THE CHICAGO COUNCIL ON GLOBAL AFFAIRS

Considering a soil initiative for Africa

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Introduction

The farms and pastoral areas of Africa have experienced a widespread, secular decline in soil quality since the early 20th century that continues today.[1] This decline greatly hinders agricultural productivity and livestock production across the continent. It threatens food security and environmental sustainability as well as economic growth and well-being—particularly for Africa's poorest and most vulnerable people.

The basic nature of this problem (particularly its scale, location, local manifestations, severity, evolution, and impacts) is neither well documented nor well understood. Many projects, programs, and institutional frameworks to combat the problem exist, often with important practical achievements. Yet while the building blocks for a solution are in place, the overall attention and resources devoted to this issue have been fragmented and inadequate. Further, viable, costed, and scalable plans for effectively addressing the challenges have not emerged.

This briefing note surveys the issue and suggests practical steps for creating partnerships and formulating plans to reverse the decline in soil quality in Africa. It suggests a number of discrete workstreams that could lay the foundation for coordinated and well-informed action. These workstreams would build on what is already in place from a technical, resource, and institutional standpoint and fill in existing gaps. This briefing note also suggests initial collaborations that could move each workstream forward. Ultimately, implementation of the ideas suggested here will require leadership and institutional collaboration at every level. The purpose is to spur and inform such leadership and collaboration.[2]

The soil situation in Africa

Healthy soils—together with water, air, genetic material, and farmers themselves—are a fundamental building block for productive crop and pastoral agriculture. They provide important services to ecosystems and to rural and urban economies. Among the most important of these soil services are to host and source nutrients for virtually all crop, livestock, and forest production; provide carbon storage (and mitigation of greenhouse gas emissions); host a variety of in-soil biodiversity; and retain and purify water resources (especially from rainfall). The first *Status of the World's Soils Resources* report concluded that the majority of the world's soil resources are in only fair, poor, or very poor condition.[3] The report also found that Africa is the region of the world with the most severely degraded land and soil resources. The International Food Policy Research Institute (IFPRI) supports these findings.[4]

Box 1

Healthy soils store water and carbon

Water stored in soils (green water) supports 90 percent of global crop and livestock production—and an even higher proportion of agricultural production in Africa. Soil's ability to absorb rainwater and hold green water is directly related to the overall health of those soils. Healthy soils act as a sponge when it rains and hold more nutrients. Less healthy soils hold fewer nutrients and less water and thus are less effective in supporting agricultural activity and mitigating flooding and erosion.

Soils also act as a carbon sink. The topmost meter of the world's soils contains three times as much carbon as the world's vegetation and almost twice as much as the atmosphere. The healthier the soil, the more vegetation it can support and the more atmospheric carbon it can sequester. Even small declines in soil health can have measurable impacts on carbon dioxide levels in the atmosphere.

Source: The Chicago Council on Global Affairs 2019

For several decades, agriculturalists have observed a long, steady—if slow—decline in soil health in Africa. This decline continues today. Of course, issues with soil quality are largely site-specific, and no comprehensive database of soil issues built from site-specific information exists. Even so, it is widely understood that the main soil-quality issues in Africa include soil erosion, loss of organic matter, nutrient deficits and imbalances, loss of soil biodiversity, soil salinization, soil acidification, and soil sealing.

For Sub-Saharan Africa, an estimated 65 percent of arable lands, 30 percent of grazing lands, and 20 percent of forest soils suffer from soil-quality degradation—much of which stems from erosion and nutrient drawdowns.[5] Such estimates are uncertain at best. Alternative estimates suggest that 80 percent of Africa's croplands and rangelands suffer from soil degradation, while other studies put the figures much lower in the range of one-quarter to one-third of agricultural and pasture lands.[6]

Whatever the true magnitude of the problem, soil degradation is extensive and important in Africa—and is distributed broadly across the continent. Figure 1 shows estimates of the extent and distribution of land and soil degradation in Sub-Saharan Africa. As of yet, no such figure exists for North Africa.

The consequences of degraded soils in Africa

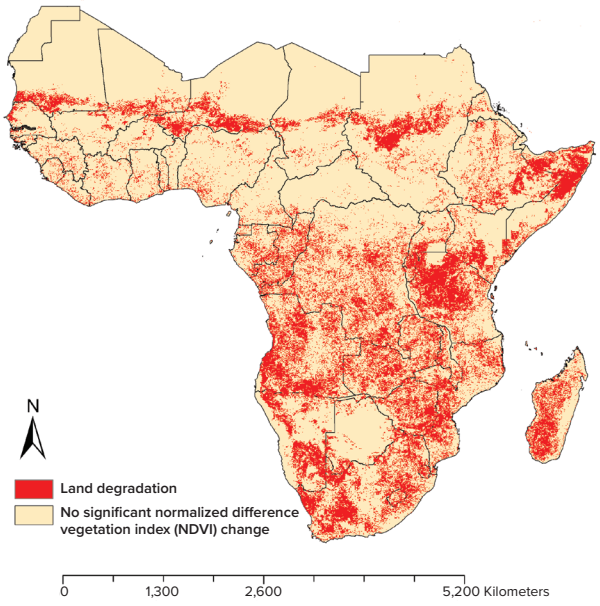
The degraded condition of soils across the African continent has many negative consequences. One of the most significant is reduced crop yields, which have been dismal in Africa. Figure 2 shows how little crop yields have grown for Sub-Saharan Africa compared to other developing regions of the world. This pattern of yields in Africa lagging far behind those in the rest of the world can be seen in the data for virtually every major agricultural crop. Overall agricultural productivity is diminishing in nearly one-quarter of Africa's cropland, pastures, and rangelands, largely as a result of declining soil health. This area is larger than the area with increasing agricultural productivity, where productivity increases would be even more rapid if soils were healthier.

This situation is getting worse, as areas with diminishing productivity expand faster than those with increased productivity.[7] This is especially important since improvement in agricultural productivity is one of the most effective mechanisms for improving the livelihoods of the poor both on and off the farm in Africa.

More broadly, the constraints on agricultural productivity posed by poor soil health reduce the growth of the

Figure 1

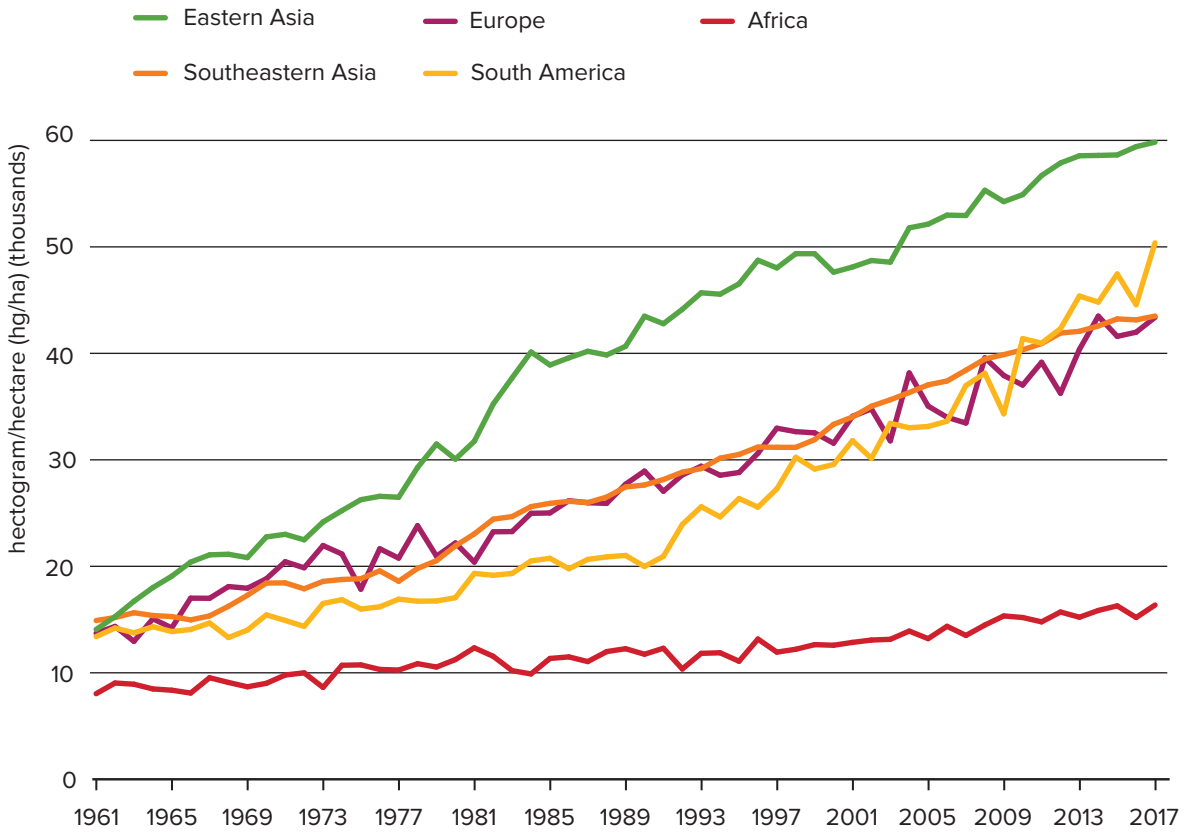
Incidence of land degradation in Sub-Saharan Africa



Source: Le, Nkonya, and Mirzabaev 2014

Figure 2

Global cereal yields by region



Source: Le, Nkonya, and Mirzabaev 2014

agricultural sector and gross domestic product (GDP). Recent estimates suggest that the impact of diminished soil fertility on Africa's crop and livestock operations alone have a cumulative annual cost of over half a percent of Africa's overall GDP.[8] Beyond these direct costs to the farming sector and to the overall economy, degraded soil health threatens food and nutrition security. It reduces the soil's ability to filter contaminants out of water supplies, capture water on water-scarce lands, and capture carbon (thus exacerbating climate change). It also makes soil more vulnerable to erosion and mineral leaching and escape and thus more vulnerable to the effects of climate change.

Human migration in Africa is often associated with reduced soil health and related problems (low productivity, low farm incomes, and failing local economies). The costs to Africa's GDP of the societal effects of soil degradation are estimated to be higher than the half percent cited above for crop and livestock operations by as much as a factor of 10.[9] The same analysis suggests that investment in improving the health of African soils would pay off handsomely. Measures to protect and build soil fertility are inexpensive. The increases in per-hectare productivity are substantial, as are the reductions that can be achieved in other negative consequences of poor soil health. As a result, Nkonya, Mirzabaev, and von Braun estimate the return on investment for measures taken to improve soil health to be as high as $4 for every $1 invested.[10]

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Box 2

What is the adequacy of soil science capacity in Africa?

The Consultative Group for International Agricultural Research (CGIAR) has important agricultural research stations across Africa. Its staff members are keen observers and close partners of African agriculture and its participants. When polled about soil science capacity in Africa, CGIAR Africa-based staff and researchers at other key institutions on the continent responded as follows.

Are capable, experienced soil scientists easy to find?

- International Maize and Wheat Improvement Centre (CIMMYT) – Properly trained soil scientists are not many—and the younger generation does not really seem to be attracted to the profession. I envisage a shortage in the near future.
- International Institute of Tropical Agriculture (IITA) – Capable and experienced soil scientists are very rare in Africa now because the lack of funding in soil-related issues has drastically reduced the number of students in soil departments at many universities and high schools.
- International Centre for Tropical Agriculture (CIAT) – There is no shortage in general. Expertise in certain areas of soil science (e.g., soil biology, digital soil mapping) is a bit more difficult to find.
- International Centre for Research in Agroforestry (ICRAF) – Soil scientists are limited in number, but more seriously they are mostly completely out of date in terms of current soil science concepts and technology. National programs are often left with one or two older soil surveyors who are not skilled in new soil assessment methods such as the use of sensors, remote sensing, digital soil mapping, spatial statistics, multivariate statistics, and genomics.
- International Fund for Agricultural Development (IFAD) – Very rare, and many are too academic.

Do you work with national extension services?

- Ethiopian Agricultural Transformation Agency (ATA) – Yes, we closely work with them. There are a good number of experts, but their capacity is limited. They need in-depth trainings on soil issues.
- CIMMYT – Yes, we work with national extension services. They often do not have sufficient training in understanding soil matters. Clearly in most cases, there is a capacity gap.
- IITA – Yes, we work with national extension services, but they do not master very well communication in soil science with farmers.
- International Fertilizer Development Centre (IFDC) – National extension services in Burundi are not very conversant with soil science. However, there is a national agricultural research institute (Institut des Sciences Agronomiques du Burundi, or ISABU) that has some appreciable capability.
- ICRAF – Yes, but their capacity is often inadequate. They often request for opportunities to develop their capacities in soil science. There is limited understanding of soil health issues and the long-term economic benefits of sustainable soil management.

Source: Rozanov and Wiese 2018

Considering an initiative to improve soil health in Africa

Reversing the decline in soil health in Africa is an important and urgent matter—and one that makes economic sense. But what exactly could and should be done to address these problems? How should efforts to address these problems be organized and at what level (global, national, local)? Answers to these questions are not readily available because of important gaps in the information, human capital, institutional structure, and financial resources needed to underpin an initiative on soils.

Information gaps

The most extensive source of information about soils in Africa is grounded in surveys and soil mapping from the 1950s and 1960s. Much of the information is now outdated and for the most part not very detailed. Some of these data have been compiled into accessible and

easily usable collections, but much of the existing data remain inaccessible and in a form that is not easily integrated into usable databases. More up-to-date or detailed information is available mostly for very specific local areas—useful only to those areas and far from sufficient for addressing strategic questions such as those posed above.

A 2015 report from the Global Soil Partnership, carried out by its Intergovernmental Technical Panel on Soils, synthesized, summarized, and interpreted existing information about the condition of soils around the world.[11] While that effort was invaluable, it also highlighted gaps and deficiencies in currently available information sets as well as the need for deepening that information and improving its accessibility.

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This is increasingly possible. Modern tools and methods make gathering information about soils more cost-effective and can provide much greater detail and resolution than ever before through the use of remote imagery (from satellites and drones) combined with soil sampling as needed. Digital methods make it possible to compile and analyze soil information and combine it with information on land use, water resources, and road and transportation grids, for example. This enables sophisticated analysis and planning at every level, from on farm management to local, regional, and national planning.

Much better information about soil is needed to guide and ensure the effectiveness of initiatives to improve soil health in Africa—whether the focus is local, national, regional, or continental in scope. At the farm level there is a remarkably widespread lack of understanding of how to improve soils and manage them for profit and sustainability. Farm-specific information and analysis is needed to improve farm outcomes. This means that human capital locally and on the farm is critical.

Human capital gaps

Improving the management of soils in Africa is, in part, a knowledge- and information-intensive endeavor. Progress will require substantial investment in human capital. Smallholder farmers commonly have only traditional, sometimes erroneous, knowledge about soil management at their disposal—with little access to or understanding of even the most basic and practical science of soils. Farmers' source of technical information on soil management issues is typically the agricultural extension programs that exist in almost all African countries.[12] These extension programs, however, are largely devoid of the specialists and field-level expertise needed to provide advice based on soil science to most farmers. Universities across Africa are also surprisingly thin in terms of dedicated soil science faculty. Further, soil scientists in public-sector institutions and at universities operate with outdated and woefully inadequate laboratory equipment and facilities to conduct even the most basic soil analysis that most farmers need.[13] The lack of sufficient human capital in soil science significantly constrains progress on soil health in Africa.

Resource gaps

The efforts and resources currently devoted to addressing the secular decline in soil health in Africa are far less than are needed. Budgets to finance activities that improve soil health are small or nonexistent at local and national levels of government, even where public support and collective action would be justified. Farmers, especially poor, smallholder farmers, often have neither the financial resources nor the capacity to manage the risk required to use recommended levels of fertilizers or to make investments in the soil health of their own farms.[14] On its own, the private sector does not have adequate incentives to finance field-level activities or the research and outreach activities that would help poor, small-farm operators improve soil management. Additionally, private-sector leadership on these issues, while not totally absent, is limited.

Support from African and global development partners has not been concentrated on soil issues. Where support has been provided, it has been minimal. While the lack of funding is widely recognized, current data on financing for soil issues are not available—another important information gap. The consequences of this relative neglect in allocating resources include lower agricultural productivity, further deterioration of Africa's natural resources, and the resulting negative effects on the incomes and food security of hundreds of millions of rural and urban Africans.

Developing a framework for a soil initiative for Africa

Improving the health of Africa's soils will ultimately depend on practical actions at the field level. However, making this happen will require support and collective actions at many levels: by the public and private sectors at local and national levels, by Africa's political and technical bodies, and by financial and technical partners at the global level.

The establishment and launch of the Global Soil Partnership (GSP) at the Food and Agriculture Organization (FAO) in 2012 was an important step toward marshaling available information about soils globally and toward creating collaborative partnerships to develop and implement programs and activities to strengthen soil health on the continent. The GSP's mandate is to improve the governance of soil resources to guarantee agriculturally productive soils that support

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food security and the provision of ecosystem services. Further, the affiliated African Soil Partnership (AfSP) and the Near East and North Africa Soil Partnership (NENA) provide platforms for institutional leadership on these issues. In both AfSP and NENA regions, plans were developed at country and regional levels to implement programs around GSP priorities. Unfortunately, lack of resources has significantly limited progress under these plans. This, together with the still inadequate information about the issue, including rapidly emerging advances in data collection and management, suggests that now is the time for a new soil initiative for Africa.

Such an initiative might take advantage of the leadership of NENA and AfSP. With support from the GSP and other partners, they could work with Africa's lead institutions for agricultural development (i.e., the Comprehensive Africa Agricultural Development Program [CAADP] institutions that include the African Union [AU]/African Union Commission [AUC], Africa's regional economic communities, ministries of agriculture, agricultural universities, and continental and subregional agricultural research and extension institutions as well as various development partners that are engaged in African agriculture, among others) to:

- Encourage farmers to invest in reinvigorating soils and provide them with technical assistance on how to manage soils for profitable and sustainable on farm results (implementation of agricultural extension)
- Teach technical professionals how to work with farmers on soils (capacity enhancement for agricultural extension)
- Support expansion of faculties and research efforts dealing with soil issues and invest in soil-related aspects of university programs and agriculture research programs
- Develop partnerships to support the above
- Create collaborative relationships with external centers of excellence (such as faculty exchanges, student exchanges, joint degree programs, joint research programs)
- Support joint development partnerships for programs at every level in the areas listed above

Many of the building blocks needed to address soil degradation and establish soil resilience and adaptation are already in place.

- **Technical know-how** exists at many centers of excellence across the world to improve and maintain soil health on any plot of land in the world. Yet on millions of farms across the globe, it is not employed.
- **Research programs** exist to expand scientific understanding and technical know-how about soil management. However, the scale of support for such research falls short of what is merited, and the geographic dispersion of such research is inadequate. Areas with the most soil health challenges have the least soil research capacity and soil research activity.
- **Institutional structures** exist in most countries (agricultural extension programs) that could be used to connect farmers with valuable technical know-how on soil management. Yet most extension programs have neither focus nor effective, up-to-date, user-friendly materials on soil issues. They also do not have adequate staff with the expertise to educate farmers and help them implement valuable soil management principles and techniques.
- **Mechanisms** exist (e.g., ministries of agriculture, bilateral and multilateral donor projects, CGIAR, and

university partnerships) that could be used to build capacity and scale up programs to develop and deliver technical and practical know-how about soils to farmers. Yet virtually none are at present sufficiently focused on supporting soil-specific initiatives.

- **Global partnerships on soil issues** exist (e.g., the GSP at FAO and its regional soils partnerships, the International Soil Reference and Information Centre [ISRIC] at Wageningen University, the Alliance for a Green Revolution in Africa [AGRA]/Bill and Melinda Gates Foundation [BMGF] soil initiative), but they have not been effective at scaling up investment in generating soil-related information, soil-related knowledge, and field-level soil management to levels commensurate with the need.
- **Financing mechanisms** exist that could be used to focus short- and long-term investment on reversing the steady decline in soil health and safeguarding soil health into the future.[15] However, investments (whether from public-private partnerships or from programs of bilateral and multilateral development partners at national, regional, and global levels) have not included a significant focus on soil management so far.
- **Political awareness and leadership** on the need for soil initiatives are beginning to emerge (e.g., recent UN documents on climate change,[16] and exhortations by Bill Gates).[17]

While many building blocks for addressing Africa's soil health issues exist, they have not yet been marshaled to mobilize the needed resources (human capital, technical knowledge, finances, institutional infrastructure and activity) to reverse the continuing decline in soil health.

An initiative to reverse declining soil health in Africa requires innovation that would involve:

- Creating a vision of how existing building blocks to address soil health issues could be harnessed for this purpose
- Identifying informational, institutional, and resource gaps that hinder realization of the vision
- Articulating a plan to achieve the vision
- Developing a committed partnership among the institutions responsible for these building blocks to realize the vision
- Establishing the partnership through launch and implementation

Such an initiative would also need to be underpinned by a clearer understanding of the current soil situation in Africa and the tools and resources needed to improve it. This would imply the need for better knowledge about the following:

- The current state of soils in Africa
- The possibility of improving existing soil maps with more detailed and up-to-date information and making use of emerging digital technologies
- The economic implications and opportunities that arise from the current, depleted state of many soils that Africa relies on the most
- The types of interventions, policies, and investments needed to improve the soil situation
- The types of partnerships and institutional architecture required to plan and carry out the recommended policies, interventions, and investments
- The extent to which human capital is in place (at the farm level, in technical agencies, and at universities) to develop and implement initiatives to improve and manage soil health across Africa
- The possible roles for Africa's own leadership and institutions and the roles for its development partners (bilateral and multilateral financial support as well as technical support from such entities as FAO and the GSP) in developing and supporting an initiative on soils for Africa

In order to make progress on the above points, partners could pursue a number of practical workstreams to provide the foundation for an initiative on African soils. These workstreams could include the following:

Soil information systems

Workstream #1 – Taking advantage of legacy information

Pillar 4 of the GSP provides an excellent context for this workstream. The partnership has a potential good delivery mechanism in place for national- and continent-level soil information products. This initiative could provide incentives for partners to implement the plans. This workstream would:

- Continue to collect and digitize existing soil information at the national level
- Link existing national databases in a continental facility
- Further develop tools to manage the accumulating data and make it easily accessible

Possible near-term steps

- Explore integration of new digital and big data approaches

Workstream #2 – Taking new approaches to soil mapping

This workstream would:

- Further develop soil analysis methods based on proximal sensing and remote sensing
- Develop a structured sampling campaign at the national level (if strategic, this could also link to the reporting requirements for the Sustainable Development Goals (SDGs), for instance SDG 15.3.1, which requires that soil organic carbon be monitored)
- Pilot this in various countries
- Further validate
- Integrate and harmonize with existing soil information systems (e.g., those from GSP, Africa Soil Information Service [AfSIS], and ISRIC)

Possible near-term steps

- Expand awareness of the existing and emerging approaches
- Understand strengths and limitations (evaluation and discussion)
- Consider collaboration on and expansion of a follow-up phase of the ongoing AGRA/BMGF-supported program

Workstream #3 – Developing user-friendly materials to guide investment in improving and managing African soils

This workstream would:

- Build on GSP materials to develop user-friendly materials on the recommended characteristics of a national soil information system to facilitate planning and support by governments and development partners
- Build user-friendly materials to facilitate implementation of the guidelines

Possible near-term steps

- Expand awareness of existing and emerging approaches
- Understand strengths and limitations (evaluation and discussion)
- Consider collaboration on and expansion of a follow-up phase of the ongoing AGRA/BMGF-supported program

Understanding the economic dimension

Workstream #4 – What are the consequences of the current state of soils in Africa?

This workstream would:

- Further understanding of the physical and economic consequences of soil degradation and the potential benefits of reversing soil degradation at the farm, country, and African levels

Possible near-term steps

- Review the latest methodology for measuring the impact of soil degradation and for estimating the potential benefits of reversing soil degradation and suggest a work program to further develop this

Workstream #5 – How much would it cost to improve the current soil situation in Africa?

This workstream would:

- Develop understanding of the costs of improving soil conditions at the farm, country, and African levels

Possible near-term steps

- Review the latest methodology for estimating the likely costs of improving soil health and develop an approach and tools to use as the basis for costing the proposed initiative

Human and institutional capital with regard to soil and soil science

Workstream #6 – What is the current situation? Is human capital in soil science in place at every level where it is needed? Do gaps exist?

This workstream would:

- Develop an initial (rough) estimate of Africa's cadre of soil science professionals at every level (in education systems, research, extension, and the private sector)
- Develop a survey of the current state of tertiary education programs and institutions in soil science
- Develop a methodology for analyzing the type of human capital that is needed and the scale of the need at each level and then implement the methodology to estimate the demand for human capital in soil science in Africa

Possible near-term steps

- Review findings of the initial work that has been carried out recently by the Eurasian Center for Food Security (ECFS) and the World Bank[18]
- Incorporate special focus on soil science in the Regional Universities Forum (RUFORUM) book (forthcoming) on tertiary agricultural education in Africa[19]

Workstream #7 – Planning for the development of soil science professionals

What could be done to deepen the pool of human capital in soil sciences in Africa? This workstream would:

- Develop a continental strategy for education in soil science at the postgraduate and undergraduate levels
- Develop and launch plans to implement strategy
- Develop an approach and materials for continuous professional training on soil science issues for field-level technicians (extensionists)

Possible near-term steps

- Discuss an initial strategy
- Develop and launch an education exchange under the RUFORUM/ECFS memorandum of understanding
- Integrate focus on soil science into a new World Bank regional project on tertiary agricultural education

Workstream #8 – How can soil science be more effective at the farm level in Africa? What type of institutional architecture is needed for this purpose?

This workstream would:

- Develop institutional mechanisms for ensuring an adequate level of professional expertise at each level of extension (and possible reform of extension) that would include the development of proactive links between agricultural research and training institutions and agricultural extension institutions to ensure the relevance and evolution of on farm applications of soil science
- Develop e-tools (apps, technologies, links to soil information systems) to ensure access at every level (local and farm) to soil information and soil management tools
- Develop, expand, and coordinate global and African efforts to improve knowledge and understanding about soil health in African settings

Possible near-term steps

- Establish a partnership between RUFORUM (and representatives of its network of universities), Africa's subregional offices (and representatives of the North African regional offices), African Forum for Agricultural Advisory Services (AFAAS)/Global Forum for Rural Advisory Services (GFRAS), CGIAR, and the Global and African Soil Partnerships to formulate the institutional architecture model within which to implement an initiative to improve and maintain soil health
- Integrate a soil theme into a BMGF/United States Agency for International Development (USAID)/World Bank/GFRAS/AFAAS initiative to develop new e-extension models
- Expand (in terms of scale and scope) the European Union's Coordination of International Research Cooperation on Soil Carbon Sequestration on Agriculture (CIRCASA) program[20]

Workstream #9 – Convene selected partners to make the case for a soil initiative for Africa

This workstream would:

- Develop materials to make the case for the type of soil initiative outlined above

- Convene a workshop among development partners (possibly in Seattle, Washington, DC, or Rome) to support the launch of the initiative
- Develop a summary of the landscape of existing soil-related investments[21]
- Develop a mechanism and plans to better coordinate existing investments and to develop new coordinated investment programs

Together, these workstreams would help fill in extant gaps and set the stage for developing and launching a soil initiative for Africa. Proactive leadership will also be needed to set the ball in motion.

Conclusion

Decline in soil health and fertility is widespread across many parts of Africa. This steady decline in soil health poses serious challenges to food security, agricultural livelihoods, water management, climate change and environmental sustainability, and peace and political stability across the continent. This problem could be reversed. Many of the building blocks already exist. A much expanded, more coordinated effort—an African soil initiative—will be needed. This will require resources, leadership, and preparation. The suggestions offered in this briefing note can serve as a blueprint for how to move forward.

Annex

Soil health: A partial survey of ongoing projects

Land degradation

Restoring Degraded Landscapes (RDL) research

This component of CGIAR'S Water, Land and Ecosystems research guides soil restoration initiatives such as:

- **Tana-Nairobi Water Fund:** This financial mechanism funds land-conservation measures on the Tana River in Kenya. Downstream water users affected by soil erosion pay for conservation agriculture initiatives upstream.
- **The 4 per 1000 Initiative:** This initiative is a five-year program to achieve a 0.4 percent annual rate of carbon sequestration in soil to mitigate climate change.
- **Soil Organic Carbon App:** This app calculates the concentration of sequestered carbon in a soil profile and the impact of soil conservation practices over time.
- **Multistripe Laser Triangulation (MLT) scanner:** This tool scans large pores in soil to predict how water moves through soil. It can help stakeholders better understand water runoff, soil erosion, and the transport of nutrients through soil.
- **Soil carbon measurement device:** This portable device measures soil carbon levels in the field, a task originally possible only in a laboratory.
- **Soil-Plant Spectral Diagnostics Laboratory:** This lab develops light-based methods to quickly analyze soil and plants at a low cost. It is also the analytical center for AfSIS and supports other spectral labs globally, including the One Acre Fund soil analytics lab.

World Agroforestry (ICRAF)

CGIAR's center has implemented the Drylands Development Programme (DryDev), which provides farm-level water and soil management support, watershed restoration, agricultural commodity production, and value chain development.

The International Center for Agricultural Research in the Dry Areas (ICARDA)

CGIAR's ICARDA develops indicators to assess changes in soil quality and conducts research on technologies that can help restore degraded agropastoral land. ICARDA promotes no-tillage conservation agriculture in the drylands of Central and West Asia, the Middle East, and Africa. Conservation agriculture improves soil health and efficient water use and reduces the need for fertilizers and pesticides.

AGRA Soil Health Program (SHP)

SHP partners with organizations in 13 African countries to:

- Support soil management research, maintain integrated soil fertility management demonstration plots, facilitate access to funds and credit, and promote community networks and extension workers
- Support local fertilizer producers, establish fertilizer-quality control systems, and raise awareness of the benefits of fertilizers
- Help universities revise their soil science courses, upgrade their facilities, train lab technicians, sponsor students, and connect female students with mentors

International Biochar Initiative (IBI)

This nonprofit advocates for the use of biochar in agriculture. Biochar, produced by burning agricultural waste, can be used as a soil amendment. It sequesters carbon and increases soil health by improving nutrient and water retention. IBI sponsors the African Soil Initiative, a nonprofit that is working to:

- Build a consortium of nonprofits partnering with farmers on climate-smart agriculture and soil remediation in Sub-Saharan Africa
- Provide technical assistance to nongovernmental organizations for biochar-related agricultural projects
- Develop an information-sharing platform for biochar research

Middle East and North Africa Regional Programme for Integrated Sustainable Development (MENARID)

MENARID's network of partners removes barriers to integrated natural resources management, develops and coordinates research, and applies sustainable land and water management practices. MENARID projects focus on reversing land degradation, managing water demands, conserving biodiversity, and mitigating climate change through carbon sequestration.

Afrisoils

Part of the FAO's GSP, Afrisoils is a mobilization tool designed to help 47 African nations increase soil productivity by 30 percent and reduce soil degradation by 25 percent over 10 years. The project compiles information on major soil threats, knowledge gaps, and potential solutions. The program is largely country driven, but program actions may work to:

- Establish a Global South cooperation network for soils and regional databases of soil properties, best practices, and successful projects
- Provide trainings and courses on soil topics, enhance soil lab facilities, and provide international postgraduate exchange programs and scholarships
- Establish a Soil Doctors Program in Africa, an existing global program that educates smallholder farmers on the principles of soil science and provides educational tools for preliminary soil testing and analysis
- Implement sustainable soil management projects through FAO networks
- Create an inventory of policies addressing soil and review the Abuja Declaration[22]

Coordination initiatives

Soil Health Institute (SHI)

SHI coordinates soil health research and technology and works with partners to apply it to the field. SHI resources include a repository of soil health studies and a tool to help agricultural producers improve drought resilience.

Africa Soil Health Consortium (ASHC)

Managed by the Centre for Agriculture and Bioscience International (CABI), ASHC partners with organizations across Africa to launch educational multimedia campaigns promoting integrated soil fertility management. ASHC is currently reviewing the campaign methods of two other projects, updating an integrated soil fertility management materials library, and training scientists to share information with nontechnical audiences.

Crop adaptation

Yam Systems for Improved Food Security in West Africa (YAMSYS)

This project develops innovations in the soil fertility management of yam-based cropping systems to increase crop productivity, food security, and income for smallholder farmers. Yams are a major staple food in West Africa, but mean yield is low due to heavily degraded soil. YAMSYS works to strengthen the yam value chain by improving the health of yam farmers' soil.

Improved Maize for African Soils (IMAS)

This project develops maize varieties that capture more nutrients from fertilizer, helping farmers overcome low maize yields caused by degraded soil and fertilizer inaccessibility. These improved maize varieties saw 20 percent higher yields than conventional varieties and were sold at the same price to smallholder farmers in Sub-Saharan Africa.

N2AFRICA

This organization works to optimize legume nitrogen fixation to benefit smallholder farmers. Legumes, by drawing nitrogen into the soil, increase soil health and crop productivity. Additionally, they provide farmers with nutritious food to sell and eat. N2AFRICA researches efficient legume genotypes and best practices for planting. It partners with organizations to disseminate legume technology.

Data and technology

Africa Soil Information Service (AfSIS)

AfSIS created an extensive African soil database with new soil samples and data collected from older field surveys. AfSIS also creates landscape information systems and develops tools to support agronomic decision-making. AfSIS helps collect data and establish

national information systems in Ethiopia, Ghana, Nigeria, and Tanzania.

ISRIC-World Soil Information

ISRIC used AfSIS data to create SoilGrids, a predictive map of soil properties across Africa. ISRIC produces, compiles, and shares global soil data and has launched projects related to:

- **Fertilizer recommendations:** ISRIC is building a Soil Intelligence System in India and a soil fertility and crop nutrient management platform for Sub-Saharan Africa to personalize fertilizer recommendations for regional soil needs. It is also implementing smart fertilizer practices in Uganda to boost rice yields.
- **Database growth:** ISRIC's soil data projects include a harmonized database for the Danube basin region and a standardized, shared soil data set for the entire world.
- **Land use:** ISRIC is trialing a soil-quality assessment tool in Europe and China and is using land degradation data in Madagascar to develop a platform that simulates the effects of different land use choices.

AGRA and Atlas AI

Atlas AI, a technology start-up that uses artificial intelligence to visualize developmental trends, recently partnered with AGRA to improve access to data on agricultural productivity. Atlas AI's technology allows for satellite monitoring of crop yields and can provide information on soil quality at very high resolutions.

Useful reference material

For more detailed background and discussion, here is a short list of useful reference materials:

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Vitousek, P. M., R. Naylor, T. Crews, M. B. David, L. E. Drinkwater, E. Holland, P. J. Johnes, J. Katzenberger, L. A. Martinelli, P. A. Matson et al. "Nutrient Imbalances in Agricultural Development." *Science* 324, no. 5934 (2009): 1519–20.

Vanlauwe, B., A. H. AbdelGadir, J. Adewopo, S. Adjei-Nsiah, T. Ampadu-Boakye, R. Asare, F. Baijukya et al. "Looking Back and Moving Forward: 50 Years of Soil and Soil Fertility Management Research in Sub-Saharan Africa." *International Journal of Agricultural Sustainability* 15, no. 6 (2017): 613–31.

Endnotes

1. This problem is not unique to Africa. Globally, it is estimated that erosion and other types of degradation of soil quality have caused the abandonment of roughly one-third of the world's arable land (see United Nations Convention to Combat Desertification, *Global Land Outlook*, 1st ed. [Bonn, Germany: UNCCD, 2017]). Further, an estimated one-fifth of the world's population lives on degraded agricultural land—that figure is nearly one-half for Africa's rural population.
2. This briefing note echoes (with more detail and with a focus on Africa) many of the messages of the Vienna Soil Declaration "Soil Matters for Humans and Ecosystems" (2015), which was issued by the International Union of Soil Sciences, the International Atomic Energy Agency, and the Food and Agriculture Organization of the United Nations at the December 2015 Celebration of the International Year of Soils.
3. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, *Status of the World's Soil Resources (SWSR) – Technical Summary* (Rome: FAO and ITPS, 2015).
4. Ephraim Nkonya, Alisher Mirzabaev, and Joachim von Braun, eds., *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development* (New York: Springer Open, 2016).
5. A. Rozanov and L. Wiese, *On Soil Scientists and Where to Find Them in Africa: Assessment of Human Capital* (Moscow: Eurasian Centre for Food Security, Lomonosov Moscow State University, 2018), http://doi.org/10.13140/RG.2.2.19448.90885.
6. African Union, "Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods" (Malabo: African Union Summit, 2014).
7. United Nations Convention to Combat Desertification, *Global Land Outlook*. See especially chapter 9.
8. Nkonya, Mirzabaev, and von Braun, *Economics of Land Degradation and Improvement*. This estimate suggests that the cost of diminished soil fertility in Africa is on the order of US$10 billion annually—a figure roughly 10 times larger than typical World Bank annual investments in African agriculture.
9. Nkonya, Mirzabaev, and von Braun, *Economics of Land Degradation and Improvement*.
10. Nkonya, Mirzabaev, and von Braun, *Economics of Land Degradation and Improvement*.
11. FAO and ITPS, *Status of the World's Soil Resources (SWSR)*.
12. Rozanov and Wiese, *On Soil Scientists and Where to Find Them in Africa*.
13. Dr. Andrei Rozanov, Stellenbosch University, South Africa, has compiled maps of universities in Africa, which carry out soil research and offer degrees in soil science, and of other research institutions that conduct soil research. These maps are available in the files below (which can be viewed in Google Earth Pro desktop): UniversitiesAfrica1.kmz ResearchAfrica.kmz
14. This situation has been noted and discussed in detail in countless analyses and projects related to fertilizer use in Africa.
15. For an emerging attempt to create such a mechanism, see the UN Convention to Combat Desertification's proposed Land Degradation Neutrality (LDN) Fund, which will support private land rehabilitation and sustainable land management projects.
16. See especially those related to the UN Convention to Combat Desertification, in particular the 2018–2030 Strategic Framework, which establishes goals to guide international efforts to combat desertification and restore degraded lands, and the Land Degradation (LDN) Target Setting Programme, which guides countries in setting LDN targets.
17. Bill Gates, "We Should Discuss Soil as Much as We Talk About Coal," *GatesNotes* (blog), March 26, 2019, https://www.gates-notes.com/Energy/We-should-discuss-soil-as-much-as-coal.
18. Rozanov and Wiese, *On Soil Scientists and Where to Find Them in Africa*.
19. Regional Universities Forum for Capacity Building in Agriculture, *Secretariat Quarterly Report* (Wandegeya, Uganda: RUFORUM, July–September 2019).
20. The European Union's project entitled Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture (CIRCASA) aims to develop international synergies concerning research and knowledge exchange in the field of carbon sequestration in agricultural soils at EU and global levels.
21. A survey of some ongoing soil quality-related projects and investments is provided in the annex of this briefing note.
22. New Partnership for Africa's Development, *The Abuja Declaration on Fertilizer for the African Green Revolution* (Abuja, Nigeria: New Partnership for Africa's Development, 2006).

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