farming in Sudan. The machine was developed by researchers at Sudan's Agricultural Research Corporation under the Climate Change Adaptation in Africa (CCAA) program, a six-year joint initiative of the International Development Research Centre (IDRC) and the UK Department for International Development (DFID).

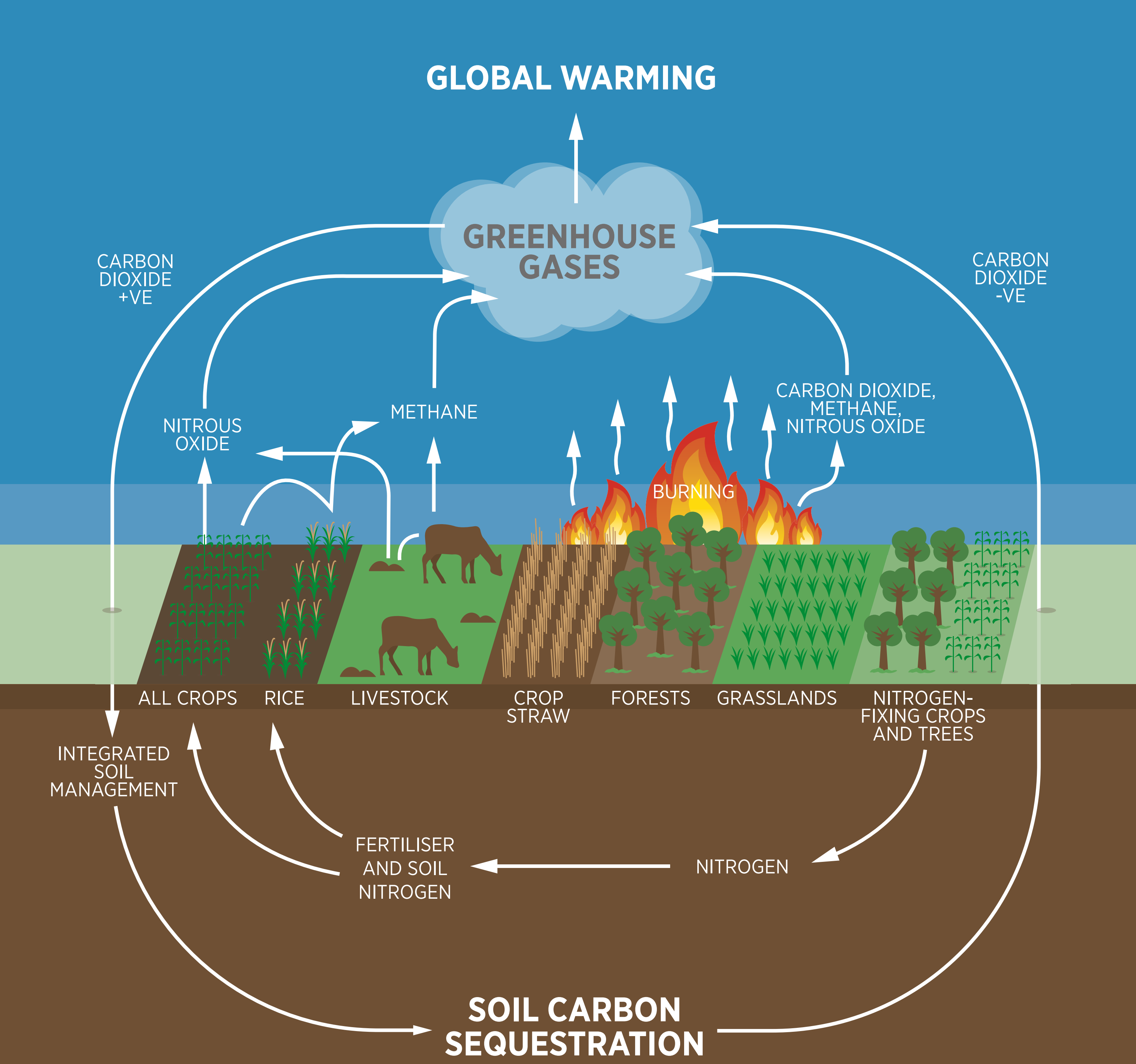
Mitigation through Soil Management

Agriculture is one of the largest contributors to GHG emissions, in particular from livestock, but soils are also responsible. The principal GHGs emitted from soils are nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2). The most powerful in terms of creating global warming are nitrous oxide and methane; they are nearly 300 times[48] and 35 times[49] as powerful as CO_2, respectively over 100 years.

Some technologies for reducing these emissions are available, but considerable research still needs to be done. For example, Urea Deep Replacement (UDP) in rice fields – the microdosing of urea – can lower the amount of nitrogen that escapes by simply using less.

Usually urea, the main nitrogen fertiliser for rice, is applied liberally, "broadcast" across fields. This is very inefficient, resulting in the loss of 60-70% of the nitrogen applied. UDP offers a climate-smart solution for rice systems. Urea is formed into tiny "briquettes" of one to three grams that are placed at 7 to 10 cm of soil depth after the paddy is transplanted. By targeting the urea to the root of the rice paddy, urea efficiency use rises by 50%. Moreover, yields rise by 25% for every 25% reduction in urea use. Some studies show up to 40% reduced methane emissions for irrigated rice. Given the success achieved by the Bangladesh Department of Agricultural Extension, where it is used on 1.3 million hectares by 2.5 million farmers, there are plans to expand its use to Africa.

AGRICULTURE IS ONE OF THE LARGEST CONTRIBUTORS TO GHG EMISSIONS, IN PARTICULAR FROM LIVESTOCK, BUT SOILS ARE ALSO RESPONSIBLE.



Agriculture's impact on climate change

Carbon Sequestration

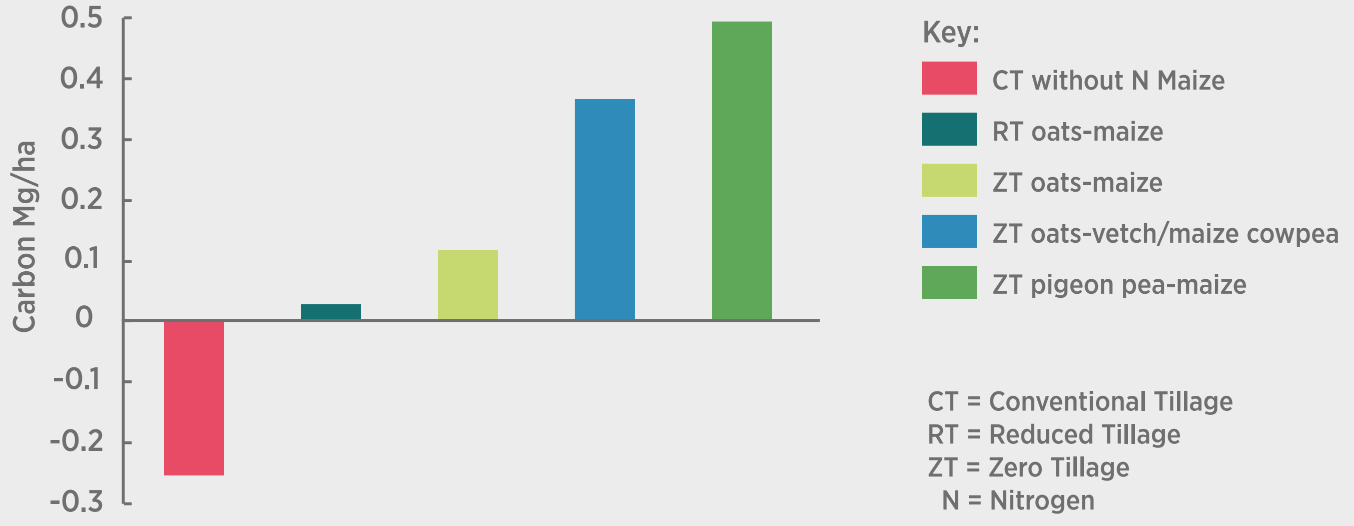
There are about 1,500 gigatons (Gt) of SOC in the soil globally, more than double the size of the amount of carbon in the atmosphere and three times the pool in plants, animals and microorganisms. In undisturbed native ecosystems, such as woodland or forest, the gains and losses are more or less balanced. However, when the land is converted to agriculture the SOC is depleted by as much as three quarters in tropical regions. Plowing releases nutrients by destroying the humus. Over centuries farmers have mined humus to grow food and in the process released CO_2 into the atmosphere. There are wide estimates of humus thus lost but the cumulative historic loss from agriculture is between 50 and 78 Gt.[50]

The challenge is to put some of this back through the process of carbon sequestration, which occurs when more organic matter is added to the soil than decays. Plants take up CO_2 from the atmosphere and convert it through photosynthesis to organic matter, part of which remains in the soil as humus. But in addition to putting the carbon back, it has to be protected primarily against wind and water erosion and other processes.

A possible approach to sequestration is conservation farming. In practice no-till systems result in greater sequestration than under-tilled crops. Sequestration is also encouraged and protected when the soil is kept covered, using cover crops or rotations or when fallows are reduced or eliminated. However, the amounts of sequestration, although large in some situations, can be small in others. There is no simple rule of thumb, but in general conventional conservation farming systems tend to sequester a maximum of 0.1 to 0.4 tons per hectare of carbon per year.

THERE ARE ABOUT 1,500 GIGATONS (GT) OF SOC IN THE SOIL GLOBALLY, MORE THAN DOUBLE THE SIZE OF THE AMOUNT OF CARBON IN THE ATMOSPHERE AND THREE TIMES THE POOL IN PLANTS, ANIMALS AND MICROORGANISMS.

The potential for carbon sequestration in a long-term experiment in southern Brazil[51]



A better alternative is to rely on agroforestry systems, typically with annual crops grown under trees. They accumulate carbon above and below ground in the range of 2-4 tons per hectare of carbon per year, roughly an order of magnitude higher than with conservation farming alone. This is particularly true for systems incorporating leguminous trees such as Faidherbia or Gliricidia.[52]

Estimates of the carbon stocks in agroforestry systems overall in Africa range from 1 to 18 tons of carbon per hectare in above-ground biomass and up to 200 tons of carbon per hectare in soils.[53] They also provide better protection from carbon loss through soil erosion.

THE POLITICAL ECONOMY OF INTEGRATED SOIL MANAGEMENT

Despite the considerable potential gains, the uptake of ISM practices in Africa remains low. This is the result of multiple factors that influence farmers' decisions. Too often, the choice is made to forgo better land management practices in lieu of more affordable, less labour-intensive or alternative uses of resources. This must be reversed by means of stronger incentives and better information.

The costs and benefits associated with maintaining and improving soil capital and resilience are both short-term and long-term, but the right incentives are not in place to encourage short-term investments whose benefits are only realised over time. Farmers incur immediate costs for labour, materials, inputs, equipment and physical structures such as terracing, while the benefits of ISM practices may only be visible over the long-term. Failure to invest in ISM may lead to a loss of future food production. Inevitably, this process of weighing up the costs and benefits is highly influenced by factors such as land tenure, access to markets, anticipated crop sales and access to finance.

Often the longer-term benefits may be significant but costly to achieve. Farmers may be able to invest, for example, in small-scale rainwater harvesting (e.g. placing plugs in gullies to conserve moisture) but large-scale harvesting may be too costly in time, labour or materials. As most of the successful major irrigation schemes in Asia were constructed with public funding, supported by both domestic and international finance, this also may be required for Africa.

In most African countries the state owns the land. With ownership comes responsibility. Based on sound land use and soil management assessments, governments need to establish the appropriate incentive structures for sustainable land use. Long-term lease regulations and protection of tenancy rights will be critical.[54] Furthermore, payments for ecosystems services related to sustainable land and watershed management can be part of a suite of needed incentive packages, and these may function best if implemented through support for collective actions.[55]

BASED ON SOUND LAND USE AND SOIL MANAGEMENT ASSESSMENTS, GOVERNMENTS NEED TO ESTABLISH THE APPROPRIATE INCENTIVE STRUCTURES FOR SUSTAINABLE LAND USE. LONG TERM LEASE REGULATIONS AND PROTECTION OF TENANCY RIGHTS WILL BE CRITICAL.

Finally, there is a need for African governments to invest in dedicated institutes that take a holistic approach to restoring or enhancing land or soils. Such programs will inevitably have to cut across departmental if not ministerial lines, encompassing agriculture, forestry, rangeland and water. Task forces cutting across ministries are needed for sustainable land and soil management. The soil science capacity in African research centres needs to be strengthened and collaboration with European and international scientists and research institutions enhanced.

The key role of soil in adapting to and in mitigating climate change is now better understood. 'Climate smart soils,' utilising integrated soil management practices offer a way forward to achieving resilience and long lasting agricultural sustainability in Africa. However, achieving this goal will only be possible through strong political leadership and dedicated policies, programs and institutions.

CONCLUSION

AS A NATURAL RESOURCE, SOILS ARE OFTEN OVERLOOKED. NEGLECTED SOILS OVER TIME RESULT IN LOW CROP PRODUCTIVITY AND FOOD INSECURITY THAT DISPROPORTIONATELY AFFECTS RESOURCE-POOR FARMERS, ESPECIALLY IN AFRICA. NURTURING, CONSERVING, RESTORING AND ENHANCING THIS INDISPENSABLE RESOURCE SHOULD INTUITIVELY BECOME A MAJOR GLOBAL PRIORITY.

Donors and governments must adopt a long-term vision upheld with financial support to restore degraded lands and create incentives for investment in environmental and social stewardship of the land. Africa's soils are diverse and varied and Africa's farmers have differing types of knowledge, resources and endowments; these must be recognised, enhanced and addressed accordingly. Integrated soil management offers the ability to sustainably intensify production and provides the intensive care and attention Africa's soils need.

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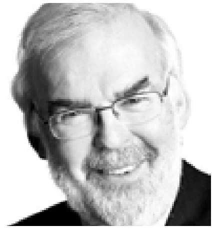

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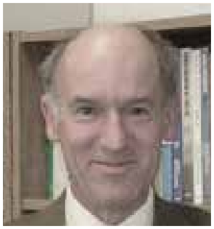

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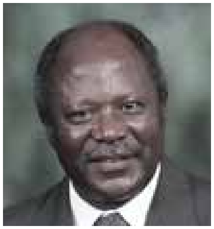

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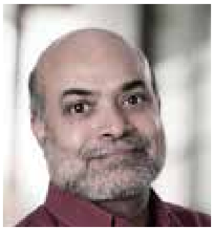

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Soil Types Map Legend from Page 6

- Acrisols
- Alisols
- Andosols
- Arenosols
- Calcisols
- Cambisols
- Chernozems
- Cryosols
- Durisols
- Ferralsols
- Fluvisols
- Gleysols
- Gypsisols
- Histosols
- Kastanozems
- Leptosols
- Lixisols
- Luvisols
- Nitisols
- Phaeozems
- Planosols
- Plinthosols
- Podzols
- Regosols
- Solonchaks
- Solonetz
- Stagnosols
- Technosols
- Umbrisols
- Vertisols
- Water body

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