



# Arresting Hunger in Sub-Saharan Africa Through a Dynamic Soil Health Information System

This document briefly explains why the new African Soil Information Service (AfSIS) is needed, how it will be assembled, and the benefits it will offer millions of smallholder farmers across the African continent.

## Africa's Soil Health Crisis

About 500 million hectares of sub-Saharan Africa's agricultural land are moderately or severely degraded. And the problem is rapidly getting worse because of increasing pressure on the land – a result of growing populations and food demand, combined with extremely low use of inorganic fertilizers and of organic sources of plant nutrients. On average, African farmers are able to apply only 10 percent of the nutrients that farmers in the rest of the world return to the soil. That helps explain why soils in southwestern Kenya, for example, lose an estimated 100 kilograms of nitrogen per hectare each year.

Soil degradation represents a major obstacle to arresting hunger in sub-Saharan Africa, because it impedes much-needed increases in agricultural productivity. The gradual spread of improved crop varieties across Africa has opened up new possibilities for accelerating agricultural productivity growth. But as long as soil fertility remains low, small farmers will derive only partial benefits from the new varieties, and they will have weak incentives to improve their



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management of another critical resource – water. Declining soil fertility means particularly severe limitations for women, given the prevalence of gender inequality in access to fertile land and to cash for buying improved seed and fertilizer.



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For those reasons, the Alliance for a Green Revolution in Africa (AGRA) is building a major program aimed at improving soil health, in conjunction with its efforts to accelerate the spread of new crop varieties. The program is based on integrating inorganic fertilizers with organic ones such as manure, grain legumes and agroforestry. The AfSIS initiative provides an excellent opportunity for CIAT to partner with AGRA in this effort by utilizing its extensive research and expertise in African soils..

## An Information Solution

In recent years, soil scientists in Africa have developed and validated a new approach for improving soil health, which is referred to as integrated soil fertility management (ISFM). It involves the practical combination of inorganic fertilizers with organic inputs to raise agricultural production while enhancing natural resources. ISFM considers not just the technical aspects of soil management, but also its economic, social and policy dimensions.

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One barrier to the adoption of ISFM on a larger scale is a lack of reliable, up-to-date information about soil health and appropriate options for enhancing it at specific locations. To overcome this obstacle, the Tropical Soil Biology and Fertility (TSBF) Institute of the International Center for Tropical Agriculture (CIAT) is embarking on a four-year initial effort to develop the African Soil Information System (AfSIS), with support from the Bill & Melinda Gates Foundation and AGRA.

AfSIS will feature a soil-health surveillance system – based on concepts akin to those used in protecting human health – which will make it possible to map areas at risk of soil degradation and provide detailed information on appropriate interventions for reversing the problem. An aggressive program of dissemination and capacity strengthening will ensure that AfSIS is readily available to diverse users, ranging from African farmer associations and extension services to research institutes and policy makers.



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Partners in the effort include the Earth Institute (based at Columbia University in New York), the World Soil Information (ISRIC) at Wageningen University in The Netherlands, and the Nairobi-based World Agroforestry Center. Playing a key role in the initiative's success will be AfricanSoils.net collaboration with national agricultural research programs across Africa, including the establishment of regional soil health laboratories in Tanzania, Kenya, Mali, Nigeria, and Malawi.

## The Global Framework

AfSIS will be developed within the framework of a Global Digital Soil Map Consortium, which will be formed and led by ISRIC. AfSIS will thus catalyze and form part of a wider initiative to digitally map some 80 percent of the world's soil resources. The Bill & Melinda Gates Foundation is providing partial funding to help with the initial launch of this effort.

One of the first key tasks will be to establish a set of common standards for storing, documenting and distributing soil data. Among other tasks, experts will need to develop norms for consistently evaluating key soil properties, such as its capacity to provide nutrients and hold water. At present, no such standards and norms exist. Yet, they are essential for ensuring the harmonization of soil data management within Africa and across the various regional nodes that will make up the Global Consortium.

On the basis of common standards, the Consortium will begin to compile so-called "legacy" data: that is, soil data that are already available (including printed soil maps) but are scattered among many institutions in fragmentary form. Buy-in from national partners is critical for making this possible.

## Building Cyber-Infrastructure

Another major step will be to develop the data management systems required to make AfSIS (and eventually the global service) available via the Internet. In this task, the TSBF Institute will build on databases already developed by the Kenya-based World Agroforestry Centre.

The new system will be distinguished from current resources by its more open "cyber-infrastructure." This is a combination of computer hardware and software, which will be designed according to the latest advances in information science, Internet technology and scientific database development. The idea of the new cyber-infrastructure is to foster a two-way flow of information, so that users, such as AGRA and its partners, can both receive and provide valuable soil information. Toward this end, templates for data collection and Web-based systems for uploading it have already been developed and tested in Africa under some of the toughest conditions imaginable.

## Maps That Make a Difference

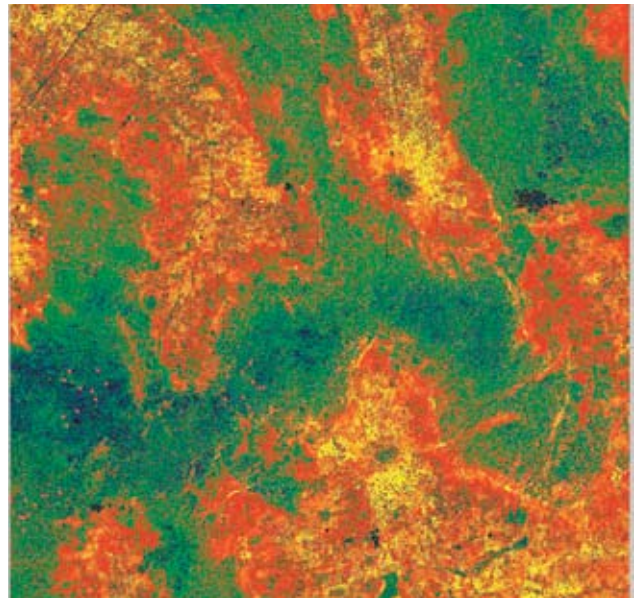
As the new cyber-infrastructure is put in place, the project will begin to construct the central component of AfSIS – a soil-health surveillance system. Soils are considered healthy when they are judged capable of delivering key ecosystem services, including a capacity to produce crops, store carbon from the atmosphere and regulate water flows. To monitor soil health requires continuous and systematic collection, analysis and interpretation of data. These consist of the legacy data mentioned earlier as well as satellite imagery, feedback from users, the results of agronomic experiments and ground observations made by trained staff of national institutions at 60 so-called “sentinel” sites (areas of 100 square kilometers) proposed for 21 African countries (see figure).



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One especially useful source of data will be that gathered through infrared spectroscopy, using procedures developed by the World Agroforestry Center. Based on the interaction of electromagnetic energy with matter, this technology has proved to be a quite reliable and cost-effective means of rapidly determining soil health. A key advantage of this tool is that it detects the presence of whole syndromes, such as the occurrence of micronutrient deficiencies in sandy soils low in organic matter. To be effective, measures aimed at improving soil health must target syndromes instead of individual nutrient deficiencies.

With such data, the project can then engage actively in digital soil mapping. This is the creation of spatially referenced information (that is, information



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linked to a specific pixel on a satellite image) about soil properties, based on statistical sampling of soils across particular landscapes. The resulting high-resolution maps will cover some 18 million square kilometers in Africa, representing geographically both soil capacities and constraints (like aluminum toxicity, a common debilitating feature of acid soils, which are widespread in the tropics). Much of the power of these maps lies in their ability, based on computer models, to predict soil degradation at locations where direct observations of soil properties have not been made. The maps will thus be highly useful for planning, implementing and evaluating efforts to enhance soil management and for targeting such efforts to particular places.

## Evidence-Based Soil Management

To be truly useful, though, the digital soil maps must be accompanied by another key component of AfSIS – a spatial database containing the results of soil management experiments carried out across Africa. On the basis of such data, computer models can be used to predict the performance of ISFM recommendations (entailing such issues as fertilizer application rates and management of soil organic matter) under diverse conditions.

Such tools are critical for what scientists refer to as evidence-based soil management. This means providing recommendations that are not generic but

rather address problems at specific locations, based on experimental results. The recommendations can then be continually refined, based on feedback from AfSIS users. Without such an approach, efforts to improve soil health will continue to depend too much on trial and error.

In building this database, the project will use household profiling at selected sentinel sites to reflect the socio-economic conditions that affect adoption of ISFM recommendations. For example, if the profiling reveals that female-headed households predominate at particular sites, then this important information (which is related to labor availability, access to credit and other factors) will be taken into account in recommending interventions to enhance soil health.



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The digital soil maps will be linked with soil management information by means of what specialists call a decision framework. This is a tool for formulating soil management recommendations, based on ratings of the environmental and socio-economic factors that determine whether interventions are likely to succeed or fail at particular locations. The decision framework makes it possible for users to match soil health problems with possible solutions and predict the possible outcomes. The outcome of the tool will feed into extension guidelines for improving the awareness and use of fertilizers by farmers, especially smallholders. National research and extension programs will be supported to develop very site- and crop-specific fertilizer recommendations using the outcome of AfSIS.

### **A Renaissance within Reach**

The traditional approach to soil mapping involves static soil classes, based on a system of soil

taxonomy, which is difficult for nonspecialists to understand. AfSIS may sound rather complicated too. The important difference is that it will actively reach out in different ways to diverse groups of users and beneficiaries.

The decision framework, for example, will formulate recommendations at the regional, national and local levels and target the information in appropriate forms to users working at each level. Moreover, the project will give special attention to the development of user-friendly Web interfaces and to the use of diverse means for sharing soil information, including Web sites, simple manuals, digital atlases and policy briefs. AfSIS will also include a set of monitoring and evaluation procedures to track progress. In addition, the project will undertake a large program of local capacity building, aimed at researchers and extension specialists working at the 60 sentinel sites.

Through AfSIS, the TSFB Institute and its partners hope to make commonplace and routine an instructive experience it had while formulating the project proposal. Malawi's Ministry of Agriculture requested guidance in improving the efficiency of fertilizer use under its bold and innovative input subsidy program, which has helped boost the country's production of staple food crops in recent years. In response, TSFB conducted a workshop in Malawi last April to help formulate a new set of policies and recommendations, which are very likely to be adopted.



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Once AfSIS is available, it will facilitate many such consultations, involving not only researchers and policy makers, but large numbers of farmer associations, extension officers and private businesses. AfSIS will thus bring within their reach the long-awaited renaissance of food production on Africa's small farms.

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