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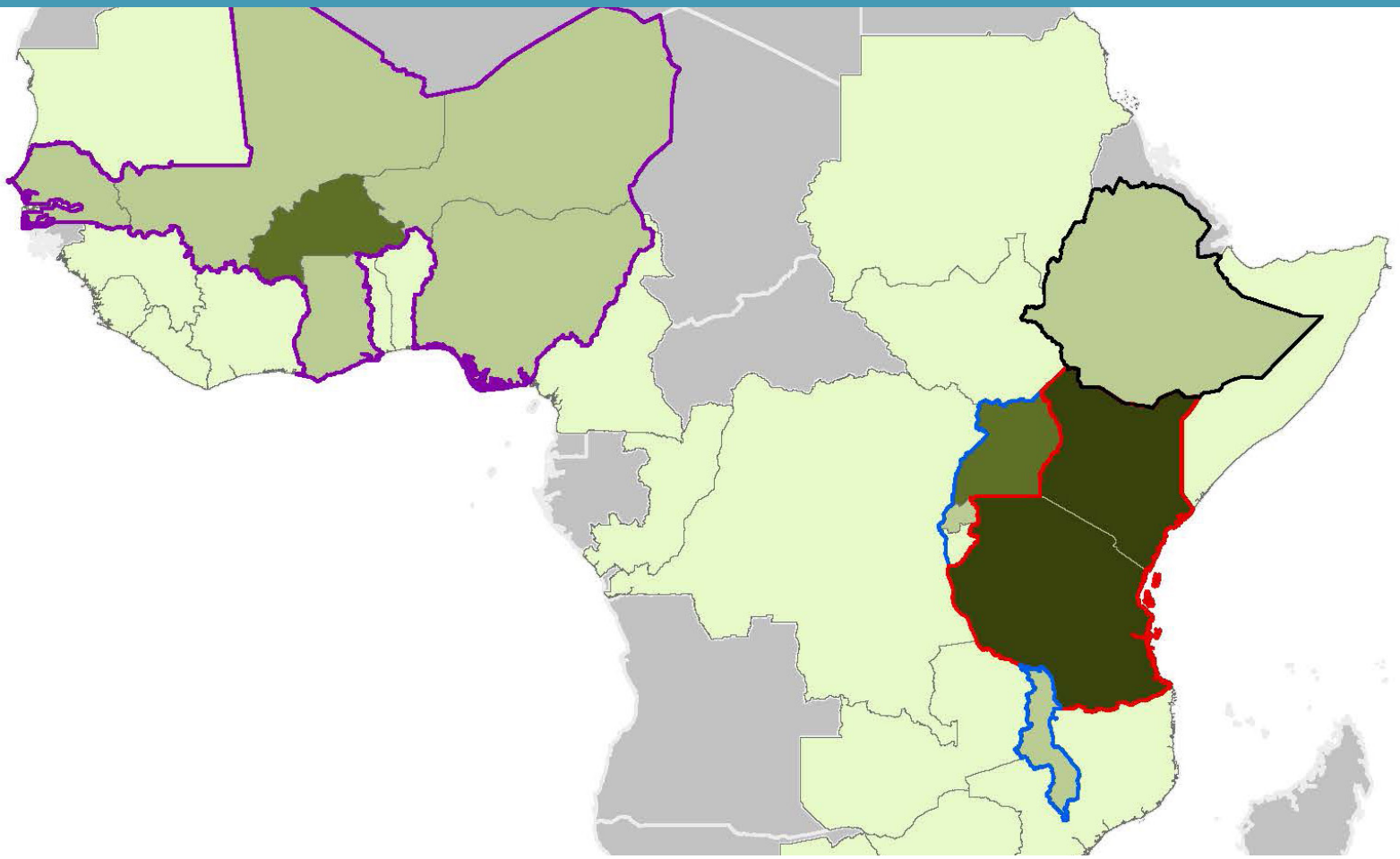

SUB-SAHARAN AFRICA SOIL FERTILITY PRIORITIZATION REPORT

I. SURVEY RESULTS

USAID
FROM THE AMERICAN PEOPLE

Collaborative Research on Sustainable Intensification
Feed the Future Innovation Lab

KANSAS STATE UNIVERSITY

REPORT

of the

Sub-Saharan Africa Soil Fertility Prioritization: I. Survey Results©

Prepared by

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL)

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Executive Summary

This *Sub-Saharan Africa Soil Fertility Prioritization Survey* was designed to better understand the perspectives of key leaders and actors from across international agricultural research centers, national agricultural research and extension stations, national universities, extension agencies, developmental agencies, agronomic/soils researchers, social scientists, regulatory agencies, private sector, and farmer organizations. Recognizing the need for a comprehensive view of the soil fertility landscape, the study aims to incorporate elements across the entire soil fertility supply chain, being inclusive of multidisciplinary approaches (production, economics, social, regulatory/policy, environmental) to understand barriers to enhancing soil fertility and the establishment of evidence-based priorities to overcome these barriers.

The *Sub-Saharan Soil Fertility Prioritization Survey* is first phase of a multi-stage effort led by the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) at Kansas State University to gather feedback on soil fertility issues in the Sahel region, including a focus on countries in West Africa, East Africa, the Great Lakes region and Ethiopia. The SIIL research team generated the initial contact list for the survey participants from a variety of professional organizations' membership lists, relevant publications, and contacts of SIIL, regional coordinators, investigators and International Fertilizer Development Center (IFDC). In an effort to broaden the scope of participants, these initial contacts were asked to provide names of other stakeholders working on soil fertility issues that might be willing to participate in the study. As a result of this process, the SIIL research team distributed the *Sub-Saharan Soil Fertility Prioritization Survey* to 1,157 stakeholders in June 2017. A total of 491 individuals (42.4% response rate) provided responses to the survey, which are summarized in this report.

Respondents identified the particular region of the expertise. Of the 491 responses, 184 reported East Africa, 170 selected West Africa, 99 indicated the Great Lakes region, and 38 reported Ethiopia as the areas where they have the most knowledge of soil fertility issues. More than 200 respondents reported their role is in research, primarily in soil and crop science. Approximately 80% of the respondents are male and more than one-third report having 20 or more years of experience in working with soil fertility issues in the region.

In general, the most frequently reported limiting factors regarding soil characteristics that contribute to poor crop yields across all four regions are nitrogen deficiencies, phosphorous deficiencies, acidity, and low soil organic carbon (C) content. For Ethiopia and the Great Lakes region, micronutrient deficiencies were also reported as part of the top five limiting factors, while low available water holding capacity was noted for West and East Africa.

Respondents were also asked to rank biophysical and socioeconomic limitations to enhancing soil fertility. Relating to the biophysical limitations, all regions reported a need for access to quality soil testing and increased availability of inorganic fertilizers. Both Ethiopia and the Great Lakes region indicated that retention of crop residues on the soil was a barrier, while limited opportunities to maintain and build soil organic matter were reported for West and East Africa.

Regarding socioeconomic/sociocultural limitations, all regions emphasized that access to financial resources was a barrier, particularly for small holders and subsistence farmers. The availability of public sector service providers to deliver appropriate nutrient management recommendations was also commonly noted as a barrier. The need for access to mechanization was reported for Ethiopia and West Africa, while

barriers related to gender equity and the need to develop private sector resources were reported for the Great Lakes region and East Africa. Refer to Appendices B through E for detailed results by region.

Results from the survey clearly indicate that there are a number of issues that impact all regions, including:

- Need for expanded research, leading to improved/updated soil fertility recommendations for site- and region-specific conditions
- Need for local soil testing facilities, particularly in rural areas, that can provide affordable, accurate services
- Training for farmers, with a focus on peer-training and on-farm demonstrations
- Need to build the capacity of extension service providers

The combined biophysical and socioeconomic results provide a clear picture of the interdisciplinary and interconnected nature of priorities to improving soil fertility across each region. Thus, plans for improving soil fertility across SSA must take an integrated approach, inclusive of the identified biophysical and socioeconomic factors. Action plans that only focus on a singular or narrow factor such as inorganic fertility availability or fertilizer recommendations alone will likely fall short of improving soil fertility. Each of these prioritized factors must be improved in such a way that no one priority is limiting. For example, though it may be quite evident that the use of inorganic fertility can improve crop yields, without the inclusion of appropriate recommendations, suitable extensions services, access to financial resources, the incorporation of organic amendments, and enabling policies, only increasing access or use to inorganic fertilizer alone will likely not be successful in improving soil fertility.

The survey results are complementary to the summit results and indicate that there are key biophysical and socioeconomic barriers and strategies that can either create an enabling environment or hinder progress towards improving soil fertility across SSA. Inorganic fertilizer access, use, availability of organic materials and related issues were prominent but many related biophysical (building soil organic C) and socioeconomic barriers (access to resources both financial and agronomic, and access to appropriate fertility recommendations and extension support) and solutions were identified as equally important to building soil fertility. Please refer to the *SSA Soil Fertility Prioritization Final Report* for overall recommendations using a combined analysis of the *SSA Soil Fertility Prioritization Survey and Summit* results.

Introduction

The health of our soils is the bases of the productivity of our farming systems, the food and nutrition security of our societies, and the improvement of livelihoods and poverty alleviation in our world. Soils of sub-Saharan Africa (SSA) are largely unhealthy due to years of nutrient mining and limited organic or inorganic resupply. As such, crop yields have stagnated and high levels of food insecurity and poverty persist. The World Bank (2013) estimates that over 80 percent of Africa's agricultural lands are degraded, having either biophysical or chemical constraints that limit food production. These degraded soils are estimated to affect 485 million Africans and cost the continent nearly US$9.3 billion annually (Thiombiano and Tourino-Soto, 2007). Without addressing soil health issues, smallholder farmers cannot benefit from yield gains offered by improved plant genetics and other associated agronomic practices. Limited by soil degradation, yield increases from improved crop varieties are estimated at only 28 percent in Africa as compared to 88 percent in Asia (IFDC, 2013).

Following the Green Revolution, SSA remains one of the only regions of the world where per capita food production has remained stagnant (Sanchez, 2002). However, there has been a renewed focus on soil fertility following the call of H. E. Kofi Annan for a "uniquely African Green Revolution." Soil fertility has been consistently identified as a primary limiting factor in SSA preventing the dramatic yield increases seen by the rest of the world. However, obstacles in overcoming barriers to achieving healthy and fertile soils have persisted. Over thirteen years after H. E. Kofi Annan's call, and numerous activities and investments in SSA soil fertility, cereal yields still hover around 1.5 MT ha^{-1} as compared with 3 MT ha^{-1} in Latin America, and South Asia, 5 MT ha^{-1} in China, and greater than 10 MT ha^{-1} in North America, Europe, and Japan (AGRA, 2016). There is now a renewed need to refocus and prioritize sustainable soil fertility efforts in an inclusive and evidence-driven way that looks holistically at the barriers to improving soil health and productivity in SSA.

Soil and plant analysis, paired with agroecologically specific fertilizer response functions, is often the first step to producing evidence-based fertilizer recommendations for efficient crop response. Though this model has been attempted across SSA to varying effect, its self-sustaining business model and adoption by smallholder farmers has been limited. Further, past soil fertility improvement efforts have often focused on inorganic fertilizer use as the primary mechanism for improving soil fertility and improving crop yields; however, in SSA conditions where soils are already degraded (i.e. limited organic matter (OM) and organic nutrient pools), a focus on inorganic fertilizer use alone has had limited success in improving SSA soil fertility. Long-term solutions, such as approaches building OM and organic nutrient pools, and supporting inputs and management practices will likely be an essential component to achieving sustainable soil fertility in SSA. These past lessons have led to the need for a more inclusive evaluation of the soil fertility landscape aiming to evaluate the entire soil fertility supply chain; one that is inclusive of multidisciplinary approaches (production, social, regulatory/policy, environmental) to understand soil fertility barriers and the establishment of evidence-based priorities to overcome these barriers. This effort to identify key soil fertility priorities considered:

- Access to quality and standardized mineral fertilizers in the marketplace
- Suitability of available fertilizer blends (including micronutrients)
- Are technologies in place to maintain and build soil OM levels which would lead to improved crop response to fertilizer
- Access to agroecologically appropriate fertilizer response curves and subsequent fertilizer recommendations.
    - Are extension service providers in place to deliver these appropriate, high-quality fertilizer recommendations to farmers?
- Access to quality soil and plant diagnostic laboratories

- Availability of high resolution soil maps
- Are strategies for integrated soil fertility management available and accessible to farmers
- Access to mechanization where appropriate (gender impacts)
- Effect of fertilizer regulations and subsidy programs
- Value and demand of the commodities produced
- Identification and development of market linkages
- Access to financial resources (gender equitable)
- Access to land tenure (gender equitable)
- Effect of intrinsic soil properties (e.g. parent material)
- Effect of environmental or climate constraints

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) led an inclusive process to identify critical soil fertility priorities in SSA focused around identifying key barriers (e.g. increasing soil organic matter, nutrient limitations – both macro and micro) and key sustainable priorities to overcome the identified barriers. This objective was realized through an inclusive and evidence-driven evaluation involving key leaders and actors from across international agricultural research centers (IARCS), national agricultural research and extension system (NARES), national universities, extension agencies, developmental agencies, agronomic/soils researchers, private sector, social scientists, regulatory agencies, and farmer organizations to systematically identify evidence-driven soil fertility barriers and priorities to overcome these barriers. Distinct priorities were established for each region, though a unified priority across regions may develop. The focus of the evaluation will be to identify opportunities for high impact across large geographical regions.

To accomplish this objective, SIIL has prioritize findings in four key SSA regions through this initial survey and culminated with a prioritization summit.

Focus Regions:
- West Africa region: Senegal, Burkina Faso, Ghana, Niger, Mali
- East Africa region: Tanzania, Kenya
- Great Lakes Area: Rwanda, Uganda, Burundi, Malawi
- Ethiopia (kept separate due to unique agroecology)

This survey in addition to the summit specifically addressed the following:
- Understand overall constraints associated with soil fertility to minimize yield gaps
- Understand the geographic distribution and area impacted by those constraints
- Prioritize, by region, efforts to overcome constraints in order to maximize the area positively impacted by research, extension, and potential adoption of improved soil management practices
- Establish research needs for soil and crop management, and nutrient recommendations for smallholder farmers
- Explore and prioritize barriers to the use of soil and nutrient management (including analytical and diagnostic tools; and simulation models) information in making crop production management decisions by smallholder farmers
- Explore opportunities and innovations (e.g. production, market, financial, social, policy) for overcoming these barriers

Following the survey, SIIL held a prioritization summit with key stakeholders to understand the driving soil fertility issues, fertilizer use issues, and other factors and priorities for addressing these issues. This process was envisioned to identify critical priorities for soil fertility research and development for the scientific community in general.

The report includes a methodology, results, observations, limitations and recommendation section. Region specific results, (Ethiopia, the Great Lakes Area, West Africa, and East Africa), are available upon request.

Methodology

In May of 2017, the SIIL team compiled an initial list of survey participants drawing from SIIL's institutional Listserv, the investigator's relevant contacts in the region and host countries, IFDC's relevant contacts, American Society of Agronomy public Listservs including the Sustainable Intensification Community and communities within the Global Agronomy Section (i.e. Agronomic Solutions for Smallholders, Agronomy in Africa, Gaining Access to Agronomic Inputs), authors of key publications (AGRA, 2016; Wortmann, 2017) and SIIL regional coordinator's relevant contacts. Additionally, relevant contacts were requested from leading regional scholars working in SSA soil fertility. At the same time, the team also drafted survey items to systematically identify evidence-driven soil fertility barriers, suggestions to overcome these barriers, and prioritize current and future innovations for research, development and scaling. To review and refine these items, the SIIL team sent the draft survey to leading biophysical and social scientists for additional input. Based on feedback collected through the pilot stage, items were finalized at the end of May. The survey sections included questions to rank a list of limiting factors regarding soil characteristics contributing to poor crop yields, rank lists of biophysical and socioeconomic limitations to enhancing soil fertility, provide recommendations to improve soil fertility five to ten years from now and report demographics (see Appendix A for a copy of the survey items).

Initial invitations to participate in the Soil Fertility Prioritization survey were sent during the first week of June under the signature of Dr. Vara Prasad. In an effort to expand the study, he also asked for recipients to identify other experts in the field who might be willing to participate in the survey. As a result of this request, an additional 81 names were added to the survey distribution list, for a total of 1,115 contacts.

The SIIL team launched the on-line survey in Qualtrics™ on June 9, 2017 with a closing date of July 5, 2017. The team also scheduled reminder messages to be sent out twice a week to all survey recipients who had not yet responded. The reminder messages were delivered on June 13, 16, 20, 23, 27, 30 and July 3. Throughout the survey administration process, respondents continued to provide contact information for others to be included in the survey. By the closing date, the SIIL team had distributed the survey to 1,157 contacts.

On July 10, the SIIL team downloaded the survey data from the on-line system, aggregated all responses and began preliminary analysis. The team used basic descriptive statistics to summarize the quantitative data in the survey. For the open-ended questions, the team conducted a content analysis to identify any common themes or trends in the responses within each region. The following section presents the survey results. Additional supporting documentation, including the survey messages and questions and data tables can be found in the appendices at the end of this report.

Results

A total of 491 individuals provided responses to the survey. Due to differences in soil conditions in Sub-Saharan Africa, survey respondents were asked to identify which geographical region they were most knowledgeable. These regions consisted of West Africa, East Africa, the Great Lakes Area, and Ethiopia (Ethiopia is listed separately due to its unique agroecology). The choice that the respondent made to this question was carried forward through the rest of the survey for reference. The survey team specified these regional designations to help organize responses to the survey. Recognizing that many people work across multiple countries and regions, the team wanted to provide a way for respondents to focus their feedback in a single region.

Table 1 below shows the number of respondents from each of the four regions. Additional demographics for the survey respondents are provided on the following pages.

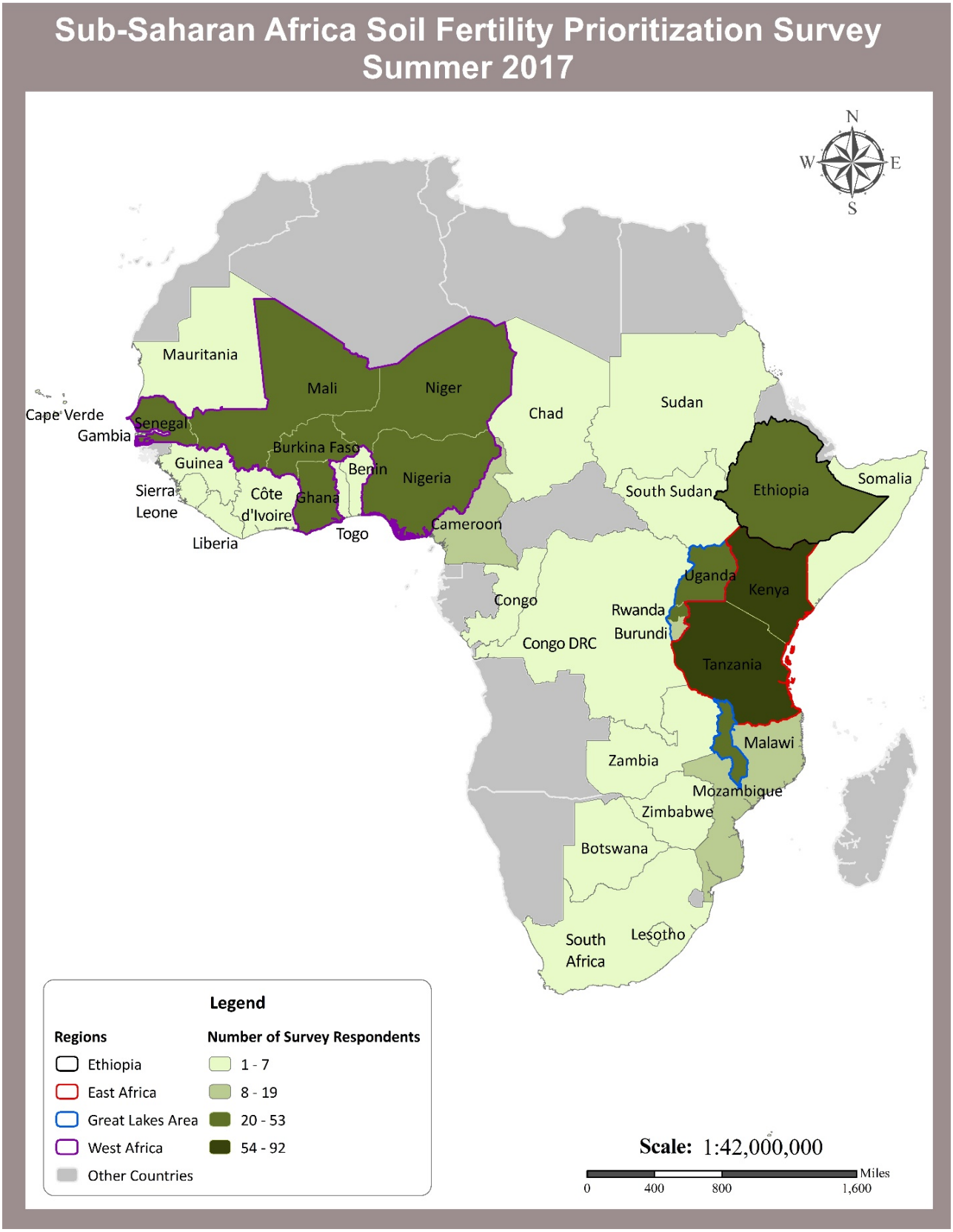
Table 1. Responses by Region

Region	Number of Responses	Percent
Ethiopia	38	8%
Great Lakes Area	99	20%
West Africa	170	35%
East Africa	184	37%
Total	491	100%

In addition to reporting their region of expertise, survey respondents could also indicate specific countries within Africa where they have experience working with soil fertility issues. Based on the region selected, respondents were able to select specific countries or write in a response. The countries included in each region were:

- East Africa region: Kenya, Tanzania
- Great Lakes Area: Burundi, Malawi, Rwanda, Uganda
- West Africa region: Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal

The map on the following page presents the countries that were identified in the survey. Similar to the results presented in Table 1 above, the majority of the respondents reported expertise in Kenya and Tanzania (East Africa) and Burkina Faso, Ghana, Mali, Niger, Nigeria and Senegal (West Africa). However, more than 20 other countries were also identified.


Sub-Saharan Africa Soil Fertility Prioritization Survey
Summer 2017
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d'Ivoire
Ghana
Liberia
Togo
Cameroon
South Sudan
Ethiopia
Somalia
Uganda
Kenya
Congo
Rwanda
Burundi
Congo DRC
Tanzania
Malawi
Zambia
Mozambique
Zimbabwe
Botswana
South
Africa
Lesotho
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Ethiopia
East Africa
Great Lakes Area
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Other Countries
Number of Survey Respondents
1 - 7
8 - 19
20 - 53
54 - 92
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0
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When asked to identify the type of organization where they work, the majority of respondents indicated that they are part of a multiple agencies. This provides perspective from multiple stakeholders (Table 2). Many individuals also selected the "other" option for this survey question, identifying land-grant institutions and other universities.

Table 2. Respondent Organization

Organization Type	**Frequency**	**Percent**	**Valid Percent***
Non-African University and/or Extension Agency	65	13.2%	18.9%
International Agricultural Research Centers (IARCS)	49	10.0%	14.2%
National University in Africa	42	8.6%	12.2%
National Research Agency in Africa	40	8.1%	11.6%
Government Developmental Agency	32	6.5%	9.3%
Non-Government Organization (NGO)	21	4.3%	6.1%
Private Sector	17	3.5%	4.9%
Farmer Organization	4	0.8%	1.2%
National Extension Agency in Africa	4	0.8%	1.2%
Regulatory Agency	2	0.4%	0.6%
Other (specify)	68	13.8%	19.8%
Total (Excluding Missing)	344	70.1%	100%
Missing	147	29.9%	--
Total (Including Missing)	491	100%	--

* Valid percent excludes the missing responses

Nearly half of all respondents reported that their primary role is in research (Table 3).

Table 3. *Respondent Role*

Respondent Role	**Frequency**	**Percent**	**Valid Percent***
Research	224	45.6%	64.0%
Teaching	31	6.3%	8.9%
Extension/Outreach	26	5.3%	7.4%
Management/Administration	26	5.3%	7.4%
Policy Development	10	2.0%	2.9%
Private-sector consultant	9	1.8%	2.6%
Farmer	2	0.4%	0.6%
Other (specify)	22	4.5%	6.3%
Total (Excluding Missing)	350	71.3%	100%
Missing	141	28.7%	--
Total (Including Missing)	491	100%	--

* Valid percent excludes the missing responses

Respondents also reported their primary discipline (Table 4). As shown in the following table, nearly half of the respondents indicated their discipline was either soil or crop science.

Table 4. Respondent Discipline

Respondent Discipline	**Frequency**	**Percent**	**Valid Percent***
Soil Science	164	33.4%	46.7%
Crop Science	68	13.8%	19.4%
Economics/Agricultural Economics	25	5.1%	7.1%
Natural Resources	20	4.1%	5.7%
Biological/Agricultural Engineering	13	2.6%	3.7%
Biology	4	0.8%	1.1%
Horticulture	4	0.8%	1.1%
Sociology	4	0.8%	1.1%
Geography	3	0.6%	0.9%
Nutrition	3	0.6%	0.9%
Forestry	2	0.4%	0.6%
Other (please specify)	41	8.4%	11.7%
Total (Excluding Missing)	351	71.5%	100%
Missing	140	28.5%	--
Total (Including Missing)	491	100%	--

* Valid percent excludes the missing responses

More than half of the respondents to the survey are male (Table 5).

Table 5. Respondent Gender

Respondent Gender	**Frequency**	**Percent**	**Valid Percent***
Male	280	57.0%	79.3%
Female	66	13.4%	18.7%
Prefer not to respond	7	1.4%	2.0%
Total (Excluding Missing)	353	71.9%	100%
Missing	138	28.1%	--
Total (Including Missing)	491	100%	--

* Valid percent excludes the missing responses

Approximately one-fourth of the respondents reported having more than 20 years of experience with soil fertility issues in one of the regions in Sub-Saharan Africa (Table 6). About another one-fourth of the respondents indicated they had 3-10 years of experiences in this area.

Table 6. Years of Experience

Years of Experience	Frequency	Percent	Valid Percent*
1	12	2.4%	3.5%
2	9	1.8%	2.7%
3	12	2.4%	3.5%
4	13	2.6%	3.8%
5	27	5.5%	8.0%
6	15	3.1%	4.4%
7	17	3.5%	5.0%
8	9	1.8%	2.7%
9	3	0.6%	0.9%
10	28	5.7%	8.3%
11	2	0.4%	0.6%
12	7	1.4%	2.1%
13	6	1.2%	1.8%
14	3	0.6%	0.9%
15	31	6.3%	9.1%
16	3	0.6%	0.9%
17	8	1.6%	2.4%
18	6	1.2%	1.8%
19	1	0.2%	0.3%
20+	127	25.9%	37.5%
Total (Excluding Missing)	339	69.0%	100%
Missing	152	31.0%	--
Total (Including Missing)	491	100%	--

* Valid percent excludes the missing responses

Regional Results

Because the agroecology varies as a function of region within Africa, the results are organized similarly. Below is a summary of the regional results; however, full results for each region are available upon request.

Ethiopia

Of the 491 participants responding to the survey, a total of 38 individuals identified Ethiopia as the country where they have the most knowledge and expertise about soil fertility issues. The demographic profile for the Ethiopian respondents includes:

- There was representations from multiple agencies working in the region NARES, IARCs and other sectors
- Half of the respondents (50%) reported their discipline as either soil or crop science
- Respondents are primarily in a research role (73.91%)
- Nearly half of the respondents reported having more than 20 years of experience (45.45%)
- 100% of the respondents are male

Responses about Ethiopia report that the five most limiting factors regarding soil characteristics contributing to poor crop yields are:

- Nitrogen deficiency
- Phosphorus deficiency
- Low soil organic C content
- Acidity
- Micronutrient deficiency

Respondents also reported on biophysical and socioeconomic/sociocultural limitations to enhancing soil fertility. Respondents rank ordered the top five limitations in each of these categories. For Ethiopia, "access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients" was clearly identified as the number one limitation (Table 7). However, there was no obvious pattern to identify the order of the five most frequently reported biophysical limitations.

Table 7. Top Five Biophysical Limitations - Ethiopia

Biophysical limitations	**1**	**2**	**3**	**4**	**5**	**Total**	**%**
Access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients	5	6	1	4	3	19	14.50%
Lack of suitable inorganic fertilizer application recommendations	4	1	6	4	2	17	13.00%
Limited opportunities to maintain and build soil organic matter	6	0	2	2	5	15	11.50%
Availability of inorganic fertilizers	5	2	3	1	3	14	10.70%
Retention of crop residues on the soil	0	5	3	4	1	13	9.90%

In addition to ranking the top five items, respondents also described the barriers that would need to be reduced to address each of these limitations. For the biophysical limitations, responses indicated the need to provide training for farmers, development agents and extension service providers as well as improving infrastructure and supply chain issues. Responses also show a need for increased access to affordable testing and more region-specific research that provides accurate recommendations for diverse areas in the country. Retention of crop residue is challenging due to the competing needs for this material, such as for livestock feed, fuel, etc. The lack of practices such as crop rotation are also barriers to building and maintaining soil organic matter.

Similar to the previous item, there was no obvious pattern to identify the order of the five most frequently reported socioeconomic/sociocultural limitations (Table 8).

Table 8. Top Five Socioeconomic/Sociocultural Limitations - Ethiopia

Socioeconomic/Sociocultural limitations	1	2	3	4	5	Total	%
Access to financial resources	8	7	3	3	1	22	19.60%
Availability or capacity of public sector (e.g., extension) service providers to deliver appropriate nutrient management recommendations to farmers	8	5	3	4	1	21	18.80%
Availability of private sector service providers to deliver nutrient management recommendations to farmers	2	3	3	2	4	14	12.50%
Lack of suitable information on the composition of manures and other C-rich soil amendments	1	1	2	5	4	13	11.60%
Access to mechanization, where appropriate	1	3	3	2	2	11	9.80%

In discussing the barriers for these limitations, respondents reported the need for farmers to have access to microcredit and training to improve financial literacy. There is also a need to engage banking organizations and government to help address these issues. Expanding research based recommendations, particularly for region-specific conditions and scale-appropriate solutions was reported, as well as the need to build the capacity of both public and private sector service providers.

Finally, respondents provided their recommendations or advice as to what is necessary to meet the future technology needs or new knowledge that will help improve soil fertility in five to ten years. These responses included:

- Increase research specific to countries/regions
- Expand testing and demonstration plots in localized regions (Woreda or district level)
    - Establish regional/mobile centers to serve small famers by conducting basic soil assessment/fertility test and provide real time suggestions
- Engage policy makers and other stakeholders
    - Set priorities
    - Address strategies – national soil strategy, irrigation, etc.
- Develop and provide training to farmers
    - Enhance training on crop rotation technology
- Identify and engage local resources to provide training
- Build capacity in public sector – including national and regional soil laboratories, universities and research centers – to provide training
- Expand access to financial resources
- Design an effective crop-livestock production system appropriate for major agro-ecological zones

Great Lakes Region

Of the 491 participants responding to the survey, a total of 99 individuals identified Great Lakes as the region where they have the most knowledge and expertise about soil fertility issues, and specifically in the following countries.

- Uganda – 37 (30.08%)
- Rwanda – 29 (23.58%)
- Malawi – 26 (21.14%)
- Burundi – 17 (13.82%)
- Other - 14 (11.38%) *Other responses included: Botswana, Democratic Republic of Congo (4), Kenya (2), Lesotho, Mozambique, South Africa, Tanzania, Zambia*

The demographic profile for the Great Lakes respondents includes:

- There was broad mix and representations from multiple agencies working in the region NARES, IARCs and other sectors
- Nearly half of the respondents (46.97%) reported their discipline as soil science
- Respondents are primarily in a research role (N=43, 64.18%)
- Nearly one-third of the respondents reported having more than 20 years of experience (27.69%)
- 70.59% of the respondents are male

Responses about the Great Lakes region report that the five most limiting factors regarding soil characteristics contributing to poor crop yields are:

- Nitrogen deficiency
- Acidity
- Low soil organic C content
- Phosphorus deficiency
- Micronutrient deficiency

Respondents also reported on biophysical and socioeconomic/sociocultural limitations to enhancing soil fertility. Respondents rank ordered the top five limitations in each of these categories (Table 9). For the Great Lakes region, "access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients" was identified as the number one limitation. However, there was no obvious pattern to identify the order of the five most frequently reported biophysical limitations.

Table 9. Top Five Biophysical Limitations – Great Lakes Region

Top 5 Biophysical limitations	**1**	**2**	**3**	**4**	**5**	**Total**	**%**
Access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients	17	7	7	8	7	46	13.20%
Availability of inorganic fertilizers	10	12	6	8	4	40	11.50%
Lack of suitable inorganic fertilizer application recommendations	1	5	10	10	6	32	9.20%
Availability of animal manures	8	8	7	4	4	31	8.90%
Retention of crop residues on the soil	4	5	10	4	8	31	8.90%

In addition to ranking the top five items, respondents also described the barriers that would need to be reduced to address each of these limitations. For the biophysical limitations, responses indicated the need to expand access to affordable testing and to build the capacity of testing labs in rural areas. Access to

inorganic fertilizers is limited as they are frequently not affordable to small farmers, as well as challenges with the supply chain, infrastructure and distribution. Responses also show a need for more site-specific research that provides accurate recommendations for diverse areas in the region. Retention of crop residue is challenging due to the competing needs for this material, such as for livestock feed, fuel, etc. Responses indicated limited availability of animal manures and the need to improve other alternatives (biomass, crop residue, etc.) to improve soil fertility.

In the Great Lakes region, "access to financial resources" was identified as the number one socioeconomic limitation (Table 10). However, there was no obvious pattern to identify the order of the second through the fifth most frequently reported socioeconomic/sociocultural limitations.

Table 10. Top Five Socioeconomic/Sociocultural Limitations – Great Lakes Region

Socioeconomic limitations	**1**	**2**	**3**	**4**	**5**	**Total**	**%**
Access to financial resources	37	10	6	3	5	61	19.40%
Availability or capacity of public sector (e.g., extension) service providers to deliver appropriate nutrient management recommendations to farmers	12	9	14	9	3	47	15.00%
Lack of suitable information on the composition of manures and other C-rich soil amendments	5	11	12	6	4	38	12.10%
Availability of private sector service providers to deliver nutrient management recommendations to farmers	1	6	12	10	5	34	10.80%
Barriers related to gender equity (e.g., access to credit, inputs, information, and/or distribution of labor, etc.)	1	7	8	9	6	31	9.90%

In discussing the barriers for these limitations, respondents reported the need for farmers to have access to microcredit and to engage banking organizations and government to help address these issues. High interest rates and lack of financial support for subsistence farmers/small holders were also reported as barriers. Expanding research based recommendations, particularly for region-specific conditions is needed, as well as building the capacity of local testing labs and both public and private sector service providers. Responses for the Great Lakes region also noted barriers related to gender equity, particularly that females frequently have little or no access to financial resources or credit, even though they may be the primary operator on family land.

Finally, respondents provided their recommendations or advice as to what is necessary to meet the future technology needs or new knowledge that will help improve soil fertility in five to ten years. These responses included:

- Increase research specific to countries/regions
- Use of sustainable soil and crop management/land management
- Provide training to farmers
    - Includes technical training and economic information
- Expand testing and demonstration plots in localized regions
    - Expand training centers at farmer level
- Engage government and private sector

- Increase research
    - Cost analysis
    - GMOs (Genetically Modified Organisms)
    - Climate resilience
    - Livestock investment
- Build capacity in public sector to provide training
- Expand access to financial resources and improved markets

West Africa

Of the 491 participants responding to the survey, a total of 170 individuals identified West Africa as the region where they have the most knowledge and expertise about soil fertility issues, and specifically in the following countries.

- Burkina Faso – 49 (17.63%)
- Nigeria – 46 (16.55%)
- Senegal – 45 (16.19%)
- Ghana – 45 (16.19%)
- Mali – 35 (12.59%)
- Niger – 31 (11.15%)
- Other – 27 (9.71%) - *Other: All, Benin, Cabo Verde, Cameroon (12), Chad, Congo, Cote D'Ivoire (4), Gambia (2) Guinea, Guinea Conakry, India, Liberia, Mauritania, Sierra Leone, Togo (3), West Africa*

The demographic profile for West Africa respondents includes:

- There respondents were distributed across multiple agencies. About 20% reported working in a National Research Agency in Africa.
- Almost half of the respondents (49.6%) reported their discipline as soil science.
- Respondents are primarily in a research role (N=86, 69.92%)
- Nearly half of the respondents reported having more than 20 years of experience (47.46%)
- 87.20% of the respondents are male

Responses about West Africa report that the five most limiting factors regarding soil characteristics contributing to poor crop yields are:

- Low soil organic C content
- Nitrogen deficiency
- Phosphorus deficiency
- Low available water holding capacity
- Acidity

Respondents also reported on biophysical and socioeconomic/sociocultural limitations to enhancing soil fertility. Respondents rank ordered the top five limitations in each of these categories. For West Africa, "availability to inorganic fertilizers" was clearly identified as the number one limitation (Table 11). However, there was no obvious pattern to identify the order of the second through the fifth most frequently reported biophysical limitations.

Table 11. Top Five Biophysical Limitations – West Africa

Biophysical limitations	1	2	3	4	5	Total	%
Availability of inorganic fertilizers	40	23	12	11	8	94	14.80%
Limited opportunities to maintain and build soil organic matter	24	12	13	16	9	74	11.70%
Access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients	20	16	10	10	10	66	10.40%
Availability of composts or other C-rich soil amendments (not including manures or mulches)	9	12	18	10	12	61	9.60%
Lack of suitable inorganic fertilizer application recommendations	8	8	9	18	9	52	8.20%

Respondents described the barriers that would need to be reduced to address each of these limitations. For the biophysical limitations, responses indicated the need to expand access to affordable inorganic fertilizers. There are limited opportunities to build soil organic matter due to the lack of use of residue management strategies and the climate conditions. There is also a need to expand access to affordable, accurate testing, as well are more research to provide site- and region specific recommendations.

In West Africa, "access to financial resources" was identified as the number one socioeconomic limitation (Table 12). However, there was no obvious pattern to identify the order of the second through the fifth most frequently reported socioeconomic/sociocultural limitations.

Table 12. Top Five Socioeconomic/Sociocultural Limitations – West Africa

Socioeconomic limitations	1	2	3	4	5	Total	%
Access to financial resources	79	16	7	10	2	114	20.00%
Availability or capacity of public sector (e.g., extension) service providers to deliver appropriate nutrient management recommendations to farmers	12	33	28	14	6	93	16.30%
Land tenure (i.e., long-term access to the same land)	16	6	23	16	10	71	12.50%
Availability of private sector service providers to deliver nutrient management recommendations to farmers	2	20	15	17	12	66	11.60%
Access to mechanization, where appropriate	5	17	12	12	16	62	10.90%

In discussing the barriers for these limitations, respondents reported the need for farmers to have access to microcredit and to engage banking organizations and government to help address these issues. High interest rates and lack of land ownership/access to collateral were also reported as barriers. Land tenure issues, including a need to review existing regulations and policies in these areas, along with gender equity concerns, specifically the very low number of women who own land, were noted. Expanding research based recommendations, particularly for region-specific conditions is needed, as well as strengthening local manufacturers to increase locally produced equipment for scale appropriate mechanization.

Finally, respondents provided their recommendations or advice as to what is necessary to meet the future technology needs or new knowledge that will help improve soil fertility in five to ten years. These responses included:

- Increase research specific to countries/regions
    - Credible nutrient and soil management research
- Promote sustainable practices
- Improved and affordable equipment
- Strengthen agricultural research and training centers
- Train public sector service providers
    - Strengthen extension services
- Develop and provide training to farmers
- Integrated approach with agriculture, livestock and forestry
- Improved policies, government support of agriculture
- Integrated social, economic and scientific approach
- Develop low cost, low risk options
- Develop private sector to promotes services for integrated soil fertility management

East Africa

Of the 491 participants responding to the survey, a total of 184 individuals identified East Africa as the region where they have the most knowledge and expertise about soil fertility issues, and specifically in the following countries.

- Kenya – 89 (41.59%)
- Tanzania – 72 (33.64%)
- Other – 53 (24.77%) - *Other: Asia, Burundi (2), Ethiopia (5), Lesotho, Malawi (12), Mozambique (7), Oromia/Ethiopia, Rwanda (11), Somalia, South Sudan, Sudan (2), Uganda (16), Zambia (5), Zimbabwe (3)*

The demographic profile for East Africa respondents includes:

- There was wide representation from multiple stakeholders including NARES and IARCs.
- Almost half of the respondents (46.67%) reported their discipline as soil science.
- Respondents are primarily in a research role (N=78, 57.35%)
- Nearly one-third of the respondents reported having more than 20 years of experience (32.33%)
- 73.33% of the respondents are male

Responses about East Africa report that the five most limiting factors regarding soil characteristics contributing to poor crop yields are:

- Nitrogen deficiency
- Low soil organic C content
- Phosphorus deficiency
- Acidity
- Low available water holding capacity

Respondents also reported on biophysical and socioeconomic/sociocultural limitations to enhancing soil fertility. Respondents rank ordered the top five limitations in each of these categories. For East Africa, "access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients" was clearly identified as the number one limitation (Table 13). However, there was no obvious pattern to identify the order of the second through the fifth most frequently reported biophysical limitations.

Table 13. Top Five Biophysical Limitations – East Africa

Top 5 Biophysical limitations	**1**	**2**	**3**	**4**	**5**	**Total**	**%**
Access to quality soil testing for pH, soluble salts, organic matter/C, and plant essential nutrients	35	25	9	9	14	92	13.70%
Availability of inorganic fertilizers	34	18	15	7	6	80	11.90%
Suitability of available fertilizer blends (including micronutrients)	11	10	16	17	11	65	9.70%
Lack of suitable inorganic fertilizer application recommendations	10	19	10	18	4	61	9.10%
Limited opportunities to maintain and build soil organic matter	14	8	11	8	14	55	8.20%

Respondents described the barriers that would need to be reduced to address each of these limitations. For the biophysical limitations, responses indicated the need for regional, well-equipped testing lab facilities that can provide affordable services to farmers. There is also a need to expand access to affordable inorganic fertilizers, particularly on a scale for small holders. Balanced fertilizer blends are also needed, along with more research to provide site- and region specific recommendations. There are limited opportunities to build soil organic matter due to the competing needs for this material, such as for livestock feed, fuel, etc.

In East Africa, "access to financial resources" was identified as the number one socioeconomic limitation (Table 14). However, there was no obvious pattern to identify the order of the second through the fifth most frequently reported socioeconomic/sociocultural limitations.

Table 14. Top Five Socioeconomic/Sociocultural Limitations – East Africa

Top 5 Socioeconomic limitations	**1**	**2**	**3**	**4**	**5**	**Total**	**%**
Access to financial resources	82	17	12	8	3	122	20.50%
Availability or capacity of public sector (e.g., extension) service providers to deliver appropriate nutrient management recommendations to farmers	17	33	28	14	6	98	16.40%
Availability of private sector service providers to deliver nutrient management recommendations to farmers	8	18	15	8	16	65	10.90%
Lack of suitable information on the composition of manures and other C-rich soil amendments	3	7	14	26	12	62	10.40%
Barriers related to gender equity (e.g., access to credit, inputs, information, and/or distribution of labor, etc.)	8	16	11	13	11	59	9.90%

In discussing the barriers for these limitations, respondents reported the need for farmers to have access to microcredit and to engage banking organizations and government to help address these issues. High interest rates and access to collateral were also reported as barriers. The need to both build the capacity of public service providers and encourage the development of the private sector was noted. Expanding research based recommendations, particularly for region-specific conditions is needed, as well as addressing gender equity issues, such as lack of land ownership by women and their lack of access to financial resources and credit.

Finally, respondents provided their recommendations or advice as to what is necessary to meet the future technology needs or new knowledge that will help improve soil fertility in five to ten years. These responses included:

- Increase research specific to countries/regions
- Expand testing and demonstration plots in localized regions
    - Establish regional/mobile centers to serve small famers by conducting basic soil assessment/fertility test and provide real time suggestions
- Develop and provide training to farmers
    - Use of fertilizers
    - Soil nutrition
    - Include use of on-farm demonstrations
- Promote sustainable practices
    - Promote retention of crop residue to build SOM
- Build capacity extension service providers
- Develop the private sector
- Improve infrastructure and access to markets

Study Limitations

The following limitations are noted for this study:

- The original contact list for survey participants was pulled from professional organization rosters. While recipients had an opportunity to provide additional contacts for participation in the survey, the sample may not be inclusive of all stakeholders, particularly those that do not belong to one of the professional organizations utilized in this study.
- A total of 585 recipients opened the survey link, representing about half of the 1,157 contacts that received the invitation to participate. While more than 80% of those that opened the survey link provided some level of response, these results may or may not be reflective of the approximately 550 individuals who did not respond to the survey.
- The majority of the responses received for this soil fertility survey related to East and West Africa. Results related to Ethiopia and the Great Lakes region were more limited, and thus may not reflect the comprehensive scope of issues in these two areas.
- In an effort to keep the survey relatively short, participants were only able to provide feedback on one region. A number of respondents indicated that limiting the feedback to a single region may not have fully captured the expertise and input that could have been provided.

- About 10% of the survey respondents represent Economics/Agricultural Economics, Geography, Nutrition and Sociology, indicating that the social science perspective may only have limited representation in the results.
- Less than 20% of the respondents to the survey are female. While this number may be reflective of the most frequently reported disciplines (soil and crop science) participating in the survey, females' perspectives may only have limited representation in the results.

Discussion

The following discussion is based solely on the results obtained from the *SSA Soil Fertility Prioritization Survey* and does not include recommendations from the *SSA Soil Fertility Prioritization Summit*. Please refer to the *SSA Soil Fertility Prioritization Final Report* for a combined analysis and recommendations.

This *SSA Soil Fertility Prioritization Survey* was designed to systematically identify evidence-driven soil fertility barriers and strategies to overcome these barriers. These survey specific results in combination with the summit results guided the development of recommendations and an action plan for stakeholders, research and development, policy makers and funding organizations, and the scientific community in general. Distinct priorities were identified for each region, though unified priorities across regions also developed. For the purpose of these recommendations, we define soil fertility as the ability of the soil to provide adequate amounts of essential plant nutrients to sustainably produce plant biomass (both grain and fodder) to meet anthropogenic requirements.

East Africa

Biophysical results for East Africa prioritized the need for quality soil testing, improved availability of inorganic fertilizers, suitable fertilizer blends, inorganic fertilizer application recommendations, and opportunities to maintain and build soil organic matter. Socioeconomic results prioritized a need for improved access to financial resources, availability and capacity of both public and private sector service providers to deliver appropriate nutrient management recommendations to farmers, access to suitable information on the composition of manures and other C-rich amendments, and gender equity.

To overcome the identified biophysical barriers, respondents for East Africa recommended the need for regional, well-equipped soil analysis labs and/or mobile testing equipment that can provide affordable, research based, and regionally specific recommendations to farmers. Fertilizer application recommendations that are site/regionally specific and are up-to-date were heavily recommended throughout. Respondents recommended the need for affordable, inorganic fertilizers that are available to smallholders at the right time, in appropriate packaging, and with appropriate recommendations. There was also emphasis placed on suitable fertilizer blends that contain both macro and micronutrients and are customized to soil types and specific crops. Additionally, respondents recommended technologies for maintaining and building soil organic matter such as use of residues, manures, and legumes and also highlighted the need for increasing farmer training and capacity building.

To overcome the identified socioeconomic barriers, respondents for East Africa recommended increased access to financial resources such as microfinance systems, enhanced farmer co-ops, and government support through subsidies, policies, and crop insurance. Respondents also recommended the need for well-trained public and private sector extension and service providers connected to regionally specific research. Emphasis was also placed on having enabling policies in place to encourage private sector involvement and partnership with public organizations. In attempt to improve access to suitable information on the composition of manures and other C-rich amendments, respondents highlighted the need for capacity building of farmers, extension workers, and lab facilities with particular focus on connecting these groups to regionally-specific research on organic amendments. The need to overcome barriers to gender equity was also identified. Respondents recommended increasing women's access to credit, education, and land-ownership and highlighted the importance of empowering women to make agricultural management and financial decisions.

Ethiopia

Biophysical results for Ethiopia prioritized the need for quality soil testing, inorganic fertilizer application recommendations, opportunities to maintain and build soil organic matter, improved availability of inorganic fertilizers, and retention of crop residues on the soil. Socioeconomic results prioritized a need for improved access to financial resources, availability and capacity of both public and private sector service providers to deliver appropriate nutrient management recommendations to farmers, access to suitable information on the composition of manures and other C-rich amendments, and access to mechanization where appropriate.

To overcome the identified biophysical barriers, respondents for Ethiopia recommended improving access to quality soil testing by building the capacity of soil testing facilities, making testing more affordable for smallholders, and increasing the capacity of farmers. Respondents also emphasized the need for suitable inorganic fertilizer recommendations and highlighted the need for training of extension service providers, on-farm demonstrations, and regionally appropriate research and extension information. There was also emphasis placed on increasing opportunities to maintain and build soil organic matter. Respondents highlighted the need for soil organic matter management, improved cropping systems practices such as crop rotation or intercropping where appropriate, and the lack of crop residues due to competing interests. Low input agriculture was also highlighted as a constraint to building soil organic matter. In order to increase the availability of inorganic fertilizers, respondents recommended improving its affordability, policies and infrastructure, and the supply chain for inorganic fertilizer as well as improving training of the use of inorganic fertilizer. Retention of crop residues was also noted as a barrier to increasing soil fertility. Respondents noted the multiple competing interests for crop residues such as animal feed, home construction, fuel for cooking, and noted the impact of open grazing policies.

To overcome the identified socioeconomic barriers, respondents for Ethiopia recommended increasing access to financial resources such as microcredit, improving financial literacy, and by engaging banks and government to expand access. Respondents also recommended the need for well-trained public and private sector extension and service providers connected to regionally specific research. Respondents noted the need for both private and public sector staff training, expanding research based recommendations, and expanding the pool of training providers. The development of the private sector and enabling agricultural

policies were also recommended to increase the availability of private sector service providers to deliver nutrient management recommendations. In attempt to improve access to suitable information on the composition of manures and other C-rich amendments, respondents highlighted the need for capacity building extension service providers and the need for more research-based information in a local/regional specific context. Respondents also recommended the need to develop affordable and scale appropriate and flexible mechanization to improve access to mechanization, where appropriate.

Great Lakes

Biophysical results for the Great Lakes region prioritized the need for quality soil testing, improved availability of inorganic fertilizers, inorganic fertilizer application recommendations, access to animal manure, and retention of crop residues on the soil. Socioeconomic results prioritized a need for improved access to financial resources, availability and capacity of both public and private sector service providers to deliver appropriate nutrient management recommendations to farmers, access to suitable information on the composition of manures and other C-rich amendments, and gender equity.

To overcome the identified biophysical barriers, respondents for the Great Lakes region recommended the need for improved access to quality soil testing that is affordable to smallholders. Respondents noted the importance of building the capacity of existing soil testing labs and training farmer's extension service providers to better understand how to utilize soil testing results. Availability of inorganic fertilizers was identified as a key barrier. The need for more affordable fertilizers and financial support such as loans and subsidies, improved policy/infrastructure and supply chains, and improved training on the proper use and benefits of inorganic fertilizers were recommended to improve the availability of inorganic fertilizer. Participants emphasized the need for suitable inorganic fertilizer application recommendations and recommended increased site- and scale specific research, expansion of research based recommendations, training of farmers and extension service providers, and improved policy and infrastructure to support this information exchange. Respondents identified limited availability of animal manures as a key barrier to improving soil fertility and highlighted the challenges with collecting manure in grazing systems. Recommendations focused on improving access and utilization of other C-rich amendments, the need for training of farmers and extension service providers, the need for better integration of crop and livestock systems with agroforestry, and increased investment in livestock. Increasing the retention of crop residues on the soil when there are competing uses for residues (e.g. livestock feed, fuel, building materials) was noted as a key barrier. Respondents recommended reducing over-cultivation, over grazing, and residue burning, the need for farmer training on the importance of residue management, and the need to develop and implement more efficient integrated crop-livestock management systems.

To overcome the identified socioeconomic barriers, respondents for the Great Lakes region recommended increased access to financial resources and highlighted the need for microcredit, loan cooperatives, and improved rural safety nets such as crop insurance and the stabilization of prices. Respondents noted the challenges to increasing access to financial resources such as high interest rates making loans inaccessible, lack of assets to use as a security, smallholder operations being too small for loan administration, and the lack of banking systems in rural areas. Respondents also recommended the need for well-trained public and private sector extension and service providers connected to regionally specific research. Emphasis was also placed on expanding the capacity of this sector, improving their training, strengthening links between

extension and farmers, the need to interconnect public and private extension service providers, and the need to encourage private sector investment. In attempt to improve access to suitable information on the composition of manures and other C-rich amendments, respondents recommended the need for capacity building of farmers, extension workers, and lab facilities with particular focus on connecting these groups to regionally-specific research on organic amendments. The need to overcome barriers to gender equity was also identified. Respondents recommended increasing women's access to credit, education, and land-ownership and highlighted the importance of empowering women to make agricultural management and financial decisions when they are often the primary operator of the family farm.

West Africa

Biophysical results for the West Africa prioritized the need for improved availability of inorganic fertilizers, opportunities to maintain and build soil organic matter, quality soil testing, availability of composts or other C-rich soil amendments, and inorganic fertilizer application recommendations. Socioeconomic results prioritized a need for improved access to financial resources, availability and capacity of both public and private sector service providers to deliver appropriate nutrient management recommendations to farmers, land tenure (long-term access to the same land), and access to mechanization where appropriate.

To overcome the identified biophysical barriers, respondents for West Africa recommended the need for increased availability of inorganic fertilizer that is affordable to smallholders, accessible at the right time with local supply. Respondents recommended increasing opportunities to maintain and build soil organic matter by improving residue management strategies, reducing residue burning, improving crop-livestock integration, and increasing training of farmers. Respondents noted the challenges of maintaining or building soil organic C due to harsh climatic conditions and competition for crop residues such as for livestock feed, fuel, and building materials. Access to quality soil testing was identified by respondents for West Africa with recommendations to increase access to well-equipped soil testing labs, improve training of lab staff, extension service providers, and farmers, and ensure soil testing is affordable. Respondents also emphasized the importance of improving access and utilization of other C-rich amendments and recommended the need for training farmers and extension service providers on suitable management practices. Increasing the retention of crop residues on the soil when there are competing uses for residues (e.g. livestock feed, fuel, building materials) was noted as a key barrier. Respondents recommended the need for suitable inorganic fertilizer recommendations providing regionally specific recommendations based on regionally specific research and emphasized the importance of connecting this information to extension service providers and farmers.

To overcome the identified socioeconomic barriers, respondents for West Africa recommended increased access to financial resources such as microcredit and government support through subsidies, policies, and crop insurance. Respondents noted the challenges to increasing access to financial resources such as high interest rates making loans inaccessible, lack of land ownership reducing collateral, limited financial support for subsistence farming and few institutions willing to work in agriculture due to high risk. Respondents also recommended the need for well-trained public and private sector extension and service providers connected to regionally specific research. Emphasis was also placed on expanding the capacity of this sector, improving their training, strengthening links between research, extension, and farmers, the need to interconnect public and private extension service providers, and the need to encourage private sector

investment. Respondents highlighted land tenure (i.e. long-term access to the same land) as a key barrier to achieving soil fertility. Respondents recommended reviewing land tenure laws and regulations and noted that farmers are unwilling to invest in fertilizers and soil fertility improvements if they do not have long-term access to their land. Access for women to land ownership was also noted. Respondents also recommended the need to improve access to mechanization, where appropriate by strengthening local manufacturing and offering financial options to access mechanization such as loans and subsidies.

Sub-Saharan Africa Combined

The most frequently reported limiting factors regarding soil characteristics that contribute to poor crop yields across all four regions are N deficiencies, P deficiencies, acidity, and low soil organic C content. For Ethiopia and the Great Lakes region, micronutrient deficiencies were also reported as part of the top five limiting factors, while low available water holding capacity was noted for West and East Africa. Respondents then identified and ranked biophysical and socioeconomic limitations to enhancing soil fertility. Relating to the biophysical limitations, all regions reported a need for access to quality soil testing and increased availability of inorganic fertilizers with a particular focus on establishing regionally specific fertilizer response recommendations and improving the delivery of these recommendations to farmers. Both Ethiopia and the Great Lakes region indicated that retention of crop residues on the soil, availability of quality organic materials was a barrier, while limited opportunities to maintain and build soil organic matter were reported for West and East Africa. Regarding socioeconomic/sociocultural limitations, all regions emphasized that access to financial resources was a barrier, particularly for smallholders and subsistence farmers. The availability of public sector service providers to deliver appropriate nutrient management recommendations was also commonly noted as a barrier. The need for access to mechanization was reported for Ethiopia and West Africa, while barriers related to gender equity and the need to develop private sector resources were reported for the Great Lakes region and East Africa.

Although the focus of the report was at the regional level, the following common themes were identified across all regions:

- Need for expanded research, leading to improved/updated recommendations for site- and region-specific conditions
- Need for local soil testing facilities, particularly in rural areas, that can provide affordable, accurate services
- Training for farmers, with a focus on peer-training and on-farm demonstrations
- Need to build the capacity of extension service providers
- Gender equity issues were noted in all regions except Ethiopia. These included women's lack of land ownership, lack of access to financial resources, and limited availability to participate in training sessions.

The combined biophysical and socioeconomic results provide a clear picture of the interdisciplinary and interconnected nature of priorities for improving soil fertility across each region. Thus, plans for improving soil fertility across SSA must take an integrated approach, inclusive of the identified biophysical and socioeconomic factors. Action plans that only focus on a singular or narrow factor such as inorganic fertility availability or fertilizer recommendations alone will likely fall short of improving soil fertility. Each of the prioritized factors must be improved in such a way that no one priority is limiting. For example, though it

may be quite evident that the use of inorganic fertility can improve crop yields, without the inclusion of appropriate recommendations, suitable extensions services, access to financial resources, the incorporation of organic amendments, and enabling policies, only increasing access or use to inorganic fertilizer alone will likely not be successful in improving soil fertility.

The survey results are complementary to the summit results and indicate that there are key biophysical and socioeconomic barriers and strategies that can either create an enabling environment or hinder progress towards improving soil fertility across SSA. Inorganic fertilizer access, use, and related issues were prominent but many related biophysical (building soil organic C) and socioeconomic barriers (access to resources both financial and agronomic, and access to appropriate fertility recommendations and extension support) and solutions were identified as equally important to building soil fertility. Overall recommendations using a combined analysis of the *SSA Soil Fertility Prioritization Survey and Summit* have been developed in the *SSA Soil Fertility Prioritization Final Report.*

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