Lomonosov Moscow State University
ECFS
Eurasian Center
for Food Security

2018

On Soil Scientists and Where to Find Them in Africa: Assessment of Human Capital

R E P O R T

On Soil Scientists and Where to Find Them in Africa: Assessment of Human Capital

Andrei Rozanov and Liesl Wiese

2018

IBSN 978-5-6040425-1-9

The content, findings, interpretations, and conclusions of this publication are the sole responsibility of the authors and can in no way be taken to reflect the views of the Eurasian Center for Food Security.

Images

Front cover: photo Andrei Rozanov; A'Melody Lee/The World Bank and Expert LLC.

“Imperfect understanding
is often more dangerous than ignorance …”

J.K. Rowling

CONTENTS

Acknowledgments

The Online World Bank–Sponsored Questionnaire

We thank Thomas Thompson (Virginia Tech, United States) and Catherine Clarke and Julia Harper (Stellenbosch University, South Africa) for their contributions toward the questionnaire optimization. We would like to acknowledge the IUSS and in particular Sigbert Huber and Barbara Birli (Austria) for circulating the request to complete the online survey for African countries via the IUSS bulletin and the IUSS Facebook page; and Niels Batjes (ISRIC, the Netherlands) for giving us access to the IUSS LinkedIn page and supporting the online survey initiative. We thank the national soil science societies: Mamadou Traore (Burkina Faso), Omar El Hady (Egypt), Francis Tetteh (Ghana), Victor Chude (Nigeria), Nancy Nortje (South Africa), and Esther N. Masvaya (Zimbabwe) for the information regarding the national soil society memberships and for circulating the questionnaire to the members. We also thank our colleagues in the countries that do not have national soil science societies: Nsalambi Nkongolo (Democratic Republic of the Congo), A. M. Gelaw (Ethiopia), and Lydia Chabala (Zambia) for assistance with estimating the number of soil scientists in their respective countries and circulating the questionnaire.

We express our sincere gratitude to all the soil scientists who took part in the survey.

Personal Communication in Africa

We thank the Global Soil Partnership (GSP), its focal points in Africa, non-focal point members, and anonymous experts who contributed their views to this assessment: Attanda Mouinou Igué (Benin), Chebukani Mpapho Fanani (Botswana), Flore Arlende Ngomeni (Cameroon), Gaius Elenga (Democratic Republic of Congo), Raphaël Ngadi Litadi (Gabon), Abdou Rahman Jobe (the Gambia), John Mussa (Malawi), Bhanooduth Lalljee (Mauritius), Rachid Moussadek (Morocco), Josephath Kutuahupira (Namibia), Addam Kiari Saidou (Niger), Victor Chude (Nigeria), Pascal Rushemuka (Rwanda), Mamadou Amadou Sow (Senegal), Ramakgwale Klaas Mampholo (South Africa), Abdelmagid Ali Elmobarak (Sudan), Geophrey Kajiru (Tanzania), Afawoubo Koffi Gbelekor (Togo), Patrick Musinguzi (Uganda), Stalin Sichinga (Zambia), and Emmanuel Chikwari (Zimbabwe).

We also thank experts and representatives from various organizations working with agriculture in Africa for providing their perspectives: Tegbaru Bellete and Mulugeta Demiss (ATA), Christian Witt (Bill and Melinda Gates Foundation), Rolf Sommer (CIAT), Leonard Rusinamhodzi (CIMMYT), Ermias Betemariam and Keith Shepherd (ICRAF), Steven Twomlow (IFAD), Prem Bindraban (IFDC), Nienke Beintema (IFPRI-ASTI), Momade Mamudo Ibraimo (IIMA), Cargele Masso and Martin Yemefack (IITA), and Guillaume Nyagatare and Hamudu Rukangantambara (University of Rwanda).

Mapping Work

We thank N. Ngenjane and P. J. Van der Walt (Stellenbosch University students) for assistance with Internet searches to locate the relevant institutions and the Google Earth work in preparing the map of the African universities offering degrees in soil science. We are grateful to the IUSS for publishing the map of the African universities on their website to get assistance from the African community regarding the position and web addresses of the mapped institutions. Special thanks go to Prof. K. Ibrahimi for assistance with identifying the universities and soil research institutions in Tunisia.

Review of this Report

We sincerely thank Bernard van Lauwe (IITA) and Pavel Krasilnikov (ECFS) for their critical review and valuable comments on this report, which have been incorporated as much as possible. Their comments confirmed the importance of the topic of human capital in soil science in Africa and the need to study the current situation in more detail to inform future investment strategies.

About the Authors

Andrei Rozanov was born in Moscow, USSR, and was introduced to soil science at an early age by his parents Boris and Irina. He grew into soil science and spent many of his school and university holidays in soil exploration expeditions as a digger traveling across the USSR from the Black Sea to the Pacific coast. He graduated from Moscow State University with a degree in Soil Science and Agricultural Chemistry in 1989. He started his research career at the Institute of Geography, Russian Academy of Sciences, and was awarded the Candidate of Geographical Sciences (soil science) degree by the V.V. Dokuchaev Institute of Soil Science of the Russian Academy of Agricultural Sciences in 1993. He moved to South Africa in 1995 to lecture in soil science at the University of the North (Limpopo). He traveled widely and consulted for the industry, NGOs, and international organizations in several African countries. Presently he is a senior lecturer in soil science at Stellenbosch University, South Africa.

Liesl Wiese is a South African soil scientist who spent 10 years as a soil science researcher at the Agricultural Research Council – Soil, Climate and Water, followed by two years working as a consultant for the Global Soil Partnership (GSP) Secretariat at the headquarters of the Food and Agriculture Organization of the United Nations in Rome, Italy. As a researcher, Liesl worked on topics of soil organic carbon assessment, land degradation, sustainable soil and land management and barriers to their adoption, as well as linking science to policy to support improved soil management. Under the GSP she chaired the GSP pillar working groups to increase sustainable soil management and targeted soil research, as well as facilitated activities and developments under the African Soil Partnership. Currently, as an independent international consultant, Liesl continues to apply her expertise in all these areas in support of overall improved soil management.

Abbreviations

AFSIS	Africa Soil Information Service
AfSP	African Soil Partnership
ASSS	African Soil Science Society
ASTI	Agricultural Science and Technology Indicators
ATA	Agricultural Transformation Agency
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
DRD-TARI	Ministry of Agriculture and Food Security – Department of Research and Development / Tanzania Agricultural Research Institute
DSM	digital soil mapping
ECFS	Eurasian Center for Food Security
EIAR	Ethiopian Institute for Agricultural Research
EU-FA	Egerton University – Faculty of Agriculture
FAO	Food and Agricultural Organization of the United Nations
GIS	geographic information systems
GSP	Global Soil Partnership
HU-CAES	Haramaya University – College of Agriculture and Environmental Sciences
IBSRAM	International Board for Soil Research and Management
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICSU	International Council of Scientific Unions
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IIMA	Agricultural Research Institute of Mozambique
IITA	International Institute for Tropical Agriculture
INRAN	National Institute of Agronomic Research (Niger)
ISFM	integrated soil fertility management
ISSS	International Soil Science Society
ITPS	Intergovernmental Technical Panel on Soils
IUSS	International Union of Soil Sciences
IWMI	International Water Management Institute
KALRO	Kenya Agricultural and Livestock Research Organization
LSSEE	Laboratory of Soil Science, Water and Environment
MAK-CAES	Makerere University – College of Agricultural and Environmental Sciences
MU-CDANR	Mekelle University – College of Dryland Agriculture and Natural Resources
NARO	National Agricultural Research Organization
NARS	national agricultural research systems
N/D	not disclosed
NENA	Near East and North Africa
NGO	nongovernmental organization
NRM	natural resource management
RoI	Return on Investment

RSP	Regional Soil Partnership
RUFORUM	Regional University Forum
SACNASP	South African Council for Natural Scientific Professions
SARI	South Agricultural Research Institute
SDG	Sustainable Development Goal
SLM	sustainable land management
SSM	sustainable soil management
SUA	Sokoine University of Agriculture
TARI	Tigray Agricultural Research Institute
TSBF	Tropical Soil Biology and Fertility
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UoN-FA	University of Nairobi – Faculty of Agriculture
UR	University of Rwanda
USDA	United States Department of Agriculture

1 Introduction

The Eurasian Center for Food Security (ECFS) has brought to the attention of the World Bank the seemingly diminishing capacity in soil expertise and stagnant or shrinking job market for soil experts within the countries of Africa. This observation largely reflects the perception of the trend voiced by many African soil science professors and post-graduate students who gathered at the RUFORUM meeting in Cape Town in 2016; it was reiterated at meetings organized by ECFS in Moscow in celebration of World Soil Day (2016 and 2017) that discussed the future of soil science. This perception of trends in soil science within the education community raises a concern for sustainable development in the agricultural, forestry, and nature conservation sectors on the continent. The soil experts can and should provide valuable inputs into development strategies, allocation of land resources, and the implementation of individual development projects from small-scale farming to large development and conservation schemes, as well as research related to sustainable development and the conservation of soil resources. The perceived decrease in soil science human capital and subsequently smaller pool of knowledge may be a worrying trend requiring corrective action.

This study aims to understand the role that soil science plays in the continent's changing landscape of agriculture, land development, and conservation from the perspective of individuals working as or with soil scientists on the continent. It also analyzes the soil expertise available in the countries concerned, as well as the perceived sufficiency of human capital to support decisions at farm, provincial, national, and regional levels as well as industrywide. Essentially, this report is the voice of the broader African soil science community, with subsequent thoughts and recommendations from the authors.

1.1 Soil Science in the Face of Challenges to Agricultural Development in Africa

Africa is the second-largest continent; it occupies 3 billion hectares of land. It is also the second most populated continent, predicted to double its current population of 1.2 billion people by 2050. African land resources are highly variable in their agricultural production potential. The seeming abundance of land (almost 2.5 hectares per person) is severely constrained by a large expanse of deserts and semi-deserts. The Sahara alone occupies 9 million square kilometers—almost a third of the total land area of the continent. Combining the Sahara and the Kalahari, Namib, Karoo, and other smaller deserts and semi-deserts with the continuous desertification (Cherlet et al. 2018), we may be facing a significant shortage of agricultural land in Africa in the near future.

The shortage of productive land, along with demand for high-value timber, drives deforestation and increases pressure on wildlife habitats of the high rainfall areas (Gibbs et al. 2010).

The availability of agricultural land in desert and semi-desert environments is restricted by water availability. In such areas crop production is impossible without irrigation. The irrigation schemes in the arid regions are relatively small in size, though large in economic importance.

Most of the population in Africa is concentrated in the areas of productive land characterized by rainfall exceeding approximately 300 millimeters/year. Agriculture is a major occupation among the African people, but its productivity is low for various socioeconomic reasons. Rural poverty and the lack of career opportunities outside of the agriculture sector lock the small-scale farmers in a vicious cycle of stagnation.

The problem of land scarcity is aggravated by widespread land degradation. Manifestations of land degradation vary from accelerated erosion in high-rainfall areas to desertification in arid and semi-arid ones. Other forms of soil degradation on the continent include loss of organic matter, nutrient depletion, soil biodiversity loss, acidification, salinization, and waterlogging (FAO and ITPS 2015). The rangelands are particularly notorious for productivity loss caused by bush encroachment in Southern Africa and for soil-related problems such as depletion of

the seed bank due to erosion in the northern parts of the continent.

1.2 Soil Science and Food Security in Africa

Statements about the importance of soils for life on Earth, agriculture, and the global economy may be found in every soil science textbook and in every proposal for funding soil-related research. There is no need to repeat them here. The contribution of soil functions to ecosystem services has led to the alignment of soil research priorities, with political declarations such as the Millennium Development Goals emphasizing soil health (Sanchez and Swaminathan 2005). The link of soil health to the Sustainable Development Goals (SDGs) is quite clear and was well described by Bouma (2014), as was the significance of soils and soil science toward realizing the SDGs (Keesstra et al. 2016). A critical review of soil fertility research contribution to African agriculture in the past 50 years and suggestions regarding the way forward were recently provided by Vanlauwe et al. (2017).

Until recently, primary agricultural production was seen as a low-tech industry and a plight of the poor or a burden on the shoulders of the landed gentry. A decrease in the contribution of agriculture to national GDP is still seen as a sign of economic development. Subsequently soil science for a long time was frowned upon as a servant of the poor (and remains so in many parts of Africa at the expense of the charitable rich).

It has been widely recognized that achieving food security is a complex challenge that requires a broader perspective that integrates socioeconomic factors with agricultural science and relevant technologies (Montanarella and Vargas 2012).

Agricultural science considers soil to be a direct part of crop production/productivity. In this case, the focus on soil is often blurred or shadowed by other topics such as fertilizer use (plant physiology and agricultural chemistry), plant genetics/seed and crop improvements, molecular biology, and so on. In agriculture, soil science expertise is often provided by professionals who have some form of soil science background but did not study soil science as a primary degree (such as agronomists).

According to many soil professional sources there is a general perception that the human capital and expertise in soil science in the focus regions of this study are presently insufficient to address the food security and environmental challenges of the 21st century. Since the above-mentioned tasks are directly linked to the SDGs, concerns regarding the human capital have drawn the attention of the World Bank.

The main question posed by investors into agricultural research and development is whether additional investment into maintaining and expanding human capital with soil expertise will produce significant returns in terms of improved quantity and quality of agricultural output, conservation of wildlife habitat, and overall quality of life for human populations. Seeing soil expert advice as a service it is also important to have a clear understanding of how this service is currently delivered and paid for in different countries and how it is valued by the service recipients. In this case, the size of the farming enterprise is less critical, but the return on investment and the annual income from farming would determine the minimal economic farm size (Hall, Scoones, and Tsikata 2017) and the accessibility of soil advisory services.

For most of the 20th century, soil advisory services in Africa were sponsored by governments and most soil scientists were government employees. Now the job market for soil scientists is starting to change. This study will show that in some African countries private advisory services are gaining traction.

1.3 Soil Science and Its Relationship to Agriculture, Development, Nature Conservation, and Economic Growth

Ways to improve soil for agricultural production and protect soil from erosion have been known to

man since prehistoric times. The geomorphological evidence of these efforts is present worldwide (Dotterweich 2013).

The first records of attempts at soil conservation with public funding and participation in Africa go back to the days of the Cape Colony (in what is now part of South Africa). The devastating 1862 drought stirred public concern and J. C. Brown, the Colonial Botanist, initiated a campaign for soil conservation that included farm visits, lectures, and interaction with the government of the Cape Colony (Grove 1989). This activity preceded (though only just) the famous book by Marsh (1864), which initiated a movement for soil conservation in the United States.

Soil conservation efforts developed into a science in the 20th century—what we now know as *soil science*. Progress has been made not only in soil conservation efforts but also in agricultural output, optimization of land use, and so on. The success of applying technologies based on advances in soil science varied from country to country (Mutsaers et al. 2017). In East Africa, however, the contribution of soil science was "modest" at best (Muchena and Kiome 1995), despite substantial investment going into the Kenyan Soil Survey. Widespread commercial farming in South Africa and, until recently, Zimbabwe, allowed soil science to make a much more profound contribution simply because of the better financial position of the farmers, who could afford to conduct farming operations with the advantage of modern research (Fey 2004; Whitlow 1988).

The advancement of science, economic development, and political processes often have different agendas. In fact, natural sciences as such do not actually have an agenda, apart from examining the composition and properties of the system components and understanding their interactions in relation to system optimization for specific purposes. In case of soil science, such inquiry is focused on a thin layer of loose material separating rock from the fluids above (waters and atmosphere) and its interactions with the biosphere. As the famous ecologist M. Samways once put it, "soil is simply a few centimetres between Life and Death."

Expertise in soil science is required for:

- scientific understanding of the functioning of the Earth as a habitable planet;
- compiling resource inventories for the use and conservation of agricultural resources and wildlife habitats;
- conducting land assessment and land use planning for agricultural development from farm to regional scale;
- ensuring national and regional sustainability of agriculture by planning and managing the state of soils and modeling sediment, salt, and pollutant redistribution within an operating agricultural system;
- managing soil fertility and enhancing crop productivity;
- optimizing land use and management at a given location within the constraints of nutrient and water supply and soil degradation hazards; and
- rehabilitating landscapes transformed by agriculture, mining, and industrial development.

Advances in soil science provide new insights into the optimization of soil management in agricultural production technologies and the conservation of soils as a natural resource. The issues of soil degradation in agriculture are of particular concern, since land users often either do not seek or ignore advice on soil management for various reasons, often with disastrous results. The consequences of not seeking or ignoring more sustainable soil management advice range from product under-recovery (yield gap) to severe land degradation, bankruptcy, and land abandonment.

Optimizing soil conditions for agricultural production is one of the main tasks of soil experts who provide advisory services to farmers. The complexity of this task is rooted in science itself.

Here it may be appropriate to note the science-industry links in applied research. The atmospheric and ocean sciences have strong support from military and navigation applications. Geology is rapidly advancing with the financial backing of mining, oil, and gas industries. Biology is largely focused on pharmaceutical and health markets. Soil science mainly relies on agricultural primary production, often with emphasis on crop production as well as the regulatory demands imposed on various industries by the environmental lobby. Rapidly expanding environmental regulations are now some of the main drivers of soil research with feedback to new policies. This cycle is also creating jobs for soil scientists in policy development and enforcement as well as in consulting, which has the aim of avoiding non-compliance penalties.

1.4 Human Capital in Soil Science in Africa

Like any other university degree, a degree in Soil Science is an investment. In Africa it is an investment by the student who sacrifices four to five years of possible work experience and income, the parents who have to carry the cost of the student's upkeep during these years of deferred remuneration, and the state that heavily subsidizes tertiary education in every African country.

This section tries to find out what constitutes the return on this investment and how can we assess the risk of such investment into building human capital in soil science in Africa. To do that we analyze the current state of affairs and future projections for soil science by asking the African representatives in the Global Soil Partnership (GSP) and the soil science degree holders themselves, and by studying the professional profiles of soil scientists on LinkedIn.

Soil expertise is critical for successful agricultural production. The success of soil science in recognizing limitations imposed on plant growth by different soil characteristics is widely recognized. Many technical solutions to soil-related problems in agricultural production are readily available, but they require on-site soil inspection or at least a soil sample analysis for successful application. This makes soil experts some of the key people in agricultural development and intensification of agriculture.

Here we would like to distinguish between *soil expertise,* the knowledge of soil-related problems and solutions, *and soil science,* the study of soils as complex systems combining biotic and abiotic components and their interactions.

Soil expertise is not limited to soil scientists, since students of agronomy, horticulture, and many other agricultural sciences acquire some level of soil expertise during their studies. Soil science is taught at all agricultural colleges and universities as a compulsory subject. For example, for a period of time in Morocco there was no university awarding a soil science degree, but some 30 soil scientists who studied elsewhere taught at agricultural colleges across the country (Badraoui 2006). The graduates may successfully apply their knowledge in agricultural practice, especially after gaining some location-specific in-service experience.

For the purpose of this study, we focused on scientists with formal university degrees of various levels (BSc, MSc, PhD) in soil science and their role in the scientific advancement, economies, and development of the study regions.

1.4.1 Soil Science Societies in Africa

The International Union of Soil Sciences (IUSS) is a professional and scientific union that works with national soil science societies, assists with the organization of events (conferences, seminars, etc.), and serves as a gateway for soil scientists to interact with each other through committees and working groups. The Union was established in 1924 as the International Soil Science Society (ISSS)—a professional organization fully supported by membership fees and private donations. The society joined the International Council of Scientific Unions (ICSU), affiliated with the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1993, and was rebranded as a union to satisfy the ICSU membership requirements.

The main event organized by the IUSS is the World Congress of Soil Science, which is held once every four years. The IUSS also publishes a monthly bulletin distributed to the members via email, which is also available on the society website https://www.iuss.org/ with some delay.

The IUSS offers individual membership and group membership. The cost of transferring individual membership fees from any African country to the IUSS, which has its headquarters in Europe, is comparable to the value of the membership fee itself. Even with the appearance of credit cards and PayPal, the practice of collecting membership fees via direct bank deposit through national societies has not changed. This is one of the reasons why IUSS membership in African countries is rather low relative to the number of practicing soil scientists.

National soil science societies are scarce in Africa. According to our correspondence with the IUSS secretariat in April 2018, *"Only a small proportion of national soil science societies in Africa are IUSS members: Burkina Faso, Egypt, Ghana, Nigeria, South Africa, Sudan (no contact since 2014), Tunisia (no contact since 2015), Uganda (no contact since 2015)."*

The three most numerous and most active societies in Africa are associated with the three largest economies: Egypt (≈780 members), Nigeria (≈1,490 members), and South Africa (≈370 members). All three of these societies hold regular national congresses and publish national journals, and often also serve the communication needs of the scientists from neighboring countries.

Regional structures are not common. The exception is the Soil Science Society of East Africa, which was created in 1975 to facilitate interaction between the soil scientists of Kenya, Uganda, and Tanzania with the IUSS because of the small number of soil scientists in each individual country. While the national numbers have grown, the three-nation structure remained and holds regular biannual conferences.

Some countries—such as Ethiopia (≈300 members), Zambia (≈250 members), and Zimbabwe (≈100 members)—have fairly numerous national soil science society members to maintain local communication and networking, but do not contribute to the IUSS.

There is also an African Soil Science Society (ASSS) (http://asssonline.org/)—an IUSS-initiated structure that has existed since 1986 and has occasionally managed to hold a continental-scale conference entirely at the expense of foreign donors. The last ASSS conference was held in Burkina Faso in 2016. Unlike the IUSS and the national soil science societies, which rely on member contributions, the ASSS is a typical international non-profit organization operating on an ad-hoc basis by soliciting donations from governments and international organizations for its activities, with varying degrees of success. It does not seem to have any private or corporate members. Neither does it seem to have an internal operating structure (divisions, commissions, working groups). For lack of members it does not have a membership list or any way of communicating with African soil scientists except through the IUSS, international organizations, and national soil science society contacts.

The total number of soil scientists in Africa is unknown. Even in the countries where soil science societies do exist, not all soil science practitioners chose to be members of such a society.

1.4.2 African Soil Science Networks and Initiatives

The 1980s witnessed the peak of activity in the establishment of various soil-related networks and programs. Some of the most popular funding streams were directed toward funding various networking activities. These mostly amounted to organizing conferences and workshops with scientists and people from various walks of life (farmers, government officials, and laymen) to create awareness and spread knowledge at the expense of knowledge production. Some such networks also became players in competing for research funding previously directed toward supporting national research institutions. This allowed such networks to conduct some independent projects as research or development implementation

agencies. The most prominent and successful of these was the Tropical Soil Biology and Fertility (TSBF).

TSBF: Tropical Soil Biology and Fertility (1984–2001)

The TSBF was launched in 1984 as the Tropical Soil Biology and Fertility Programme with an aim to "Strengthen national and international capacity to manage tropical ecosystems sustainably for human well-being, with a particular focus on soil, biodiversity and primary production; reduce hunger and poverty in the tropics through scientific research leading to new technology and knowledge; ensure environmental sustainability through research on the biology and fertility of tropical soils, targeted interventions, building scientific capability and contributions to policy."

After several funding cycles the program was absorbed by the International Center for Tropical Agriculture (CIAT) in December 2001, when an agreement between CIAT and the TSBF Programme resulted in the latter becoming an institute of CIAT. In part, this step was necessary to reduce the human cost of program closure and transfer some of the human resource liabilities to the Consultative Group on International Agricultural Research (CGIAR). The institute ceased to exist prior to 2015.

AfNET: African Network for Soil Biology and Fertility (1988–2001)

Established as the TSBF implementing agency in Africa, AfNET ceased to exist as an independent network when it became a platform of the CIAT Soils Research Area.

Another international development–oriented soil research structure—the International Board for Soil Research and Management (IBSRAM) (1983–2001)—generated several networks: ASIALAND Management of Acid Soils; ASIALAND Management of Sloping Lands; and PACIFICLAND Management of Sloping Lands and Soil Erosion Consortium. IBSRAM followed the fate of TSBF by being absorbed by one of the CGIAR institutes—the International Water Management Institute (IWMI). Subsequently the non-core soil-focused programs at IWMI were phased out as part of the CGIAR business restructuring.

A few of smaller "networks" have been implemented since then, most of which did not live through more than one funding cycle. One of the recent networking projects with all-Africa ambitions is *Le réseau Carbone des Sols pour une Agriculture durable en Afrique* (African Soil Carbon Network) (http://www.reseau-carbone-sol-afrique.org/historique), which started in 2013.

A new global network hosted by the Food and Agriculture Organization (FAO) of the United Nations—the **Global Soil Partnership (GSP)**—was established in 2012. Because of the nature of FAO operations, the GSP focuses on interaction with national governments but includes numerous private and institutional partners. The GSP was a major conduit of information for this study through its national focal points, most of whom are representatives of national government through agricultural ministries.

In this context, informal networking platforms offered by the Internet companies become a useful and mostly free-of-charge way for soil scientists in Africa to truly communicate, to share their interests and achievements outside of the formal setting imposed by the format of scientific journals. One such network—**LinkedIn**—was used in this study.

1.4.3 The Global Soil Partnership

Ensuring food security for growing populations over the long term depends on the availability of sufficient fertile soils and water to produce high-quality food in sufficient quantities. Global soil resources are limited and considered non-renewable in the human time frame. These resources therefore need to be managed sustainably to ensure the availability of sufficient fertile soils for future food production (Montanarella and Vargas 2012; Montanarella et al. 2016).

The GSP (http://www.fao.org/global-soil-partnership/en/) was established under the FAO in 2012 as a framework based on partnership and participatory approaches at all levels (from the local to global scale) to support sustainable soil management

(SSM) for all land uses. This was in recognition that the development of specific soil management measures appropriate for adoption by local decision makers would require multilevel, interdisciplinary initiatives by many stakeholders through effective partnerships (Montanarella et al. 2016). In 2015 the Intergovernmental Technical Panel on Soils (ITPS) of the GSP published an assessment of the status of soil around the world, its role in providing ecosystem services, and the threats to its continued contribution to these services (FAO and ITPS 2015). The specific global threats to soil functions that support the provision of ecosystem services identified in the report are erosion, compaction, acidification, contamination, sealing, salinization, nutrient imbalance (both nutrient deficiency and nutrient excess), losses of soil organic carbon and biodiversity, and waterlogging. The ITPS concluded that current trends in soil condition may result in serious negative consequences that will affect large parts of the population in vulnerable regions in the forseeable future. It further considered the global community to be ill-prepared and ill-equipped to adequately rise to this challenge, unless countries change trajectories to address four main priorities: (1) to implement sustainable soil management to increase the supply of healthy food; (2) to stabilize or increase global stores of soil organic matter; (3) to stabilize or reduce global nitrogen (N) and phosporus (P) fertilizer use and simultaneously increase fertilizer use in regions of nutrient deficiency; and (4) to improve the availability of soil data to boost knowledge about the current state of and trends in soil condition (Montanarella et al. 2016).

To facilitate the implementation of GSP activities and establish an interactive consultative process with national institutions working with soil-related issues, Regional Soil Partnerships (RSPs) were established. The RSPs work closely with FAO Regional Offices and build on existing regional networks and processes to provide guidance on regional goals and priorities related to sustainable soil management. Countries included in this study fall under two RSPs: (1) North African countries fall under the Near East and North Africa (NENA) Soil Partnership; and (2) Sub-Saharan African countries fall under the African Soil Partnership (AfSP). At the national level, GSP national focal points are designated by FAO member country representatives to interact with the Secretariat and GSP partners.

The GSP's mandate is to improve the governance of soil resources to guarantee agriculturally productive soils to support food security and the provision of ecosystem services. As a voluntary partnership, the sovereign right of each state over its natural resources is respected and adhered to. In order to achieve its mandate, the GSP addresses five pillars of action to be implemented in close collaboration with its RSPs. These five pillars focus on: (1) promoting sustainable soil management; (2) encouraging investment, technical cooperation, policy, education, awareness, and extension in soil; (3) promoting targeted soil research and development; (4) enhancing the quantity and quality of soil data and information; and (5) harmonizing methods, measurements, and indicators for SSM. The development of human capital in soil science and soil science expertise therefore falls under the umbrella of Pillar 2.

Regional implementation plans were developed for seven of the GSP RSPs, including NENA and AfSP. These implementation plans define the regional priorities in terms of soil challenges, as well as outcomes and activities to be implemented over a five-year period under the five GSP pillars. However, dedicated funding has not been available for all activities in these implementation plans; thus they were in part prepared to provide the priorities for the allocation of available financial resources and to support fund raising processes.

The regional implementation plan for the NENA region (which includes Algeria, Egypt, Libya, Morocco, Sudan, and Tunisia) states that soil degradation is driven by the complex interaction of various aspects such as climatic and economic factors, institutional challenges, national policies, conflicts, and population growth and pressure. The mismanagement of croplands and inappropriate use of water resources in irrigation, unplanned urban expansion, land encroachment, overgrazing, and infrastructure extension are some of the major causes of soil degradation listed in the plan. The plan also states that low priority is often given to

soil degradation by governments as a result of weak political will (GSP/FAO 2015).

Generally, in terms of improved soil management, the implementation plan prioritizes the need to create a decision support system for target areas to effectively assess and improve soil quality as the main element of natural and cultivated capital, as well as to conserve good-quality soils and rehabilitate degraded soils. This includes the implementation of relevant SSM and sustainable land management (SLM) practices and monitoring the impact of such implementation on soil quality. The plan also calls for the promotion of soil science throughout the whole education process as well as during the production of agricultural products. It highlights the need to assess the available capacities and training needs of local technicians, teachers, and stakeholders alike. It suggests that soil education should be included in both primary and secondary school to allow learners to observe the life cycle of annual and perennial crops and understand the vital role of soil as an anchor for plants and buildings, a source of nutrients, and a filter for water. In terms of tertiary education, the plan notes that many universities have decreased soil science training or converted soil science into an optional subject. As a result, there is a shortage of young soil scientists to follow the implementation of soil-related projects and to design, assess, and monitor soil protection and management practices. Activities listed in the implementation plan therefore include introducing soil science in primary and secondary school curricula and throughout the full education and professional process, activating extension services on SSM/SLM, and linking soil science to other disciplines to attract young people and support the role of soil in, for example, natural resources and geospatial sciences (GSP/FAO 2015).

In Sub-Saharan Africa (in the AfSP) soil is considered to be the main resource base for many people, especially the rural population. In the AfSP regional implementation plan, sustainable soil management is considered to be vital to achieve the goals of food security and increasing resilience to climate change in the region. With about 65 percent of arable lands, 30 percent of grazing land, and 20 percent of forest soils degraded in the region, restoring soil and increasing food production is critical in Sub-Saharan Africa. Some of the main soil management challenges in the region include crop production on poor-quality soils using poor management practices, often accompanied by the low use of external inputs. With time, this results in further soil degradation and subsequent declines in food production and quality. Low soil productivity and perceived yield gaps in many countries often lead to importing food instead of producing enough domestically.

To support the implementation of SSM in the region, the implementation plan proposes the establishment of a regional tertiary soil science training exchange program to increase the number of soil scientists trained. In many tertiary institutions, soil science is taught as primary degree and often it has not been integrated into agricultural and other environmental science programs or courses. The purpose of the exchange program is therefore to enable students from countries where soil science degrees are not available to study in other countries in the region. In addition, the assessment of soil curricula at the tertiary level is proposed to identify curricula in need of updating or review. The implementation plan further proposes that soil science education be included at the secondary school level to educate learners from a young age on the importance of soil. To support the provision of soil extension services in the region, an activity is included to implement the Global Soil Doctors Programme, with land users as the main target audience (GSP/FAO 2016). The Global Soil Doctors Programme is being developed under the GSP to promote the establishment of a farmer-to-farmer training system that would build the capacity of smallholder farmers in the practice of SSM and soil testing methods.[1]

Meetings for the NENA and African Soil Partnerships were held with GSP focal points in June 2018 at FAO in Rome to review activities implemented to date

[1] For details about the Global Soil Doctors Programme, see http://www.fao.org/global-soil-partnership/pillars-action/2-awareness-raising/soil-doctor/en/.

and national priorities in relation to the regional implementation plans for the period 2018–19. The African countries represented during the NENA meeting were Algeria, Morocco, Sudan, and Tunisia. Some of the challenges impeding the implementation of soil-related activities concerned with human capital were listed as the lack of developed extension services, a lack of awareness among rural communities about the consequences of soil degradation, and insufficient human capacity to support the Sudan Soil Information System (SUSIS), for example (GSP/FAO 2018a).

The AfSP meeting was attended by national focal points or their representatives from 32 countries, who presented the soil-related activities implemented since the last regional meeting in 2015 and highlighted priorities for future activities (GSP/FAO 2018b). Prior to the meeting, focal points were asked to complete a questionnaire to indicate their priorities in terms of SSM in preparation of a dedicated soil program launched under the GSP for Africa called *Afrisoils: Boosting soil productivity for a food and nutrition secure Africa,* which was discussed during the meeting. Among other questions, focal points were asked whether more soil scientists are needed in their countries, to which all respondents answered "yes." During feedback in the meeting, most if not all countries specified the need for capacity development to:

- train more soil scientists;
- train existing soil scientists in digital soil mapping (DSM), geostatistics, soil pollution control and regulatory frameworks, soil and water management, and more;
- train technicians in soil testing and soil laboratory methods;
- train soil extensions services; and
- enhance farmers' capacity to adopt and use SSM technologies.

1.5 Objectives

The objectives of this report are to focus on the perceptions of soil science individuals and those working with soil scientists to provide an overview of:

- the status quo of human capital in soil science in Africa,
- the current need for soil scientists in Africa, and
- soil science education and training at tertiary level.

2 Methodology

The core methodology of this research was based on opinion polls.

A stratified approach was followed, which included the following five lines of investigation:

1. Assessment of African soil science presence on LinkedIn.

2. Broad-based electronic survey of soil scientists with voluntary participation.

    a. The survey, based on the Google Forms service, was launched via an announcement in the IUSS bulletin, which published the call for participation in its May 2018 bulletin.

    b. The call for participation was also posted on the Facebook pages of the IUSS and the South African soil science society, both of which have a large following of many African soil scientists.

    c. Further effort was made to contact the available national soil science societies with a request to circulate the call for survey participation to the national society members. We approached some known soil scientists with the same request in the African countries that do not have a formal scientific union structure for soil scientists.

    d. Additional effort was made to promote participation via LinkedIn professional networking. The call was published on the IUSS LinkedIn page. Apart from that, Dr. A. Rozanov invited all the African soil scientists (LinkedIn members with degrees in soil science) as personal contacts. The total number of such contacts was 445.

3. Email correspondence with the Global Soil Partnership (GSP) focal points in Africa or, in isolated cases, other individuals actively involved in the GSP to determine the need for human capital in soil science at national levels. Emails were sent individually to GSP members in either English or French, and in some instances extended communication was entered into to discuss responses or request clarification.

a. The following questions were posed:

1. Are more soil scientists needed in your country?

2. Do existing soil scientists need more knowledge and skills to implement and support SSM?

3. Are there sufficient soil research and extension services in your country?

4. Do soil research and extension services need more knowledge and skills to implement and support SSM?

5. Do farmers have sufficient capacity and knowledge of SSM and relevant practices?

If the answer to Question 1 is yes, can you please clarify further below?

6. What are more soil scientists needed for? (i.e. for soil survey, soil mapping, research, advisory services, consulting services, education, or others).

7. Where are soil scientists needed? I.e. in government, universities and/or colleges, private sector, research institutions, farmers' cooperatives, consulting companies, sales and marketing (i.e. fertilizer companies), corporate agribusiness, or others?

8. Do you have a rough estimate of how many additional soil scientists would be ideal and their specific expertise needed (i.e. for soil survey, soil mapping, research, advisory services, consulting services, education, or others)?

9. Is there succession planning in place to support the replacement of retirees and keep the existing positions filled?

4. Email and personal correspondence with individuals from selected key institutions in or involved in Africa to determine the need for and use of human capital in soil science at institutional level. Emails were sent individually to institutional representatives.

   a. The following questions were posed:

      1. Do you need/use soil scientists in your projects? For what kind of projects? (i.e. research, soil restoration, implementing specific agricultural production systems, etc.).

      2. What are soil scientists needed for within projects? (i.e. for soil survey, soil mapping, research, advisory services, consulting services, education, others).

      3. Do you work with national extension services and if so, are these sufficient in terms of understanding soil issues?

      4. Are capable, experienced soil scientists easy to find or do you ever perceive a shortage?

      5. Do you have criteria in terms of the level of advanced soil science degrees required? I.e. Undergraduate, MSc or PhD?

      6. Has the need for soil scientists increased or decreased over the last 10–20 years?

      7. Do you employ soil scientists in-house or use consultants as needed?

      8. Do you try to find local/African soil scientists or international, or both?

      9. Do you think more soil scientists are needed in terms of the work your organization is doing, or perhaps existing soil scientists need more specific expertise? If yes, for what purpose?

      10. If there was funding available to support soil-related work to improve general soil health and productivity in Africa for increased sustainable food production and agriculture, would it be well-spent to train more soil scientists?

   b. The above questions were posed to the following Institutions:

      - Agricultural Transformation Agency (ATA)
      - International Centre for Tropical Agriculture (CIAT)
      - International Fertilizer Development Centre (IFDC)
      - International Fund for Agricultural Development (IFAD)
      - Agricultural Research Institute of Mozambique (IIMA)
      - International Institute for Tropical Agriculture (IITA)
      - International Maize and Wheat Improvement Center (CIMMYT)
      - World Agroforestry Centre (ICRAF)

   c. General communication was entered into with the following institutions:

      - Bill and Melinda Gates Foundation (personal communication via Skype)
      - International Food Policy Research Institute (IFPRI) and its Agricultural Science and Technology Indicators (ASTI)
      - International Water Management Institute (IWMI)

One of the initial requests in the terms of reference for this work supplied by the World Bank was a roster of soil scientists in Africa.

An immediate question arises in this regard: Do we count the people holding formal soil science qualifications or people working as soil scientists?

After consultations with the World Bank the scope was limited to **people holding qualifications as soil scientists AND working as soil scientists.** This excludes people who do have qualifications, but who are unemployed or employed in a different profession. The latter cases may occur as a result of the scarcity of jobs requiring skilled soil scientists or personal circumstances related to remoteness of residence from the job location, family arrangements, illness, or disability, or simply loss of interest by the individual in soil matters or the soil scientist reskilling for other job options.

In this case, a reasonable rough estimate formulated as a Fermi problem may seem sufficiently appropriate.[2] However, even such a rough estimate of the required human capital rests on the following *a priori* knowledge:

- What duties (tasks) do soil scientists perform at their work places?
- What is the overall scope of work?
- What is the average productivity of a soil scientist in performing the above tasks?

Surprisingly, these seemingly trivial questions cannot be explicitly answered.

[2] A *Fermi problem* is an estimation of a number of the piano tuners in Chicago based on estimation of the number of pianos, required tuning frequency and productivity of the tuners. See https://en.wikipedia.org/wiki/Fermi_problem.

3 Results and Discussion

As mentioned in the methodology section, this assessment is based primarily on the opinions and perceptions of individuals, and results should be considered and interpreted in this light. Opinions were mostly obtained from individuals expressing their views about their own careers, the organizations they work for, or the countries in which they live and work. It is therefore possible that others from the same organizations or countries may not agree with responses captured in this report. We have made every effort to respect and maintain the integrity of the opinions as provided, and where assumptions were made in their interpretation, this is clearly stated in the text.

3.1 How Many Soil Scientists Are in Africa?

One of the tasks given to us by the World Bank was to estimate the number of soil scientists in Africa and provide an assessment of future requirements for soil scientists on the continent. The exact number of soil experts was not possible to obtain because of the lack of registration procedures for soil science professionals in most African countries. Such statistics are simply not collected. The only exception is South Africa, but there the number of registered professionals constitutes less than half the number of soil science society members. Professional registration is required only for consulting soil scientists.

The graduation numbers from African universities would have been a rather reliable source of information, except that some countries (e.g., The Gambia) do not have universities offering degrees in soil science, so students from those countries who are interested in soil science are compelled to study abroad. Many soil scientists of previous generations, from a wide range of African countries, have also studied abroad and would not be reflected in the records of national universities.

We contacted several national soil science societies and some individuals of authority in various African countries to obtain an estimate of current numbers of soil science professionals. The 11 countries assembled in the Table 1 represent almost half the African population and almost a quarter of its land area.

The most populous soil science societies in Africa (in Egypt, Nigeria, and South Africa), which are presented

Table 1. **Approximate Number of Soil Scientists per Country, 2018**

Country	Population, millions	Land area, 1,000 km²	Agricultural land area, 1,000 km²	Soil scientists			
				Total	Per million population	Per km²	Per km² agricultural land
Central African Republic	5	662	54	2*	0.4	0.00	0.04
Djibouti	1	23	17	1*	1.1	0.04	0.06
Egypt	95	1,010	39	780	8.2	0.77	20.11
Ethiopia	104	1,104	400	300*	2.9	0.27	0.75
Ghana	28	238	136	150*	5.4	0.63	1.11
Morocco	35	446	303	90a	2.6	0.20	0.30
Nigeria	186	924	718	1,500	8.0	1.62	2.09
Senegal	15	196	41	25*	1.7	0.13	0.61
South Africa	56	1,220	974	370	6.6	0.30	0.38
Zambia	16	752	241	250*	15.6	0.33	1.04
Zimbabwe	16	391	162	100	6.3	0.26	0.63
Total	542	6,966	3,044	3,543	n.a.	n.a.	n.a.

Note: Data on numbers of soil scientists are as reported by the soil science societies (rounded to the nearest 10 for the countries with more than 100 society members) or estimated (*) by the local experts. Data on population and land area are from FAOSTAT. n.a. = not applicable.
[a] Data from Badraoui, 2006.

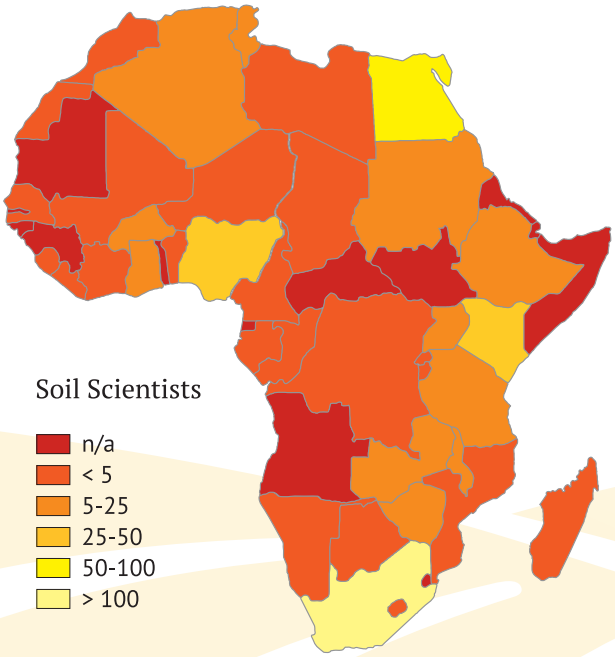
in Table 1 together with some of the smaller soil science communities, would imply that Africa has at least 4,000 soil scientists. However, the average number of soil scientists appears to be around 6.4 per million population and one can expect that the total number may be closer to 8,000 people. The average land area per soil scientist, however, is about 2,500 square kilometers, which may lead us to an estimate of some 12,500 soil scientists on the continent that covers 30 million square kilometers.

3.2 African Soil Scientists on LinkedIn

LinkedIn is a networking tool provided by Microsoft. This network, though less popular than Facebook, focuses on professional interactions rather than social ones. We decided to use LinkedIn rather than ResearchGate (another popular networking service among soil scientists) because the latter is focused on publishing researchers, while we were interested in a broader spectrum of soil scientists.

Personal communication (messaging and email contact) via the LinkedIn network is limited to an individual's circle. To create such a circle, A. B. Rozanov contacted all the African soil scientists that follow the IUSS group on LinkedIn by selecting scientists with an affiliation in African countries. To do that, he analyzed the group membership of more than 3,400 subscribers. A further effort was made to contact soil scientists present on LinkedIn who did not follow the IUSS group. That required a keyword search within specific countries.

Figure 1. **African Soil Scientists on Rozanov's LinkedIn Network by Country**



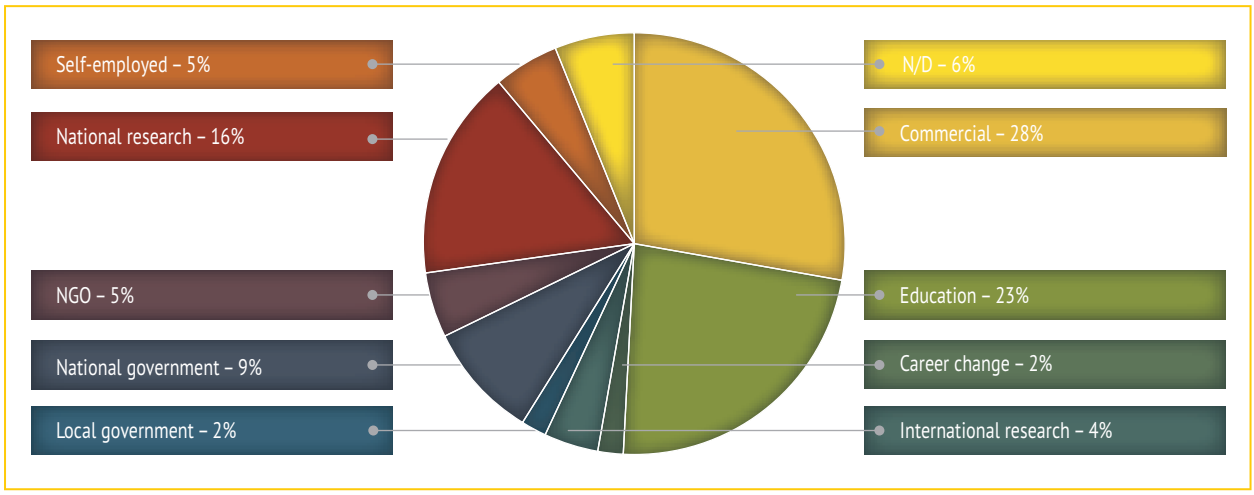
A. B. Rozanov issued 570 invitations to the scientists located in the above manner and created a personal network of 445 African soil scientists who accepted the invitations. The number of his soil science contacts represented in this network per country is shown in Figure 1. Once the network had stabilized and stopped growing, the contacts were downloaded using the built-in LinkedIn tool. These contacts received additional demographic and employment analysis. This study is very small compared with another World Bank–sponsored study, performed jointly by the Solutions for Youth Employment Coalition and LinkedIn on youth employment (Barbarasa, Barrett, and Goldin 2017), but nevertheless it provides a reasonable sample from the community of soil scientists in Africa.

The soil science segment of the LinkedIn network is currently dominated by South African soil scientists, who comprised more than 35 percent of the total number of African contacts (157 out of 445). This may have somehow affected the proportion of soil scientists employed in the commercial sector, which is rather strong in South Africa compared with many other African countries. Indeed, 82 out of 157 (66.6 percent) of soil scientists working in the commercial sector within this network are South Africans. Keeping this skewed distribution in mind, we analyzed the employment of soil scientists in Africa.

All the contacts were manually assigned one of the sectoral affiliations based on the individual LinkedIn profile inspection and the stated most recent place of employment. In some cases, it was difficult to determine the current employment category (some users simply do not indicate their present position). In the latter case the employment sector was noted as N/D (not disclosed).

According to the information provided on LinkedIn, half the soil scientists working in Africa (Figure 2)

Figure 2. **Employment Sectors Associated with the Soil Science Degree Holders on the LinkedIn Network**



Note: All the contacts were manually assigned one of the sectoral affiliations. N/D = not disclosed; NGO = nongovernmental organization.

are engaged in education (23 percent), national research institutions (16 percent), and national and local government structures (9 percent and 2 percent respectively). The industry engages some 33 percent of soil scientists (28 percent are commercial enterprises and 5 percent are self-employed consultants). The international research organizations and nongovernmental organizations (NGOs) (including UN structures) employ 9 percent of the studied population sample. Of the African soil science degree-holders, 2 percent had to change their occupation and 6 percent are most likely unemployed, looking for different opportunities to build a career.

It is often sad to see the broken hopes and aspirations of graduates whose life plans were shattered by unemployment and lack of demand for their skills, which took years of income sacrifice to acquire. Among the LinkedIn users we see soil science graduates working in second-hand car dealerships, the tourism industry, breweries, and various other fields unrelated to soil science, agriculture, or the environment, while still following the IUSS news and applying for jobs in the field of their training.

Gender analysis shows that, among the soil scientists using LinkedIn, only 14 percent are women. The low number of women may be attributed to the nature of soil science as a profession, which may require extended absence from home and the ability to perform physically demanding tasks, raises personal security concerns while conducting field investigations, and so on. As more tasks appealing to women appear in soil studies, the number of women engaged in this field is bound to grow.

We also used the LinkedIn network to promote the awareness of the broad-based World Bank–sponsored electronic survey among the personal contacts, as well among the members of the IUSS LinkedIn group.

3.3 Broad-Based World Bank–Sponsored Electronic Survey

This survey was sponsored by the World Bank and conducted from May 1 to September 1, 2018. The invitation to participate was sent to the soil scientists living and working in Africa through various channels, of which IUSS was the main information conduit.

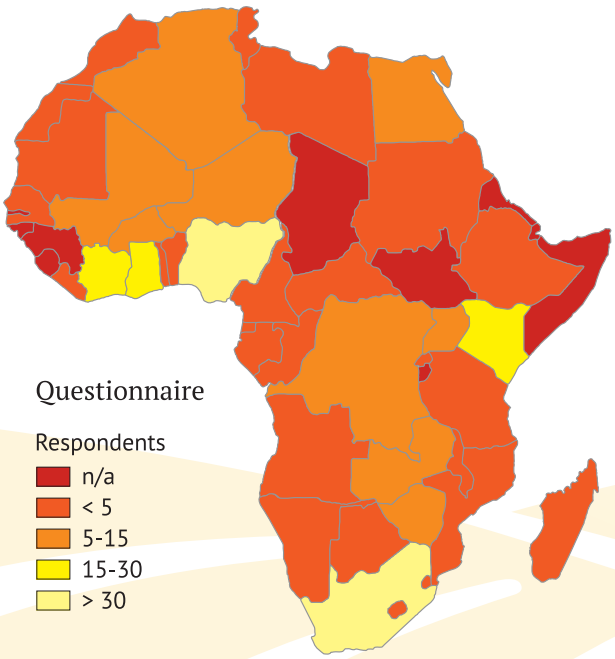
The IUSS bulletin (May 2018 edition) and the IUSS groups on Facebook and LinkedIn were used to promote the survey. The survey was completed, but not closed, on September 1, 2018. The survey was left open for the possibility of more data to be collected in future should more people wish to participate.

In total, 381 responses from 40 (out of 54) African countries were collected using three identical survey forms published in English (314 responses), French (62 responses), and Portuguese (5 responses). Of 381 respondents, 309 (81 percent) contributed comments presented in Appendix 1.

Some 95 percent of the respondents were indeed born in an African country. The survey explicitly asked for the contribution from soil scientists living and working in Africa. The contribution of two Europeans with vast work experience in Africa was also retained in the statistical assessment.

The sample sizes for this survey (381) and LinkedIn analysis (455) were similar and represent close to 10 percent of the estimated population of soil scientists in Africa (conservatively ≈ 4,000 individuals, as suggested in Section 3.1). The survey results corresponded to some extent with the findings of the LinkedIn contacts analysis. The number of responses per country varied substantially (Figure 3) and reflected not only the total number of soil scientists, but also the level of their interest in this survey and their desire to contribute, as well as the extent of our reach using the communication methods mentioned above. In some countries, access to the Internet may be a limiting factor. This obstacle is of particular importance to soil scientists residing in or conducting fieldwork in remote locations with poor or no Internet service.

Figure 3. **Response Level per Country in the World Bank–Sponsored Survey of Human Capital in Soil Science in Africa**



About women. Once again, this World Bank–sponsored survey confirmed that soil science in Africa remains a male-dominated profession (Figure 4), though with a somewhat higher proportion of women (17 percent) than the 14 percent observed on LinkedIn. Their comments, however, clearly show (Commentary Box 1) that the problem is in part associated with the prejudices of some employers rather than with the hardship of being a soil scientist and unattractiveness of this occupation to women.

The stratification of the respondents according to their *education* level (Figure 5) is rather striking, and shows a distinct domination of people with doctoral degrees (53 percent). Only 10 percent of the sample are graduates with a BSc degree or a technical diploma. That may be explained by the fact that the soil science society communication channels are reaching primarily those soil scientists in academia.

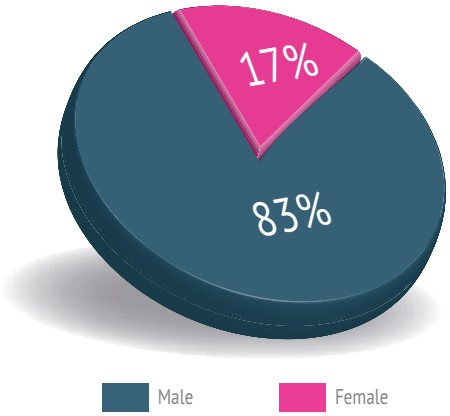
On the other hand, it also shows a low demand for skills with qualifications below the MSc level, which is certainly true for most African countries. We see that directly in respondents' comments. One of the Nigerian soil scientists responded with indignation:

> *As a recent graduate of Soil Science, who is willing to contribute to Soil Science as it relates to agriculture and environment, I am encountering difficulties getting a placement for out-of-school practical work experience (as a volunteer, intern, or even an assistant to any researcher in any organization). There is little or no regard for B.Agric. holders in Nigeria as a result of limited work places. Why these difficulties after 5 years of education?*

The above result is not particularly surprising, considering another remark (Commentary Box 2) showing that soil science is taught in more than 100 tertiary institutions in Nigeria, which obviously results in tough competition for employment in a

seemingly tight job market. According to our study of Internet resources, some 20 Nigerian universities offer specialization in soil science.

Figure 4. **Proportion of Male and Female Respondents in the World Bank–Sponsored Survey of Human Capital in Soil Science in Africa**



Commentary Box 1

- As a female, when looking for a job in soil science, I was laughed at outside of universities. I spent three years doing part-time/underpaid work mainly in … chemical lab analyses, before finding my current job, which still has nothing to do with soil science strictly speaking, but is at least very interesting and challenging.

South Africa

- As a woman, I have struggled to fit in and be recognized as a scientist. Many of us end up working in other fields. … Regionally there are a number of established male soil scientists but they keep the doors closed to the women colleagues. There is a lot that we can do in Soil Science, but we lack resources and conducive environments to use our skills.

South Africa

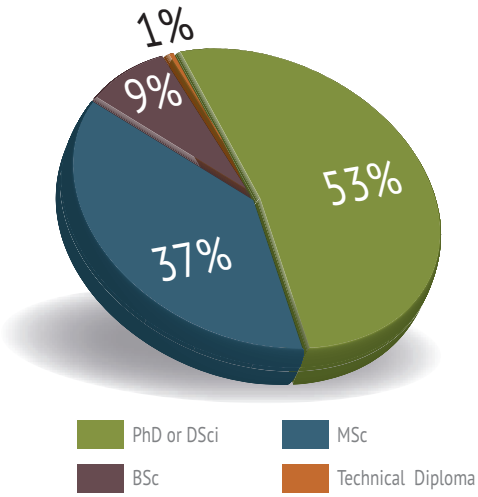
- Je suis pédologue de formation, malheureusement j'utilise 20% de mes connaissances en pédologie dans mon poste actuel, je trouve que les compétences en pédologie ne sont pas assez valorisées.[1]

Tunisia

Note: 1 Commentary to the announcement of the World Bank survey of human capital in soil science in Africa on LinkedIn.

Soil science is taught throughout Africa (Figure 6), mainly as part of agricultural university programs. However, mainly in North Africa (e.g., Tunisia and Algeria), soil science degree studies are offered as part of geology programs within science faculties. Multiple universities on the continent offer both undergraduate and post-graduate programs with soil science as a major or one of the two major

Figure 5. **Level of Education among the Respondents**



Commentary Box 2

- Il faut renforcer et augmenter le niveau de formation en sciences des sols. Ceux qui sont bien formés partent à la retraite alors que la relève n'est pas assurée. Il faut trouver des moyens financiers pour valoriser les expériences des anciens qui vont à la retraite.

Burkina Faso

- Soil Science as a distinct subject started in the 1950s … at the degree level and currently it is being taught in over 100 tertiary institutions in Nigeria. The affiliation of Soil Science as a subject in Agriculture will … expand into environmental issues in the future.

Nigeria

- We still have a lot of investments to do especially in funding of research projects. Currently soil scientists are still in the scarce skills category but the opportunities to prove our services are so limited …

Zimbabwe

Figure 6. **Universities Offering Degree Programs in Soil Science in Africa**

subjects—for example, a BSc in soil science and agronomy.

The underutilization of BSc graduates drives the youth into investing additional years of their lives in advancing their qualifications to the MSc and PhD level. A commentary from Ghana indicates that the numbers of highly skilled soil scientists are expected to continue growing:

> *Compared to the developed world, we still lag behind both in terms of technology, creativity, and human personnel. For the past decade, the trend has been changing with more postgraduates being trained to fill in the void (about 30 PhD soil scientists are being trained in my institution for the past four years alone).*

Education in soil science is one of the main topics addressed by the respondents. Some 10 percent of the comments touch on this issue. They mostly address the inadequate quality of teaching facilities (particularly laboratories), shortage of equipment, lack of funds to maintain it, and lack of skilled personnel to operate it. Low salaries for skilled laboratory personnel (substantially lower than the salaries of academic staff) result in grave skills shortages in the labs and poor performance of both educational and research facilities, low quality and reliability of measurements, and poor or no practical experience for students.

Low student numbers at soil science departments are often justified by the common refrain of the "subject difficulty," "low salaries upon graduation," and general lack of interest on the part of the students. The students complain that lecturers make soil science look "excessively difficult."

Specialization of soil scientists in Africa (Figure 7) is strongly skewed toward soil chemistry and fertility (33 percent). Almost 19 percent are generalists, which is very useful considering that the opportunities to work in large teams of narrow specialists are limited and many soil scientists, particularly those engaged

Figure 7. **Specialization of African Soil Scientists**

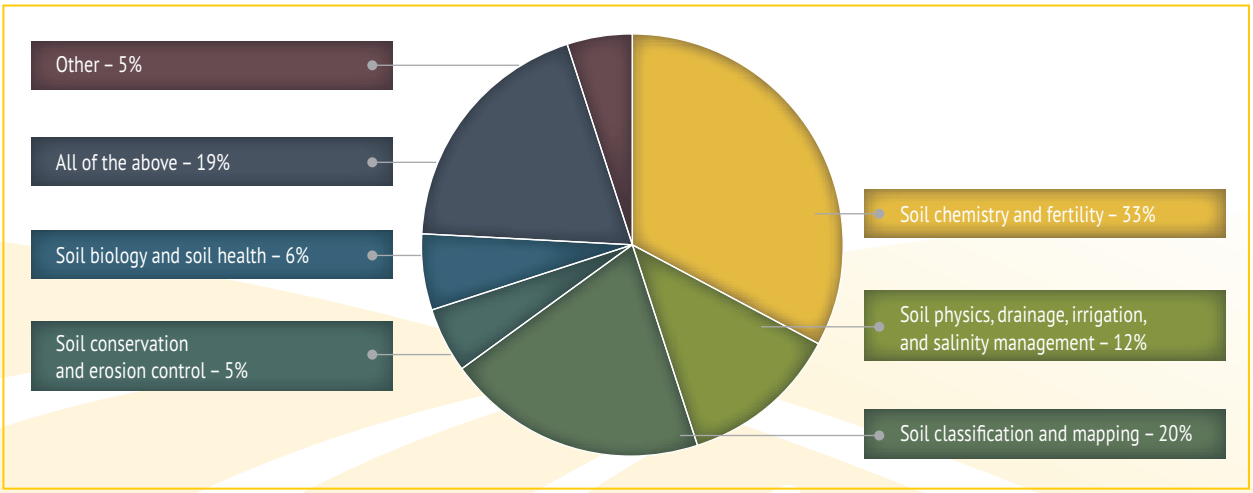


Figure 8. **Distribution of Respondents' Age**

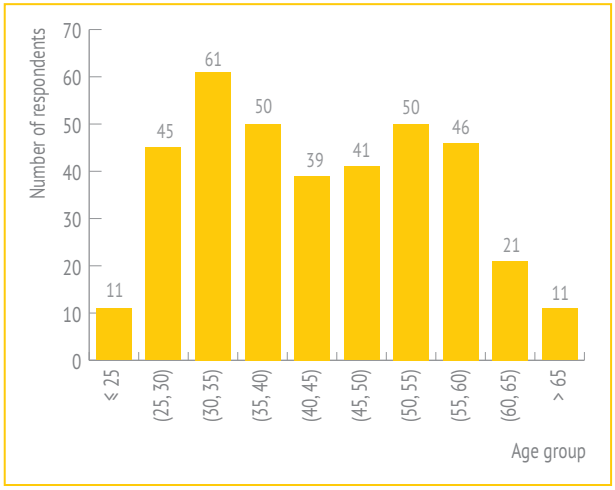
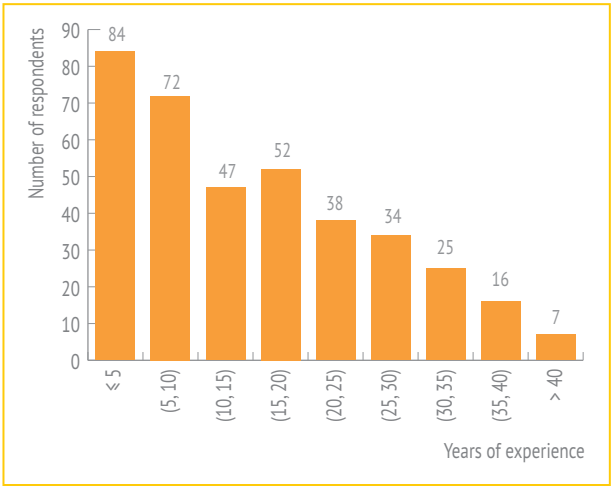


Figure 9. **Years of Professional Experience Reported by Survey Respondents**



with the industry, face diverse and multiple tasks. It is not clear why 5 percent of the respondents chose the option "Other" or how to interpret this choice. It is possible that the latter respondents specialize in rather narrow fields (e.g., clay mineralogy) or have reskilled into other fields such as remote sensing or water management, for example.

The age distribution among respondents gives a clear picture of an almost even distribution, with minor peaks for ages 30–35 and 50–55 (Figure 8). This reflects a normal "generational gap" characteristic of stagnant small organizations with fixed staff structure where vacancies become available only upon retirement, promotion to management, or resignation of existing staff members.

Years of professional experience is another important factor in the assessment of human capital and is part of investment into human capital. We see a strong presence of specialists under the age of 40 with fewer than 10 years of practical experience (Figure 9). However, the problem of employment is acute for many soil science graduates across the continent (Commentary Box 3).

Judging from the responses to this questionnaire and the LinkedIn analysis, the overall risk of becoming a soil scientist and not finding employment in soil science is relatively low; this can be estimated at 4–8 percent. These data are based on the numbers of soil science graduates who could not find employment as soil scientists or have chosen to follow opportunities in other careers. Such risks are not evenly spread between different African countries and require assessment on per-country basis for which this study does not have sufficient data.

Commentary Box 3

- La science du sol est mal comprise par les décideurs et les pédologues sont très mal employés.

Burkina Faso

- Even with graduate papers, acquiring jobs seems so hard. As for me, I do farming so that I can practice all the knowledge I gained.

Kenya

... most soil scientists struggle to be employed and there is still a lot of racism in the discipline of soil science.

South Africa

... more facilities and tools are needed to practically train soil scientists, more employment opportunities are needed.

Zambia

- Presently, there are few soil science jobs available unlike in previous years when there were a number of opportunities available for graduates. If it continues like this, soil science is going to become obsolete.

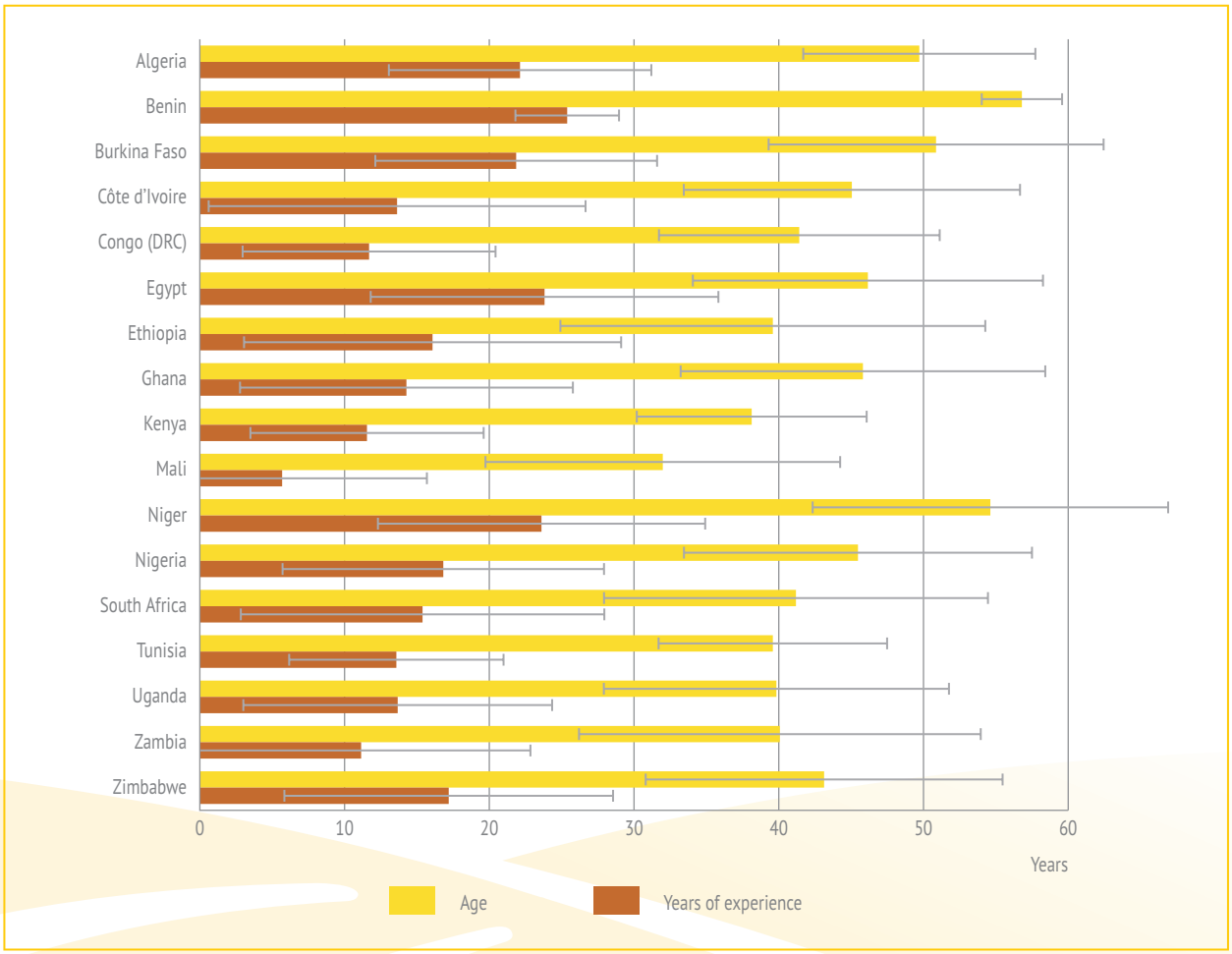
Zimbabwe

A common concern is the aging population of soil scientists mentioned in responses from several African countries. The data in Figure 10 confirm these worries. Judging from the results of this survey, the aging population of soil scientists may be a problem particularly in Algeria, Benin, Burkina Faso, and Niger, where the advanced average age and long work experience are associated with small standard deviations of these parameters. Countries such as Côte d'Ivoire, Egypt, and Ghana should probably start looking into the matters of succession planning.

Good succession planning is important to avoid such demographic problems in the science community. Once the experienced generation is gone, there will be no one to teach the new generation and all the work may have to be restarted. Part of the continuity problem is related to the members of the older generation themselves, who may not have sufficiently documented their experience for future studies by those coming after them. A low level of publication outputs and poor recordkeeping is a common problem for many African research institutions and universities. The importance of knowledge and skills transfer between generations is highlighted in one of the comments from Burkina Faso (Commentary Box 3).

The employment of experienced retirees on a contract basis may be one of the important steps to ensure the continuity of knowledge transfer. In South African universities, such retirees often occupy positions of Extraordinary Professors. Such posts come with no funding commitment on the part of the university, but allow a retired professor to use the university

Figure 10. **Age and Years of Experience, Selected African Countries**



Note: For countries with more than five responses, a more detailed analysis was possible. Error bars represent the standard deviation.

affiliation to solicit research funding, co-supervise post-graduate students, and use the common facilities including the library.

The Democratic Republic of Congo, Ethiopia, Kenya, Mali, South Africa, Uganda, Zambia, and Zimbabwe show a healthy proportion of age and experience distribution, with an average of age of soil scientists near 40 with large standard deviations.

We assume that the very participation of retired soil scientists (1 percent of the respondents) in this survey (Figure 11) indicates their willingness to contribute further to the development of soil science, agriculture, and food security in Africa through consulting and mentoring.

Education and research institutions remain the main **employers** of soil scientists. Some 64 percent of the respondents work in research and education institutions. Soil scientists actively work at (or with) agricultural, development, environmental, and engineering companies as employees or consultants (20 percent of the respondents). Only 3 percent seem to work in production or dealerships associated with agricultural inputs (mainly fertilizers), while 4 percent of the respondents do not practice within the soil science field at all—either as a result of a career change or lack of employment opportunities that require their professional skills. Another group of non-practicing soil scientists is made up of the people in an advanced stage of their careers who have moved into institutional management positions with mostly administrative duties (8 percent).

Looking at the nature of the institutions that employ soil scientists (Figure 12), we see that the education sector in this survey is entirely represented by universities. Although we did not get responses from soil scientists employed at agricultural colleges, we know that they exist, though usually not more than one per college. National research institutions and central and local government employment account for 30 percent of the jobs among the employed (excluding PhD students and unemployed) respondents. However, both local and international businesses (fertilizer companies, farmer cooperatives, etc.) engage only a small proportion—10 percent—of employed soil scientists. Self-employed consultants add substantially to the overall service delivery and comprise 8 percent of the total number of respondents. However, combining the number of self-employed soil scientists with those working in both international and local businesses we see that the commercial sector offers 18 percent of employment—a number significantly lower than the 28 percent observed in the LinkedIn study above.

Despite the relatively small proportion of soil scientists directly involved with the industry, their past and present contribution toward agribusiness in Africa is quite significant. Multiple industries and agricultural commodity producers that employ or

Figure 11. **Employment Sectors Identified by Respondents**

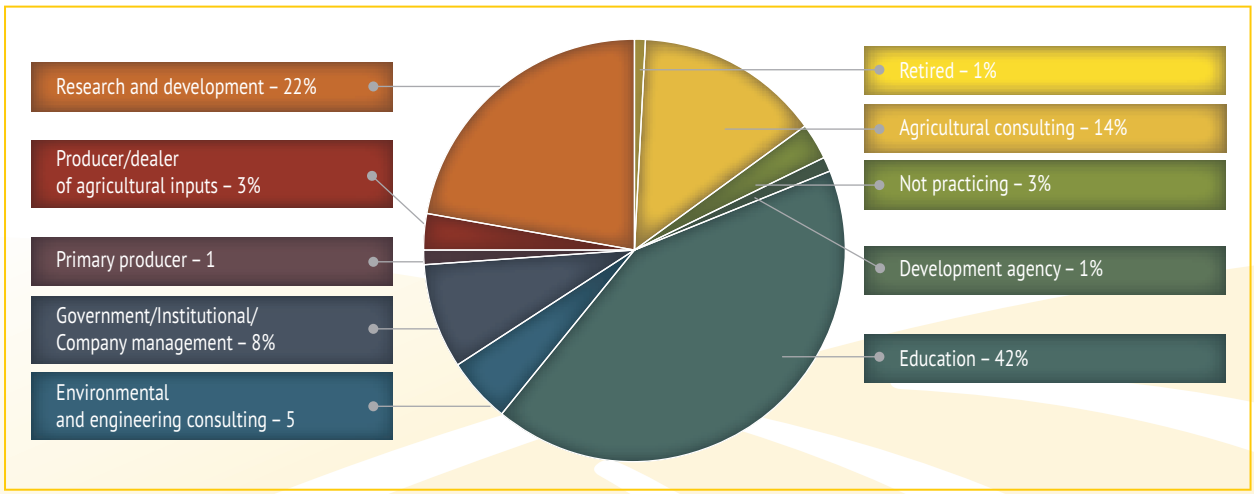
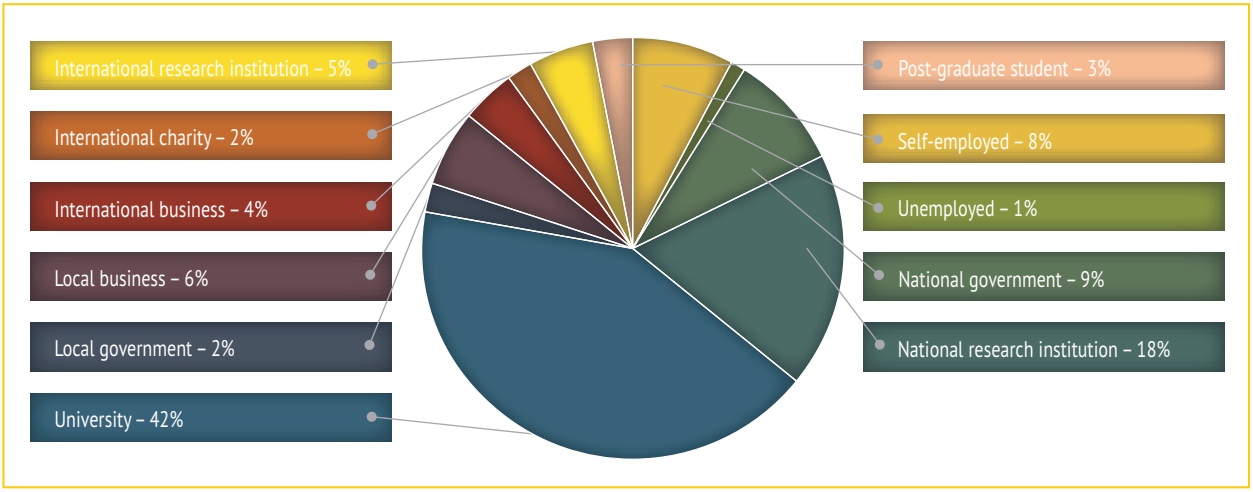


Figure 12. **Occupation/Employer Category among African Soil Scientists**



contract soil scientists (among a wide range of other agricultural experts) show stable and significant growth in both yields and total output throughout Africa. These industries include sugar, cocoa, coffee, tea, banana, macadamia, avocado, wine, timber, and so on.

In contracting specialist services, the size of the producer is of critical importance. Indeed, only large producers (cooperative, government, or private) can afford such services, which include site visits, analytical support, professional reporting, and recommendations. The main characteristic of such businesses and their use of soil consultants is the availability of operating capital to implement the recommendations.

In South Africa, Mozambique, Namibia, and many other countries, large producers often use soil scientists to conduct soil surveys prior to establishing orchards and plantations or repurposing the land use for new crops, installing irrigation systems, and so on. The major South African pulp and timber companies, SAPPI and Mondi, contract soil scientists on a routine basis to guide business expansion, establish new plantations, support site-species matching, and so on.

Processing businesses such as sugar mills often contract soil scientists as part of their extension services to support primary producers—the out-growers, who are often small-scale farmers supplying the industry.

Some industries fund fully, or in partnership with governments, commodity-focused research institutes that employ full-time soil scientists. Here we can mention CRIG (cocoa) in Ghana; MSIRI (sugar) in Mauritius; CRIN (cocoa) in Nigeria; SASRI (sugar) and ICFR (forestry) in South Africa; and NaCORI (coffee) in Uganda; among many other such institutes operating in Africa.

Other industries prefer to collect levies from producers and contract research on a competitive basis as required, a practice common in South Africa. This approach allows them to rapidly change focus from production constraints to marketing, transport, or whatever problem seems to be limiting short-term or long-term business success. Such sectors include wine and table grapes, oil seed, soft fruit producers, and so on.

When it comes to research, the international research institutions (mainly the CGIAR structures, such as IITA, CIAT, and ICRAF) feature prominently; 22 percent of full-time researchers or 5 percent of all respondents are affiliated with them (Figure 12). That fact alone indicates a rather low level of investment into soil research by national governments in Africa.

The funding structure of research globally and, indeed, in Africa started to change in the mid-1980s. That was a time of the major global shift from direct institutional funding of long-term research programs toward

project-based, short-term funding, transforming research groups into businesses in constant search of venture capital. Since venture capital in Africa is quite scarce, its role—particularly in the field of soil science—was taken over by development agencies.

Fundraising became the primary focus of research centers, groups, and networks both national and international. Since venture capital has a rather short patience, many such projects and initiatives terminated after one or two funding cycles, lasting from a year to a decade. Low return on investment and the absence of marketable technologies were, and still are, the main characteristics of such enterprises.

One of the results of the new funding policy was the abandonment of long-term systematic studies in favor of short-term project activities. In soil science, such a funding policy is detrimental to the science itself, since the patchy observations guided by diverse immediate needs at disconnected locations do not contribute much to the broader understanding of soil-landscape relations, soil processes, spatial distribution of soil populations, and so on.

Obscure wishes for business development compete in the minds of researchers with the search for funding to maintain and upgrade the heritage infrastructure (Commentary Box 4).

Commentary Box 4

- Could Institutions engage in profitable ventures to fund their own research? Can we creatively engage with other disciplines to build technology devices to enhance both field study and laboratory analysis? I believe the Science has many job opportunities to offer if we dare to encourage creativity and take advantage of technologies.

Ghana

- Soil science activities in Africa are still in the development stage, obsolete equipment and poor funding affects the sector. Most farmers ignore soil testing. Modern soil scientific equipment is urgently needed and collaboration is also important.

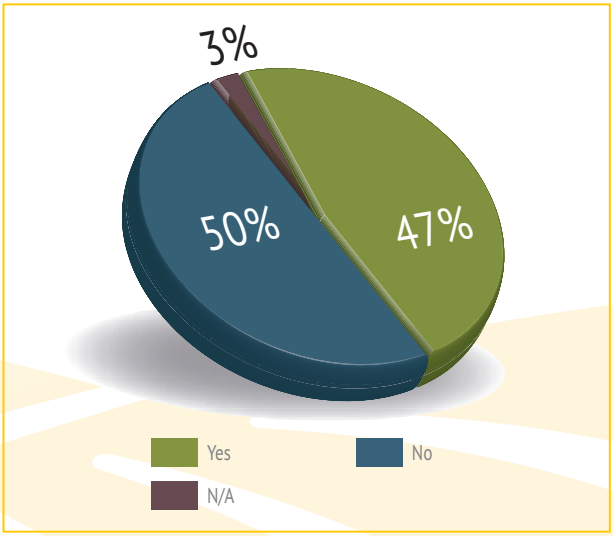
Nigeria

Figure 13 clearly shows that almost half the respondents have to generate funding or drive sales for their employers. For those employed by the fertilizer industry, this is their main occupation, while for those working in education and research it is a major part of their duties, leaving less time for conducting the actual work.

There is certainly still a lot of work for the soil scientists to be done across Africa to inform science, agricultural development, and nature conservation. The urgency of such work is not always clear. When it comes to government funding, the question arises of whether a soil survey is the best investment at any given moment considering a wide range of other problems the African governments have to tackle: from infrastructure development to health care and military challenges. Unlike government funding, private funding of soil science and the provision of soil-related services has clear immediate and long-term needs and objectives. Nonetheless, as we see later in this document, representatives from the GSP highlight soil survey and mapping as one of the primary areas where more soil scientists and work is needed.

The proportion of time soil scientists spend on fieldwork is reflected in Figure 14. Mostly people engaged full time in soil survey (classification and mapping) spend more than half of their time in the

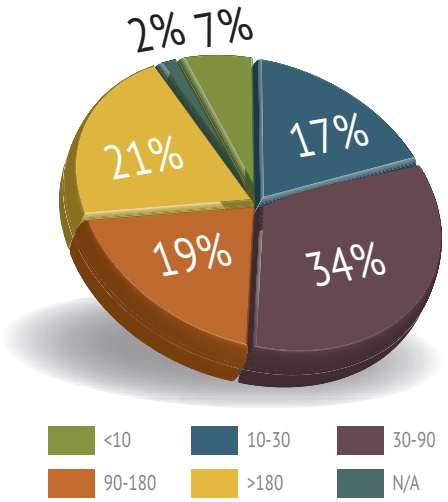
Figure 13. **Do Soil Scientists Have to Generate Funding or Drive Sales for Their Employers?**



field (Commentary Box 5). The researchers associated with universities and research institutions spend less than three months a year on fieldwork.

The overall job satisfaction assessment on a scale of 1 (low) to 5 (high) shows that soil scientists across Africa love their work and are dedicated and happy people (Figure 15a). Here the average score is 3.6±1.0.

Figure 14. **The Number of Days per Year the Respondents Dedicate to Fieldwork**



Commentary Box 5

- Dans mon pays, la science du sol est un domaine connu des institutions administratives activant dans l'agriculture et l'environnement. Beaucoup d'études sur les sols, avec la création de 2 bases de données (Nord et Sud du pays), mais il reste encore à faire malgré les différents programmes de cartographie.

Algeria

- Au Sénégal la pédologie est une comme condition indispensable dans les études des grands projets d'aménagements, l'état a érigé un institut de pédologie qui tarde à prendre son envol par ailleurs …

Senegal

- My company is a new start-up and works with the combination of EMI [electo-magnetic induction] surveys and satellite monitoring services to help our clients better understand their soils and irrigation. As our company grows, we gain more and more acceptance by the local producers.

South Africa

Support services are often regarded as a major stumbling block in the performance of soil studies. We often hear that a lack of cars or fuel for transportation to the study locations, a lack of money for casual labor to excavate profile pits, the poor quality of analytical support, and so on negatively impact the productivity of soil scientists, particularly in the government sector.

Surprisingly, the assessment of the responses across Africa shows a normal distribution for the degree of satisfaction with support services (Figure 15b) with an average score of 3.2±1.1. However, analytical services particulary draw a lot of criticism in the comments (Commentary Box 6), along with problems in workflow funding. As one could expect, the pay satisfaction is slightly below average: – 2.9±1.1 (Figure 15c).

We can provide a more detailed analysis for countries with more than five responses (Figure 16).

The soil scientists in Algeria (4.0 ± 1.1), Benin (4.2 ± 0.8), Egypt (4.3 ± 1.0), Ethiopia (4.0 ± 1.0), and South Africa (4.0 ± 1.0) mostly assess their level of **job satisfaction** as rather high, while the other countries apart from Tunisia show a moderate level of job satisfaction. The nature of the problem in Tunisia with a job satisfaction level of 2.4 ± 1.1 is not clear and requires verification on a bigger population sample and possibly corrective action on the part of the employers.

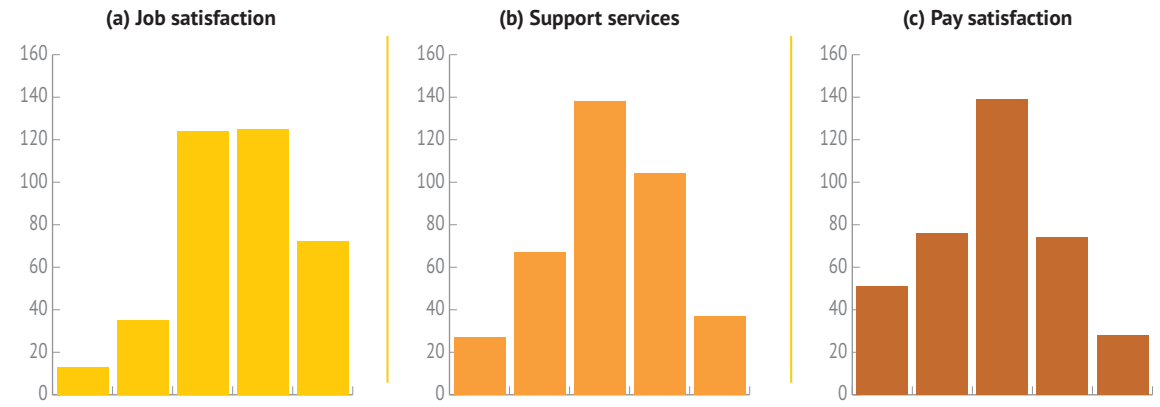
Pay satisfaction is a sensitive issue. No attempt was made to inquire into the absolute values of remuneration in different countries. The respondents from Algeria (2.1 ± 1.2), Burkina Faso (2.6 ± 0.7), Côte d'Ivoire (1.9 ± 0.7), the Democratic Republic of Congo (1.9 ± 1.1), Ethiopia (2.8 ± 1.5), Mali (2.5 ± 1.2), Nigeria (2.8 ± 0.9), and Tunisia (2.0 ± 0.7)—47 percent of the 17 countries used in this survey—feel that they are inadequately compensated.

The soil laboratories are the scapegoats that quietly take the blame for all the failed field trials, inexplicable anomalies in soil samples, and delays in submission of research and contract reports. They mostly work as

subcontractors of soil scientists and do not hear all credit they get in the boardrooms, particularly if they are not affiliated within the organization of the main contractor.

There are three main categories of soil testing laboratories, all of which perform mostly the same type of analysis: government, private, and research laboratories. The latter are usually hosted by

Figure 15. **Number of Respondents Showing Satisfaction on a Scale of 1 (Low) to 5 (High) with (a) the Job Itself, (b) Support Services, and (c) Pay Level**



Commentary Box 6

- La science du sol a toujours existée en Afrique, dans la mesure où, les africains ont toujours maintenu un lien étroit et de respect par rapport au sol et les autres composants du sol.

Malheureusement, l'état actuel de la science du sol est nettement en-dessous du niveau qu'elle devrait avoir. Compte tenu de la qualité des laboratoires en Afrique, du niveau de formation de la majeure partie du personnel qui y travaille et également des salaires nettement en dessous de la qualité des spécialistes et chercheurs qui évoluent dans ce domaine.

Au delà de ces aspects, on peut citer aussi, des liens pratiquement inexistants entre les chercheurs et spécialistes du sol Africains.

Cabo Verde

- Le principal problème des sciences du sol aujourd'hui en Afrique est la fiabilité des résultats d'analyse dans les laboratoires, la qualité des équipements de laboratoire ce qui amène à collaborer avec certaine Université du Nord. La formation et le renforcement de capacité des cadres et techniciens aux nouvelles méthodes d'étude des sols.

Benin

- Lack of soil data for drawing maps, etc.

Equatorial Guinea

- We need more advanced laboratories in our department.

Egypt

- The lack of quality laboratories and research infrastructure is very frustrating for any soil scientist born, trained, living and working in Africa.

Kenya

- ainda em estado incipiente em Moçambique. Precisa-se de mais capacitacao e formacao de recursos humanos na area de ciencias do solo

Mozambique

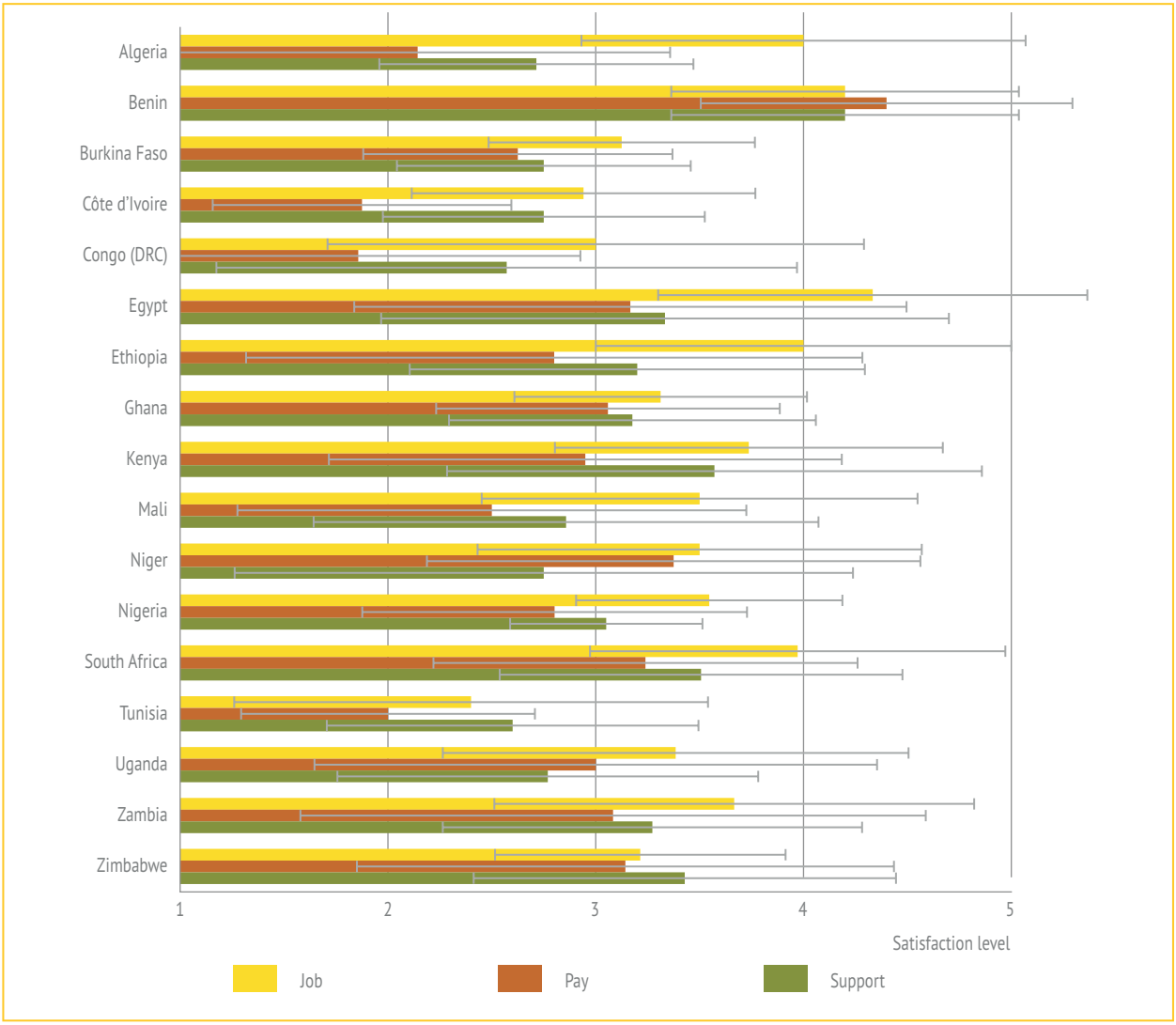
- La science du sol a connu de beaux jours avec des formations solides, des spécialistes qui aiment leur métier; aujourd'hui la science du sol n'est pas suffisamment associée dans le processus de prise de décision pour l'utilisation du sol, et les jeunes s'y intéressent de moins en moins car "c'est salissant et c'est mal payé", disent-ils; du coup, les perspectives de la science du sol ne sont pas très prometteurs surtout avec la forte concurrence des forestiers qui s'accaparent le monopole du discours sur l'environnement.

Niger

- A lot ... needs attention, especially in the areas of soil survey, financing and equipping the laboratories.

Zambia

Figure 16. **Job, Pay, and Level of Support Services Satisfaction, Selected Countries**



Note: Responses are on a scale of 1 (low) to 5 (high); countries in the sample have more than five respondents per country.

the soil science departments at universities and research institutions. Government laboratories are often autonomous entities within departments of agriculture at different administrative levels (national, provincial, and so on).

Government and research laboratories usually have a well-trained staff complement, but are often underfunded and suffer dramatically from the lack of equipment maintenance and upgrade funds. In some cases, they simply cannot perform a certain type of analysis because of broken equipment or unavailable required reagents. This problem persists from the 1960s, when the Irish soil chemist Jim Brogan made one of the first assessments across several African countries commissioned by the FAO (Brogan, Lemos, and Carlyle 1965). All these problems and more were recently highlighted again (Bakker et al. 2016) in a study carried out in Ethiopia.

The private agricultural laboratories mainly operate on a small profit margin (≈25 percent) compared to the medical labs. They are highly vulnerable to foreign exchange fluctuations because of the fluctuating cost of imported chemicals and maintain low prices of soil analysis by hiring staff with only in-service training to perform the analysis. However, most private laboratories seek (and some have) a certain level of

accreditation as part of their quality assurance and service marketing.

Our survey shows that outsourcing soil analysis by research organizations to private laboratories is becoming more and more common. Hence the researchers pay only for analysis that may be covered by research funding that they managed to solicit for an individual project. This means they do not have to worry about equipment maintenance, analytical staff, and supply of chemicals. Obviously, the net product is a reduced quality of analytical results, since private agricultural laboratories are mostly geared for fertilizer advisory services and show less precision in their work than a dedicated research lab.

All the above problems and probably much more (including lack of petrol for fieldwork, understocked libraries, unreliable Internet and electricity supply, and so on) are reflected in the assessment of the support services (Figure 16).

The soil scientists in Algeria (2.7 ± 0.8), Burkina Faso (2.8 ± 0.7), Côte d'Ivoire (2.8 ± 0.8), the Democratic Republic of Congo (2.6 ± 1.4), Mali (2.9 ± 1.2), Niger (2.8 ± 1.5), Tunisia (2.6 ± 0.9), and Uganda (2.8 ± 1.0) all assess the support services as inadequate (below 3). Only the respondents from Benin report a good quality of service (4.2 ± 0.8), while soil scientists from the other countries analyzed here find the technical support they receive to be fairly adequate (above 3).

Still, one should note the expanding use of soil testing services across the continent. Farmers and other land users are having better understanding of soil quality and the value of soil analysis. South Africa alone has some 60 laboratories processing 400,000–600,000 soil samples per year.

Advisory services to farmers make up one of the main contributions by soil scientists toward food security—both national and household security—in their countries. The demand for such services is growing, but the quality of services requires better and braoder training of agricultural advisers as well as more marketing efforts to promote their services (Commentary Box 7).

Only 17 percent of the respondents report advisory services as their main occupation (Figure 17). All the other soil scientists associated with education and research are also involved in assisting farmers to various degrees, from regularly to occasionally. In

Commentary Box 7

- Soil science is only a partial expertise of what is needed to understand and support farmers. We need more interdisciplinary-trained scientists and should not worship specific biophysical disciplines.

Ghana

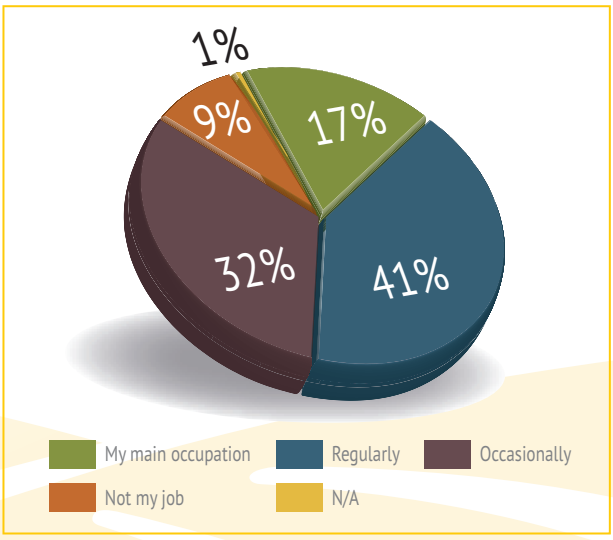
- I can only comment about the sugarcane industry where I work. My impression is that there is … scope for improvement, the more so as there are new challenges in terms of climate change, soil conservation, etc. We need to better communicate with the farmers on these and other soils-related issues.

Mauritius

- Many farmers (commercial) now know the value of soil science in their business. Am so optimistic that in the nearest future, soil science as a discipline is going to command important aspect in the development of modern Agriculture in Nigeria and Africa at large.

Nigeria

Figure 17. **Frequency of Advisory Services Interaction with Farmers**

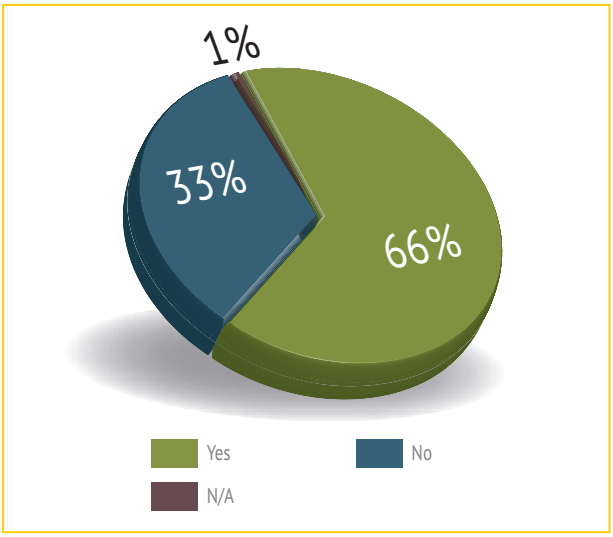


Note: N/A = no answer.

fact, 90 percent of all the respondents do interact with the industry in some way and contribute toward advancement of agricultural production on the continent.

Almost two-thirds of the respondents (66 percent), including all the self-employed soil scientists and most of the university lecturers and researchers engage in private consulting (Figure 18). These consulting services are an important way for soil scientists who have predominantly office jobs to gain practical experience.

Figure 18. **Percentage of Respondents Engaged in Private Consulting**



Commentary Box 8

- Nombreux sont les agro-industries qui s'intéressent véritablement à l'importance qu'a la Pédologie dans la bonne marche de leur structure. Dans l'avenir, nous devons d'abord amener ces structures à beaucoup s'intéresser au sciences du Sol. Ensuite, amener les entreprises de construction à consulter un spécialiste des Sciences du Sol avant tout travaux de construction afin, d'éviter tout effondrement.

Côte d'Ivoire

- There is such a need for soil consulting to expand, especially mobile soil-testing clinics since extension services for testing are widely unavailable.

South Africa

There is genuine growing interest among land users in soil issues (Commentary Box 8) that require expert consultants. However, agricultural and environmental consulting is a highly competitive business with multiple local and international players. Soil science is public knowledge and has few trade secrets that can be used to protect the job market for soil scientists. In fact, this market is strongly targeted by representatives from complementary disciplines.

As one of the commentaries to this survey by a Nigerian soil scientist points out:

> *The non-availability of national/regional soil research coordinating center and a regulatory body makes studies in soils a job for all. Zoologists, Botanists, Geographers and several other people of diverse backgrounds do regularly engage in soil investigations, sampling, analyses and thereafter try to interpret the data without any formal training in the field of soil. Yet, sustainable use of soil resources calls for adequate understanding of their properties, their potentials, capabilities and constraints to specific land use type.*

We hear a similar statement from Botswana:

> *A lot of interference in soil science works from other professionals who know very little about soils. Should be regulated.*

In response to such calls, in 2013 South Africa introduced a job market protection mechanism for soil scientists by an Act of Parliament as a part of the licensing process for consulting services by natural science professionals—the South African Council for Natural Scientific Professions (SACNASP) (www.sacnasp.org.za).

Our survey has shown that in almost every African country there are soil experts with knowledge of local soil conditions, local agricultural production constraints, and an arsenal of local solutions. This growing human capital of soil scientists and their accumulated knowledge about local conditions in Africa needs to be utilized better. These experts are

already making a substantial contribution toward increasing agricultural output, conserving natural resources, and adapting to climate change and many other challenges facing Africa in the 21st century.

3.4 Survey through the Global Soil Partnership

From the RSP implementation plans and recent NENA and AfSP meetings (as discussed in Section 1.4.3) it is clear that country representatives to the GSP perceive a strong need to boost capacity development in relation to SSM to increase food production and build resilience to climate change. Included are the need to train more soil scientists and to train existing soil scientists in additional skills, as well as to increase the capacity of extension services, farmers, laboratory technicians, and more.

Five initial questions were posed in English and French to GSP representatives to ascertain the national soil-related capacity needs. Responses were received from 34 countries, as presented in Table 2, which shows the number of positive and negative responses. Contributing individuals are mostly based at national ministries of agriculture and national agricultural research institutions, with isolated contributors based at universities.

From Table 2 it is clear that not only are more soil scientists considered to be necessary in the majority of countries, but existing scientists need more knowledge in relation to SSM. For example, one respondent stated that in Morocco:

> *SSM is a new concept for some of our soil scientists because they have a classic knowledge on soil science and they need to improve their capacity on SSM.*

Furthermore, national soil research and extension services are mostly considered inadequate, further skills development is required in both these areas, and farmers in all countries are considered to have insufficient capacity and knowledge of SSM and relevant practices. A respondent in Zimbabwe highlighted that farmers understand the general aspects of SSM, but they:

> *get limited when they are faced with challenges that require alternative solutions. They may not explore alternative solutions if they stick to past experiences. Challenges brought by climate change and variability, for example, may not be addressed by lessons of past*

Table 2. **Questions about Capacity Development Needs Posed to GSP Representatives**

Question	Yes	No	Responding Countries[a]
Are more soil scientists needed in your country?	32	2[b]	
Do existing soil scientists need more knowledge and skills to implement and support SSM?	32	2[b]	
Are there sufficient soil research and extension services in your country?	5[c]	29	
Do soil research and extension services need more knowledge and skills to implement and support SSM?	33	1[d]	
Do farmers have sufficient capacity and knowledge of SSM and relevant practices?	0	34	

Note: Questions were posed in 42 countries; 34 responded.
[a] Cabo Verde and Mauritius, which are not visible.
[b] Democratic Republic of Congo and Egypt.
[c] Djibouti, Equatorial Guinea, Guinea, Niger, and Senegal.
[d] Democratic Republic of Congo.

experiences, but by innovative platforms that involve researchers.

Also, in Gabon:

Farmers have a great need for capacity building to understand SSM and adopt relevant practices.

The Democratic Republic of Congo and Egypt were the only two countries where it is perceived that more soil scientists are not needed and existing soil scientists are considered to be well-skilled. For the Democratic Republic of Congo, this was further clarified by the respondent, indicating that there are a number of renowned soil scientists in the country who are competent, well trained, and capable of supporting sustainable soil, land, and forest management. In addition, soil laboratories are led by capable soil scientists. There may be potential to strengthen capacities in the management of peatland soils, though. As for research and extension services, these exist, but are considered insufficient in relation to the large areal extent of the country. The indication that improved knowledge and skills are not needed for research and extension services (Question 4) is assumed to refer only to research services, which are already provided by competent scientists. However, the same may not apply to extension services. The response from Egypt was not clarified, but judging from Figure 1, there appears to be a relatively large number of soil scientists in Egypt (between 50 and 100) which is in line with this response. However, agricultural extension services in Egypt are considered weak, insufficient, and in need of improved knowledge and skills. The same goes for Egyptian farmers who are reported to have insufficient capacity and knowledge of SSM and relevant practices.

In Zimbabwe, for example, the respondent highlighted the need not only for soil scientists, but also for technological advancement, as follows:

Existing soil scientists require skills to conduct research and offer advisory services that are required by various stakeholders. In order to offer services more efficiently and effectively, there is also need for technological advancement in many organizations, including government institutions. National soil analysis laboratories such as at the Chemistry and Soil Research Institute would require to be capacitated with modern equipment that improves service delivery. For this modern equipment and improved methodologies to be effective, soil scientists would require requisite training.

The importance of well-equipped soil laboratories and well-trained staff was echoed by Uganda:

There is no soil and plant nutrition research institution at all, and this has affected soil services. For example, the national laboratories have become "out of date" raising national outcry on quality of soil testing. There is need to improve the country's laboratory testing services with modern equipment/advanced techniques in soil testing. The current laboratories are using wet chemistry rather than complementing such methods with modern techniques that are widely used across the globe.

Respondents from five countries said that research and extension services are sufficient in the country. Further clarification was requested from Niger. It was explained that in Niger there is the National Institute of Agronomic Research (INRAN), seven universities, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and private laboratories, all of which contribute to soil research activities. However, there is a perceived lack of coordination of efforts and lack of awareness of important information and activities, as well as a lack of relevant policies to support soil-related work. The issue of coordination was in part echoed by Zambia in the comment that:

The Soil Research Team under the Zambia Agriculture Research Institute is a structure loosely coordinating soils research in a fragmented system running soil physics, soil chemistry, soil microbiology, soil fertility (agroforestry), and soil mapping and survey.

The importance of effective coordination was also highlighted as a key challenge in many African countries during the third AfSP meeting in Rome this year (GSP/FAO 2018b), which emphasized the fact that human capital in soil science is one of many factors

that affect soil management and research. Generally, though, extension services are not considered to be sufficient in most countries (Commentary Box 9).

Following the responses in Table 2, we wanted to understand why more soil scientists are needed, where they are needed, and whether they would find employment. The question of job opportunities is beyond the scope of this study, so we limited the assessment to determining whether succession planning is in place to ensure continuity in soil science work. An additional set of questions was sent to individuals representing 42 African countries, with responses received from the 22 countries presented in Figure 19.

Why are more soil scientists needed?

The primary area where more soil scientists are needed was identified as soil survey and mapping, which is a primary task for soil scientists, especially pedologists. Several countries indicated that they have outdated national or subnational soil maps at coarse resolution based on old data generated from the 1960s to the 1980s. Higher-resolution soil maps are developed mostly for small areas, as part of specific projects or developments. Along with the need for more soil surveyors and mappers, respondents indicated the need for specific training in geographic information systems (GIS), digital soil mapping (DSM), geostatistics, remote sensing and the interpretation of satellite and airborne images, digital data processing, and more. In Benin the respondent highlighted that it is rare for young soil scientists to emerge from university, and the few who had graduated in soil science were not recruited. However, the reason for non-recruitment was not provided, nor whether vacancies were available at the time. Soil science is taught at the University of Abomey-Calavi in Benin under the department of plant production with an option to major in soil science.

The respondent in Cameroon highlighted that young soil scientists have gaps in their ability to study and map soils since they do not have the opportunity to obtain on-the-ground experience. Furthermore, universities in Cameroon need to strengthen their

Commentary Box 9

About Extension Services

- There are agricultural extension services, but they are not operational for lack of material and financial means.

Gabon

- Nigeria has an agricultural extension service but it's very weak, poorly funded.

Nigeria

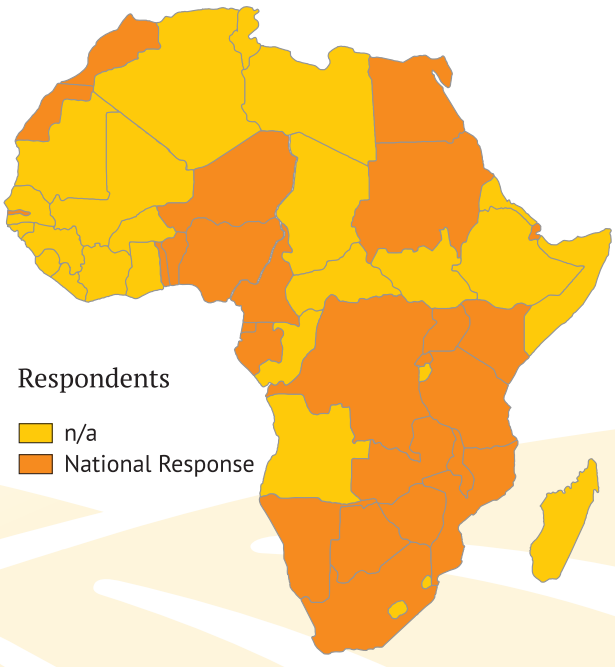
- Agricultural extension services are essential in Cameroon. These services exist ... but they have no specific training on soil aspects. They very often confuse the farmers and furthermore, there is no quality control of fertilizers for sale on the local market.

Cameroon

- There are extension services but they need to be equipped and capacitated in soil science related matters. Since our learning institutions focus more on teaching crop and livestock production. There are no courses offered in Namibia apart from South Africa.

Namibia

Figure 19. **The 22 Countries that Responded to Additional Questions on the National Need for Soil Scientists**

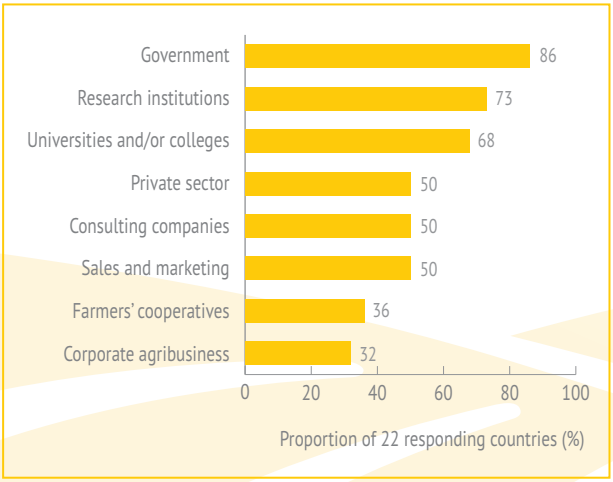


capacity for soil science education for both research and extension services in the field of soil science. In addition, to improve communication between soil scientists and farmers, it is considered important to train soil scientists in popularization, which is not currently done. In Equatorial Guinea the respondent indicated that there is no-one working as a soil scientist. Instead there are mostly agricultural engineers (some with specialization in soil) working as generalists. There is no university offering a soil science degree in the country.

The next most listed needs were in the areas of research and advisory services linking with extension and farmers, and training/education. Other needs highlighted included soil laboratory staff, support for soil and water conservation, irrigation suitability assessments, and irrigation development, along with expertise in soil physics, precision agriculture, soil microbiology, running soil information management systems, and farm planning, as well as land use and management permits or regulations.

In Uganda soil scientists are required to advise on nutrient management for improved plant varieties and to support national capacity in policy formulation based on data soil survey and agrochemical use data. The private sector and farmers need to be guided on the use of several soil test kits on the market and need assistance to interpret the results. Field support is also needed in the use of foliar and conventional fertilizers, as well as to conduct soil suitability assessments for crop production.

Figure 20. **Employment Sectors that Need Soil Scientists: Proportion (Percentage) of the 22 Responding Countries Where They Are Needed**



Which employment sectors need soil scientists?

Many respondents indicated that soil scientists are needed in most or all of the sectors listed in the question (i.e., government, universities and/or colleges, the private sector, research institutions, farmers' cooperatives, consulting companies, sales and marketing, and corporate agribusiness). The most frequently listed sectors, however, were governments (especially ministries related to agriculture and land resources), research institutions, and universities or colleges. The University of Rwanda, for example, currently has six soil science lecturers and at least three soil science staff vacancies.

Figure 20 depicts the proportion of the 22 responding countries (presented as percentage) that indicated the employment sectors where soil scientists are needed.

Uganda provided more detail, specifying the need for soil scientists on private farms, international and local nongovernmental organizations (NGOs) involved in agroforestry and natural resource management, and private large-scale companies with large-scale farms and extension inputs distribution systems as well as large irrigation farms (for soil and water control).

Botswana indicated that there are currently two soil scientists at the Ministry of Agriculture and

> *about 5 soil surveyors who we were trained internally after completing Land Management. They need training in soil science.*

In Sudan it was stated that:

> *government is not funding soil research and soil monitoring activities, which need to be funded and strengthened. In the private sector [soil scientists] are needed, but we all know that soils are overlooked, and therefore people think that soils need no care from them and the private sector will not recruit anyone for the sake of soil. Extension is an important*

sector in this regard and needs to be highlighted and brought to the forefront.

Roughly how many additional soil scientists are needed?

Estimating the number of additional soil scientists needed in a country is not a simple task, yet respondents were requested to provide their best estimates. Responses varied from single numbers per country to a more detailed breakdown of required numbers per sector or field of expertise, all the way to large numbers per country without further clarification. The responses are summarized in Table 3, including clarifying comments where provided. Totals per country range from none in the Democratic Republic of Congo and Egypt as already discussed, to 1,000 over the next five years in Nigeria, with various numbers in between. A number of countries indicated the need for decentralized availability of soil scientists to serve more remote areas and ensure knowledge availability in different provinces or districts. This is especially linked to soil scientists to be employed by governments.

With rather large numbers of additional soil scientists considered to be essential to support agricultural production in many countries, any additional soil

Table 3. **Estimated Number of Additional Soil Scientists Needed, per Responding Country**

Country	Number of additional soil scientists needed	Additional respondent comments
Benin	~ 20	
Botswana	• Pedologists: 5 • Soil physicists: 2 • Agro-chemists: 2	
Cameroon	Ideal would be to have: • Soil survey and mapping: 40 • Consulting scientists: 60 • Education: 30	The great diversity of soils and ecologies of Cameroon calls for a large number of soil scientists in all areas of expertise.
Congo, Dem. Rep.	None	Existing soil scientists are numerous, but the most famous and renowned may reach 20 since there are two soil scientists per province.
Egypt	None	
Equatorial Guinea	• Mainland: 20 • Insular region: 15	
Gabon	~ 20	
Gambia, The	• Soil survey and mapping: 3 • Agricultural and advisory services: 6 • Tertiary training: 9 • Research: 3	
Malawi	• Soil survey: 2 • Soil mapping: 2 • Research: 3	
Mauritius	At least 5	
Morocco	Annually: • Soil survey: 10 • Soil mapping: 10 • Research: 20 • Advisory services: 20	
Mozambique[a]		There is currently less than 1 soil scientist in each district. There are 110 districts in Mozambique.
Namibia		We are 2 soil scientists in the Ministry who try to classify and map Namibian soils. A third person moved to an administrative position. Due to lack of manpower and capital, we scale down government research farms.

Country	Number of additional soil scientists needed	Additional respondent comments
Niger	• Soil survey and mapping: 1 • Agricultural advisory services: 5 • Tertiary training: 5 • Research: 6	
Nigeria	1,000 soil scientists will be needed in the next 5 years	
Rwanda		Difficult to estimate because the soil information system value chain does not function well and currently many young graduates from universities have much difficulty finding jobs.
South Africa	At least 205 soil scientists to cover all local municipalities at government level.	Additional numbers will be needed in the private sector and research institutions to do soil survey, soil mapping, research, provide advisory and consulting services, and education. Specific expertise needed is pedology, soil chemistry and precision farming and/or soil information instruments (GIS and remote sensing).
Sudan	Between 400 and 500 soil scientists for: • Soil survey and mapping, trained in the field of DSM, • Researchers in the field of soil fertility and reclamation, and • Soil educators along with extensionists.	Consultancies could be done by the research institute if well equipped with scientists, equipment and research funds.
Tanzania	• Soil survey: 12 • Soil mapping: 10 • Research: 12 • Advisory services: 6 • Education: 5	
Togo	• Soil study, soil mapping, research: 40 • Education: 15 • Consulting services: 10 • Advisory services: 10	
Uganda	Within the next 5 years: • Soil fertility/plant nutrition: 200 • Soil surveys/soil mapping: 70 • Government officials/policy: 121 (for 121 districts) • Consultancy: 50 • Extensive large farms: 100 • Private business: 100 • Soil laboratory: 90	
Zambia	• Soil survey: 300 • Soil mapping: 50 • Research: 100 • Advisory services: 50 • Consulting services: 100 • Education: 300 • Others: 50	
Zimbabwe	Government: 40 with the objective of decentralising services.	Currently all soil science services are centralised in the capital city, Harare. For decentralisation to be successful, requisite infrastructure will be required. Such capital investment would ensure that the national quest for increased crop productivity and improved food security is addressed.

[a] The comment for Mozambique is information acquired through an institutional survey.

science graduates would of course need employment. An important question, which was not asked in this survey (since it would not be an easy one to answer), is how many vacancies currently exist in each country in different employment sectors. Instead, the question asked was whether succession planning is in place to support the replacement of retirees and keep existing positions filled. This question was

triggered by the age distribution of soil scientists from the electronic survey and concerns from about the aging population of soil scientists. This concern was mirrored in the GSP survey by a number of countries (Benin, Gabon, Gambia, Togo, and Tanzania), which commented that existing soil scientists are reaching retirement age and there is a lack of young scientists to replace them.

Is succession planning in place to replace retirees?

The question is very general, and judging from the responses, respondents mostly (and understandably) responded in terms of the organizations where they are employed (some comments are provided in Commentary Box 10). In this survey, succession planning appears to be the exception rather than the rule. Responses received from the Democratic Republic of Congo, Equatorial Guinea, Malawi, Nigeria, Togo, and Zimbabwe indicate that succession planning is in place, at least in terms of relevant policies and procedures in relation to retirement of existing scientists. However, this does not necessarily apply when scientists resign from an organization, as indicated by the respondent from Zimbabwe:

> *There is no proper succession planning as staff may change from government to other organizations. However, the anticipated succession takes place when staff reaches 65 years of age. Government procedures for succession are standard and based on professional credentials and experience.*

As indicated by the respondent from Uganda, because of the lack of succession planning in combination with the limited training in the area of soil science over the years, existing positions may be filled by non-soil scientists.

In Benin, the respondent uses his own situation as example:

> *I am retired but there is no one to replace me in Mapping and Land Evaluation Division.*

In response to an enquiry about a national institution dealing with or supporting soil research, he responds:

> *It is the National Institute of Agricultural Research of Benin. There is a Laboratory of Soil Science, Water and Environment (LSSEE) which is located in the Agricultural Research Center of Agonkanmey based in Abomey-Calavi about 15 km from Cotonou. In the LSSEE there is a Land Mapping and Evaluation Division, a Fertility and Land Fertilization Division, a Land Conservation Division, a Soil, Water and Plant Analysis Division and an Administration and Accounting Division. The Soil Analysis Division operates at 60% and the Fertility Division at 20%. The other Technical Divisions no longer work.*

In the same breath, respondents from Nigeria and Rwanda invariably commented that young soil scientists often struggle to find employment. This echoes the opinion of respondents in the electronic assessment, who expressed their frustration at not being able to find employment in their field of study. Clearly there are needs at both ends of the

Commentary Box 10

About Succession Planning

- More or less sensitive planning through the expression / estimation of the needs and the training or reinforcement of the capacities of the research executives who are already in function with the support of the WAAPP (West Africa Agricultural Productivity Program).

Togo

- There is a succession plan to fill in existing vacancies through the government recruitment process. Once a gap exists, either officers within the department are identified and called for promotional interviews or the post is advertised for any qualified person to apply. In either case interviews are conducted to screen the candidates and identify the best qualifying.

Malawi

- There was no succession plan. Another problem is there is no institution producing soil scientists.

Botswana

- There is no continuation program in place. The reason being our leaders do not understand the importance of soil scientists.

Namibia

spectrum—there is soil-related work to be done and there are trained people who want to do the job. Yet in many cases, the needs of both remain unfulfilled. This implies that the expressed "need for more soil scientists" does not necessarily mean that there are not (always) enough trained soil scientists "out there." Rather, it points to the complexity of the issue and the interaction of factors such as quality of training, quality of graduates, job opportunities, economic factors affecting the filling of vacancies or creation of new jobs, the existence of relevant value chains that support the demand for soil scientists, and more.

3.5 Survey of Key Institutions

To complement the survey through GSP representatives, individuals from various key institutions working in agriculture in Africa were contacted to understand to what extent soil scientists are perceived to be available, are used (for what and where), and, ultimately, whether there seem to be enough (well-trained and skilled) soil scientists available in Africa or not. This includes both African and non-African soil scientists living and working in Africa. Most experts were asked to respond to the set of questions provided in Section 2 (discussed below). With other institutions, L. Wiese discussed with institution representatives more generally to understand how important soil science is considered in relation to their work, or what relevant information is available on human capital in soil science in Africa.

3.5.1 Questionnaire Responses

Soil scientists are employed to a greater or lesser extent by all the institutions included in this survey for a wide variety of projects and purposes within projects. These include research projects around soil health, soil restoration, and soil carbon mapping; site-specific agricultural management practices and farm-level decision making; natural resource management (NRM) projects; multidisciplinary projects (including the link between soil fertility and human nutrition) in the field and laboratories to support policy and planning decisions; projects to understand soil constraints for crop production and targeting interventions; demonstration projects; soil acidity amendment projects; integrated soil fertility management (ISFM) projects; and more. Tasks to be fulfilled by soil scientists include soil survey and mapping, assessing soil health and fertilizer requirements, training national agricultural research systems (NARS) scientists, improving soil fertility and soil management, providing soil advisory services, and designing research that have components intended to improve crop productivity. Within projects they also interpret agronomic data; evaluate the ecological footprints of some of the crop production systems and help design ways to minimize the negative effects; conduct baseline assessments for targeting sustainable land and soil management interventions; guide policy decisions on sustainable agricultural intensification, climate smart agriculture, and sustainable land management; monitor impacts of interventions on soil health and the status of soil health at national and global level; assess soil health in economic assessments of alternative policies and intervention options; conduct research to better understand soil processes and how to predict soil health responses to management; write joint proposals; and more.

There are some differences between institutions regarding the level of soil science degrees (BSc, MSc, and PhD) required. This mostly depends on the nature of work to be performed. For example, at the World Agroforestry Centre (ICRAF), *"All levels are required but there is need for a core of PhD level soil scientists that are up to date in modern soil science concepts to lead others."* CIAT currently employs soil scientists at all three levels; at IITA, the need for training soil scientists in Africa is raised at all levels (both research soil scientists and extension soil scientists). At the Agricultural Research Institute of Mozambique (IIMA) the level of training is far less important than the need for soil scientists themselves because they are considered scarce. For example, a respondent from the International Fertilizer Development Centre (IFDC) stated that: *"For research we need more in-depth trained people but indeed MSc level might suffice for implementation programs. These (complementary expertise) are not available overall."* However, the respondent further stated that at times it may depend on the quality of the training received

because *"Educational levels differ greatly between universities. A PhD in one country may be equivalent to an MSc in another."* In Ethiopia, respondents from the Agricultural Transformation Agency (ATA) pointed out the dependence on the level of training available in the country as follows: *"MSc and PhD are the criteria as there are no undergraduate courses purely on soil science. Graduates from plant science/geography or chemistry/physics fields study Soil science at MSc or PhD level."*

Generally, it seems that the need for soil scientists has increased over the last 10–20 years because various issues with and around soils have gained significant momentum and soil fertilization activities have increased. At the same time, many respondents perceive a decline in the number of soil scientists, so they are not always so easy to come by (Commentary Box 11). Perceptions differ, though, as respondents from IITA stated, *"The number of soil scientists in Africa has certainly decreased significantly, but the need may not have increased for now because of the lack of general interest on soil issue. The number of funded soil related projects has decreased significantly in IITA during the beginning of years 2000."* Also, the respondent from the International Maize and Wheat Improvement Center (CIMMYT) said, *"In my opinion, the need has decreased because soil science needs to be complemented by another skill such as agronomy or statistics and modelling. Soil Science 'sensu stricto' might not be demanded."*

Commentary Box 11

Are capable, experienced soil scientists easy to find?

- 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.

CIMMYT

- Capable and experienced soil scientists are very rare in Africa now because the lack of funding in soil related issues have reduced drastically the number of students in soil departments in many universities and high schools.

IITA

- 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.

CIAT

- 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 programmes are often left with one or two older soil surveyors who are not skilled in new soil assessment methods such as use of sensors, remote sensing, digital soil mapping, spatial statistics, multivariate statistics, genomics.

ICRAF

- Very rare and many are too academic.

IFAD

In the case of a less research-oriented focus, the need for soil scientists may be different. There, the need is more for generalists with a solid understanding of soil issues, multidisciplinary collaboration skills, and the ability to effectively interact with farmers. In this case, agronomists with good knowledge and understanding of soils, for example, are considered more valuable. At the International Fund for Agricultural Development (IFAD), for example, what is required are *"practical people to assist with project design, implementation and execution, not academics. Regarding soil scientists, we require all aspects in Africa but with a strong agricultural production background and empathy with farmers. Many are too academic and become detached from the target groups we are trying to assist. Ideally, we need good practical agronomists with a background in soils. An agronomist is a soil scientist who understands plants. We need good practical agronomists who also understand mechanization."* In IFAD projects, it was highlighted that soil scientists would require remote sensing skills and in-depth training in systems. Furthermore, soil scientists are employed in-house at IFAD, but not directly as soil scientists—rather as good generalists.

Similarly, at IFDC where research, training, and implementation are important, the following general comment was made in terms of specific expertise: *"Soil science and agronomy are so intertwined these days that an agronomist can serve as a soil scientist in many ways. Soil scientists may have more soil-specific knowledge, while agronomists may be more broadly trained. It remains unclear to what extent similar*

insights and capabilities are available or required." In fact, the specificity of the work conducted by IFDC in terms of focusing on everything to do with fertilizer, in combination with the wide range of areas where this is addressed, creates a more diverse need for scientists and expertise: *"IFDC does the entire range from soil sampling up to, for instance, market assessment of fertilizer requirement, which calls for insights in differences in soil fertility through mapping, to marketing and policy recommendations. We also support policy development. IFDC has well-attended trainings (these may be attended by technical soil scientists/ agronomists but also people from business [fertilizer and those operating in the food value chain]). So, IFDC actually is the only international research and implementing organisation in the world that does everything related to soil fertility, plant nutrition and fertilization, and operates along the entire value chain as far as my knowledge goes.*" Furthermore, existing soil scientists may require additional skills development since: *"Basically, there might be trained people out there, but current educational systems do not specifically teach about plant nutrition and fertilization. Worldwide education in these fields has declined (many studies have simply disappeared). While there seems to be renewed interest to develop new—especially MSc and PhD—courses, no entity is willing to finance such an endeavour. While IFDC could use more soil scientists, more specific expertise is needed regarding crop nutrient demands, fertilizers to meet those demands, and soil analysis and interpretation.*" Further important knowledge listed by IFDC respondents includes expertise on soil amendments (especially organic amendments), the related domain of organic matter recycling and processing, and both organic and inorganic fertilizers, as well as basic requirements for the proper design and implementation of (location specific) ISFM practices. Nonetheless, soil scientists are mainly employed in-house and: *"IFDC – if funding allows—can definitely use more highly trained soil scientists to do more research, advanced mapping, methodology development for fertility recommendations, training, awareness raising, investment needs in plant nutrition and fertilization, policy recommendations etc.—everything to go from a soil property to policy changes (e.g., subsidies are tied to specific fertilizer products which might do more harm than good and new products ought to be included in policy programs).*"

All respondents indicated that they work with national agricultural extension services, with the majority indicating that extension services do not have sufficient understanding of soil issues (Commentary Box 12). The respondent from CIAT, however, indicated that extension services in Kenya are perceived to have sufficient understanding of soil issues. This was briefly discussed further via email, upon which the respondent clarified that: *"The national scientists that I am working with have reasonably good understanding of soil science. I am not expecting somebody working at [national research institutions] to be an in-depth expert of a very narrow field. The contrary, these people should have solid broad understanding of the entire field.*"

Commentary Box 12

Do you work with national extension services?

- Yes, we closely work with them. There are good number of experts but their capacity is limited. They need in-depth trainings on soils issues.

ATA

- 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.

CIMMYT

- Yes, we work with national extension services, but they do not master very well communication in soil science with farmers.

IITA

- National extension services in Burundi are not very conversant with soil science, however there is a national agricultural research institute (ISABU) which has some appreciable capability.

IFDC

- 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.

ICRAF

Finally, when asked whether money would be well spent to train more soil scientists to support soil-related work to improve general soil health and productivity in Africa, different responses were received (Commentary Box 13). The saying "beauty is in the eye of the beholder" comes to mind. Similarly, the number of soil scientists needed, the level of degree and specific expertise they need to have, and so on is a function of the primary focus of each institution, the projects to be implemented, and so many other factors.

3.5.2 General Communication

This section presents the results of general conversations, conducted outside the confines of a questionnaire or survey, with institutional representatives during the course of the study.

Bill and Melinda Gates Foundation

During a Skype conversation, the representative from the Bill and Melinda Gates Foundation indicated that with regard to Africa, the Foundation has largely adopted a focus on innovation around digital soil mapping. The Foundation recognized the need to invest in crop-specific agronomy designed to conduct demand and delivery–driven research at scale. Furthermore, it looks at an integrated approach from research to development in agriculture in order to set up research to solve specific problems. Questions with regard to the availability of capacity, be it in terms of soil scientists or agronomists, how the research system works, how data are exchanged between different organizations, and so on become more relevant in projects at the country level. When the need for specific capacity arises, it is dealt with on a case-by-case basis, but within a systems approach of the larger project and aim.

The representative mentioned that the Agricultural Development team at the Foundation is currently revisiting its perspective on capacity building. He emphasized the importance of assessing capacity building needs based on anticipated future research priorities. For the body of work around soil and agronomy, the Foundation has a strong focus on geospatial or spatial dimensions because: *"We think it is important to be able to work at scale and to solve at scale."* The Foundation then works together with national partners to identify the necessary institutional tweaks or capacity building issues and provide input into the planning of appropriate solutions. The

Commentary Box 13

Should we invest to train more soil scientists to improve soil health and sustainable food production and agriculture?

- Currently, I would say, No. There are other disciplines where we are in dire need to increase our expertise, such as social science very broadly speaking and experts on Gender more specifically.

CIAT

- Yes, of course. However, this would require a need assessment to determine priority areas.

IITA

- There has been a lot of research in this area, i.e., work to improve soil health and productivity. I am not convinced that training more soil scientists would make a difference. A proper investment might be how to put all these scattered initiatives together and draw lessons from them. You may need to ask current soil scientists to work with Data Scientists more.

CIMMYT

- It is an imperative to train more African soil scientists in current science and technology for sustainable land management and agricultural production systems. The older guard are retiring and are not up to date. There is no one to teach a younger generation. / Yes, capacity development is our major activity in Africa. For instance, we support the establishment of soil spectral labs in more than 12 countries in Africa that we give the necessary technical support including trainings.

ICRAF

- I think it would be better spent to train existing scientists, both within and outside of IFDC. As with many careers, regardless of one's education, what is taught in the classroom often does not necessarily translate into skills needed in the field, but form a solid basis. However, if there was more soil-related work to do, more soil scientists would be needed.

IFDC

respondent highlighted the need to systematically assess the need for capacity building at country level. For example, for work such as soil health assessment, surveillance, monitoring, and diagnostic work at scale and the accompanying agronomy pipeline, it would be important to determine what a modern research system would look like and what pieces would need to be connected, as well as to determine the capacity that needs to be built in terms of staffing or development of capacity around particular disciplines.

According to the Foundation representative, a key consideration in terms of capacity was to anticipate future needs in soil science and agronomy. For example, what would these fields look like in the next 10 to 15 years, what would be the nature of the work done, and what would be the interaction between different disciplines? Answers to these questions would inform the type of capacity that needs to be developed to cater to future needs. Furthermore, links need to be strengthened between data science and implementable recommendations, working together with governments and private sectors to find relevant solutions to agricultural challenges. Recognizing the importance of soil science in isolation from solution development is not sufficient. Rather, test driving potential solutions at scale and making the connection between data and implementable solutions would be important to create sufficient examples of how sciences are and can be used to provide solutions with sufficient return on investment. In other words, links between data science and implementable recommendations need to tell a story at scale to become compelling and relevant.

International Water Management Institute (IWMI)

Having witnessed the demise of the International Board for Soil Research and Management (IBSRAM), the representative of IWMI told us the following in a correspondence that he allowed us to make public in this study:

The interest in soil science, like in the interest in geology, hydrology, and many other fields seems to be somewhat cyclical and is strongly linked to current problems and perceptions in the society—*"it comes and goes, comes and . . . . The soil-dedicated agricultural research centres—IBSRAM and TSBF—died long ago, but then recently Germany and France started to re-discover 'soils' as fundamental"* science contributing toward our understanding of how nature works.

In response to the following questions:

1. The need for soil experts in both industry and government—is there a big demand?
2. Is there really a shortage of skills?
3. Who employs soil scientist and why is there a perception that they are not enough?
4. What may be the return on investment (RoI) into training more soil scientists and how to rationalize/optimize training needs?

he wrote: *"In the CGIAR, soils are still strong in Africa through CIAT, IITA and ICRAF, but the requirements on 'soils' and 'soil scientists' have strongly changed. . . . In this light, I would answer Q1–3 by denying demand for 'soil scientists' per se, and think there are more soil scientists graduating than needed. In fact, we have/had in IWMI a whole bunch, but everyone had moved on to other tasks/disciplines, as otherwise they would be without a job. . . . Despite all the breeding of soil scientists, we in Africa are still struggling with analytical lab capacities, but this capacity could today be provided by the private sector, like dedicated med labs. . . . I think the RoI would be very low unless the curricula get[s] reformed and the new generation knows how their knowledge can be applied in a social and economic context to drive change along an impact pathway which they are facilitating."*

International Food Policy Research Institute (IFPRI) and its Agricultural Science and Technology Indicators (ASTI)

Open-access data and analysis of agricultural research investment and capacity in some low- and middle-income countries is available on the ASTI website (www.asti.cgiar.org/data), facilitated by IFPRI. Data collection involves in-country survey rounds through their network of national focal points,

covering government, higher education, and non-profit agencies involved in agricultural research. Data from the private sector are not included because of a lack of availability. The surveys are checked for data quality; after validation the information is loaded into the data management system to calculate national-level data that are available on the ASTI website. Data on soil research are available in terms of discipline studied by researchers or research focus. However, when looking at research focus by commodity, soil science falls under "natural resources" and would not be flagged as a discipline per se. Data on researchers are presented as full-time equivalent (FTE) researchers (with official researcher status). The FTE calculations consider the proportion of time scientists actually spend on research, as opposed to on other activities.

For this study, Dr. Nienke Beintema extracted the 2016 data from ASTI on scientists with PhD, MSc, and BSc degrees in soil science in Ethiopia, Kenya, Tanzania, and Uganda. Data are presented in Table 4 in terms of head counts, as well as the proportion of total agricultural researchers by degree within government and higher education. Data on "soil scientists" are available only from larger agencies in the respective countries, since a different survey, which does not include information on tertiary degrees, is used for smaller agencies. Therefore, additional data present the proportion of head counts from the number of agencies surveyed (column 3), as well as the main agencies where 10 or more soil scientists are employed (column 4).

From Table 4 we see that soil scientists are still employed to a large extent in both governments and higher education institutions in these countries. Of the four countries, Ethiopia has the largest total number of soil scientists in the assessed institutions—more than double that of Kenya, which is second in line. Ethiopia also has the largest proportion of soil scientists with a BSc degree as their highest qualification (78 in total), most of whom are employed in government. In Kenya, Tanzania, and Uganda it appears that MSc and PhD degrees are more important, both in government and in higher education institutions. Kenya has the largest proportion of soil scientists with PhD degrees (a total of 47). The proportion of soil scientists in relation to agricultural scientists (which includes scientists in crop sciences, animal and livestock sciences, natural resources, fisheries and aquatic resources, forestry and agroforestry, socioeconomics, food science, extension, education, age engineering, and so on) varies between countries and also between different levels of degrees within countries. In the Tanzanian government, more than 10 percent of agricultural scientists with PhD degrees are soil scientists.

Table 4. **Data on Soil Scientists in Ethiopia, Kenya, Tanzania, and Uganda, 2016, Collected through ASTI**

Country and sector	Headcounts				Proportion of soil scientists to total agricultural scientists (%)				Agency coverage		Main agencies (with 10 or more soil scientists)
	PhD	MSc	BSc	Total	PhD	MSc	BSc	Total	Proportion headcounts (%)	Agencies (total)	
Ethiopia											
Government	10	34	67	111	5.8	3.4	4.3	4.0	100	9 (9)	EIAR (35); SARI (22); TARI (33) [a]
Higher education	9	27	11	47	6.9	5.5	6.4	5.9	63	5 (9)	HU-CAES (17); MU-CDANR (22) [b]
Total	19	61	78	158	6.3	4.1	4.5	4.5	88	14 (18)	
Kenya											
Government	17	12	3	32	7.2	2.9	2.3	4.1	84	3 (5)	KALRO (26) [c]
Higher education	30	12	1	43	7.7	6.7	2.1	7.0	54	9 (34)	EU-FA (10); UoN-FA (13) [d]
Total	47	24	4	75	7.5	4.1	2.2	5.4	68	12 (39)	
Tanzania											
Government	10	27	1	38	11.2	8.7	0.7	6.9	90	4 (6)	DRD-TARI (38) [e]
Higher education	18	9	1	28	6.4	4.3	4.2	5.4	78	1 (6)	SUA (28) [f]
Total	28	36	2	66	7.5	6.9	1.2	6.2	84	5 (12)	
Uganda											
Government	5	6	2	13	4.8	3.8	3.8	4.2	76	1 (6)	NARO (13) [g]
Higher education	11	4	0	15	4.8	2.6	0.0	3.8	51	7 (15)	MAK-CAES (13) [h]
Total	16	10	2	28	4.8	3.2	2.9	3.9	60	8 (21)	

Source: 2016 data extracted from ASTI (www.asti.cgiar.org/data).
[a] EIAR = Ethiopian Institute for Agricultural Research; SARI = South Agricultural Research Institute; TARI = Tigray Agricultural Research Institute.
[b] HU-CAES = Haramaya University – College of Agriculture and Environmental Sciences; MU-CDANR = Mekelle University – College of Dryland Agriculture and Natural Resources.
[c] KALRO = Kenya Agricultural and Livestock Research Organization.
[d] EU-FA = Egerton University – Faculty of Agriculture; UoN-FA = University of Nairobi – Faculty of Agriculture.
[e] DRD-TARI = Ministry of Agriculture and Food Security – Department of Research and Development / Tanzania Agricultural Research Institute.
[f] SUA = Sokoine University of Agriculture.
[g] NARO = National Agricultural Research Organization.
[h] MAK-CAES = Makerere University – College of Agricultural and Environmental Sciences.

4 Conclusions

Throughout the 20th century, soil science was one of the most supported research and development directions in Africa. It guided agricultural expansion, production intensification, and the conservation of natural resources. The core national and regional research infrastructure in Africa was established during colonial times. The decolonization process was accompanied by attempts on the part of the former metropoles and international development agencies to sustain the research institutions inherited by the newly independent countries by investing in education and assisting with the maintenance of research infrastructure.

With the exception of only a few countries, such as Egypt and South Africa, this investment into soil science and associated human capital and research infrastructure was largely driven by international development agencies rather than the national governments, jeopardizing the long-term sustainability of these efforts.

The international aid for the African soil research landscape started to change in the mid-1980s, when the focus shifted from supporting national institutions to establishing continental and regional networks. Such networks had a short life span and essentially were projects that terminated once the funding was exhausted. The roll-back of international support for national institutions was not matched by increased spending by national governments. Subsequently, many institutions created by post-colonial development investment have experienced substantial budgetary reductions first and most of all on research infrastructure, followed by reduced human resources spending.

Investment into soil science and to some extent human capital within this field has declined in the beginning of the 21st century. The focus shifted from supporting institutions in some individual countries to supporting ambitious mega-projects such as the Africa Soil Information Service (AFSIS), which can utilize large amounts of funding at once, reducing the load on the staff at the donor agencies and seemingly serving the whole continent.

Africa has a vast expertise in soil science supported by a substantial investment into human capital by individuals who chose to study soil science, as well as governments and international organizations that support education and research in this field. This expertise is not equally distributed among individual countries. There are some distinct centers of excellence, which include Algeria, Egypt, and Tunisia in North Africa; Ethiopia and Kenya in East Africa; Burkina Faso, Côte d'Ivoire, Ghana, and Nigeria in West Africa; the Democratic Republic of Congo in the central part of the continent, and South Africa, Zambia, and Zimbabwe in the southern part of it. Some of these centers have a strong influence on the neighboring countries, particularly smaller ones that offer education and facilitate regional collaboration. These efforts, however, require substantial support and improvement. Not surprisingly, the biggest African economies (Egypt, Nigeria, and South Africa) have the most numerous human resources in the field of soil science.

This expertise, however, often seems to be underutilized by the industry and development agencies because of an absence or inefficiency in marketing soil-related services and competition with agronomic and environmental consultants. Our study has shown that training up to the MSc level is required for successful investment of the human capital in soil science, to secure jobs for the graduates and to provide services at market-required level of expertise.

From this assessment, it becomes apparent that there is more to be investigated and understood about the nature of human capital in soil science. Looking at the scenarios in different countries, there is clearly no generic problem or solution that would apply to every country. For example, in some countries it may be very important to invest in training more soil scientists, as well as training existing soil scientists in additional skills. In other countries, perhaps it would be more important to create employment opportunities for existing soil scientists who are either unemployed

or are employed in jobs completely unrelated to their training. This would include investing in skill refreshment or reskilling existing scientists, as well as developing the necessary value chains to support job creation. A country-by-country study is essential to enable a more detailed analysis of the supply and demand for soil scientists to make specific recommendations. We expect, for example, that in a number of countries the real market demand for soil scientists may be substantially lower than the numbers provided in Table 3.

Furthermore, this study confirms the continued and perhaps even increased demand for soil-related work (especially in the research sector), as well as the need for more specialized skills from soil scientists. In this respect, tertiary soil science training may need to update curricula to include the skills required in the modern agricultural context. In addition, soil scientists need access to various support services such as analytical laboratories and advanced analytical tools. In order to optimally utilize current and additional soil science capacity, available and functioning facilities laboratories are essential. Similarly, access to advanced analytical tools, remote sensing information, and other tools and products currently advancing the delivery of soil-related information in various regions of the world are indispensable.

The level of participation of women in soil research and advisory services is still rather low. It seems that the shortage of employment opportunities for female graduates is more acute than it is for male graduates.

There seems to be a low demand for graduates with qualifications below the MSc level, and the young people who have already spent four years to acquire a Bachelor's degree are forced to invest more time and money into advancing their qualifications. This increases the cost of human capital. It appears that most (but not all) African countries have soil scientists and facilities to train them. In countries where soil science training is not currently available, potential decisions to initiate soil science training at existing tertiary institutions would require more in-depth consideration within the national context to weigh national investment against investment in updating regional training facilities, for example.

Thinking about investment

The scope and focus of this study were not intended to make a case for investment per se. The goal was rather to obtain an overview of the status and future demand of human capital in soil science as perceived by individuals working as, or with, soil scientists. However, the assessment results and perceptions of respondents indicate that soil scientists are an important part of agricultural production and research on the continent. Furthermore, it becomes apparent that there is more to be investigated and understood about the nature of human capital in soil science, where it is critically needed (regionally, nationally, institutionally, sectorally), and how investment could be customized at regional and national levels to ensure optimal return on investment in appropriate forms.

Looking at the scenarios in different countries, there is clearly no generic problem or solution that would apply to every country. We would not recommend that investment be blindly channeled into training more soil scientists in or for all African countries. Instead, we recommend that, as part of investment planning, a more in-depth analysis be conducted at the national level to understand where a critical soil science mass would have the greatest impact on the increased production of nutritious food to support food security. This would include an analysis of the role of soil and soil science knowledge within agricultural production and the agriculture industry, the national economy, systems related to farmers' access to appropriate soil-related information, and more.

For example, in some countries it may be very important to invest in training a critical number of additional soil scientists, ensuring that there would be employment available to absorb the newly graduated soil scientists, and/or training existing soil scientists in additional skills. In other countries it may be more important to create employment opportunities for existing soil scientists, including investing in skill refreshment or reskilling of existing scientists, and

developing the necessary value chains. To discuss this further, we use an example from The Gambia.

The Gambian example

In response to the question concerning what soil scientists are needed for in The Gambia and where, the GSP focal point replied: *"Soil scientists are needed for all of the above [i.e., for soil survey, soil mapping, research, advisory services, consulting services, education]; part of my unit's mandate is to provide soil surveys, advisory services, training and in some cases consultancies, but the unit lacks adequate professionally trained soil scientists presently. The only research institution does not have more than two soil scientists. Soil scientists are badly needed in all these institutions [i.e., in government, universities and/or colleges, private sector, research institutions, farmers' cooperatives, consulting companies, sales and marketing, corporate agribusiness]; in fact, there are very few soil scientists in the country at the moment."*

With regard to succession planning, he said: *"The continuous training of the younger generation in soil science is not being encouraged at all required levels and so a vacuum is being created as there are very few, if any, young ones to succeed the retirees. Therefore, succession planning is not practically in place for now as far as I'm concerned."* To further understand the potential cause of the lack of young soil scientists, he was asked: *"How did this happen? (I.e. was there no interest amongst younger generations to study soil science? Are there no easily accessible facilities to train as soil scientists? Something else?)."* He responded: *"All of your above-mentioned suggested reasons are true for the lack of smooth succession/replacement of capacity in soil scientists in the country.* ***More people seem to be motivated in the education, technology and commerce subject areas than agriculture and soil science.*** *Low performance in science subjects is also a contributing factor but generally lack of interest in soil science may be a major contributing factor."* Upon enquiring about the availability of soil science training in The Gambia, his response was: *"****There are no soil science degrees offered in the country,*** *it's only tenable abroad; however, agricultural programs offered by the College and the only university do offer individual courses in soil science as part of requirements for the fulfilment of the award of a BSc in agriculture."*

So, in The Gambia there are a number of potential actions that could address the issues at hand. For example:

1. Invest in the training of a critical number of young Gambian students in soil science at universities outside the country (within Africa or elsewhere) with the aim of filling specific Gambian positions upon completion of their degrees. Agricultural soil science degrees normally require four years, plus another two years for MSc training and an additional three years to obtain a PhD (should postgraduate training be needed). In the worst-case scenario, this implies that for the next four to nine years, the current perceived gap in soil science human capital in the country will remain, which leads to the next potential action.

2. Invest in the creation of key soil science positions if vacancies do not already exist. From Table 3, The Gambia needs an additional 21 soil scientists (3 for soil survey and mapping, 6 for agricultural and advisory services, 9 for tertiary training, and 3 for research). All these positions do not necessarily need to be created. A more in-depth analysis would be essential to determine the institutions and positions that would ensure the best contribution to agricultural production and food security in the country. These key positions could be filled on a fixed-term contract by non-Gambian soil scientists with the understanding that Gambian soil scientists would fill the positions once they have completed their training. As part of succession planning, a sufficient handover period would be included to ensure the smoothest possible transition.

3. A critical point of evaluation becomes the issue of soil science training in the country, which is currently not provided. Once again, more in-depth assessment would be critical to determining the best course of action. For example, the following actions could be taken:

    a. Develop a full soil science curriculum within a Gambian tertiary training institution and create the required vacancies for lecturers. Once again, these can be sourced from outside The Gambia as needed, with the aim of eventually replacing

these lecturers with Gambian soil scientists. However, retaining at least some international soil science lecturers could also be beneficial and considered. Of course, the value of retirees should not be underestimated, so including retirees at least as guest lecturers would be vital to retain and transfer the historical knowledge of Gambian agriculture and soils. OR

b. Invest in improving existing tertiary soil science training facilities in other African countries, as well as supporting Gambians to attend these facilities. OR

c. Simply invest in bursaries to train young Gambians at already well-functioning international facilities.

These are only some of the areas to be considered in terms of optimizing investment in human capital in one country of 54 in Africa, and by no means constitutes a full analysis.

5 Recommendations

Based on our analysis of the broad-based and institutional surveys, we make the following five recommendations:

1. Considering the diversity of capacity and associated needs in different African countries, each country should embark on its own study and assessment of human capital in soil science and formulate strategic measures to align human capital with development objectives related to food security, agricultural development, and economic growth. These measures would include creating critical soil science positions where they do not exist, or reopening critical positions that may have been closed.

2. Most African countries have extensive expertise in the quality of soil resources. However, this expertise is often not adequately utilized by the governments, development agencies, or agribusinesses. We recommend closer interaction between investors in agricultural projects and national soil experts to maximize the benefits of locally available knowledge. The local soil experts can significantly improve the return on investment in projects related to both development and conservation by optimizing appropriate land use and management of appropriate soils.

3. The continent has an extensive and well-distributed system of universities offering degrees in soil science, often in combination with other agricultural disciplines (e.g., agronomy and horticulture), which can forge the human capital required to provide services to agricultural development. The smaller countries that do not offer national soil science degrees are served by regional and international training facilities. At the regional level, these facilities are often located in neighboring countries. This cooperation should be maintained and strengthened as a current priority, even above investing in the development of national soil science training infrastructure where this does not currently exist.

4. Almost half of the soil scientists participating in this survey are employed in the education sector. This shows a need for broader investment in job creation for soil scientists in agricultural consulting, including both public and private extension services. Research institutions require significant support to maintain research infrastructure and outputs through institutional funding, as well as an uninterrupted flow of research projects addressing national development and food security priorities.

5. The employers of soils scientists should continuously invest in human capital development by broadening the range of skills and equipping staff with modern tools and methods (i.e., digital soil mapping, earth observation, remote sensing, statistics, water management, in-depth training in systems, etc.).

6 References

Badraoui, M. 2006. Connaissance et utilisation des ressources en sol au Maroc. Rapport général '50 ans de développement humain et perspectives 2025', pp: 91–117.

Bakker, G., J. P. Okx, M. Assen, and T. Solomon. 2016. Ethiopian Soil Laboratory Infrastructure; CASCAPE Scoping Mission. Wageningen, Alterra Wageningen UR (University & Research centre), Alterra report 2722.

Barbarasa, E., J. Barrett, and N. Goldin. 2017. *Skills Gap or Signaling Gap? Insights from LinkedIn in Emerging Markets of Brazil, India, Indonesia, and South Africa*. Washington, DC and Mountain View, CA: Solutions for Youth Employment and LinkedIn.

Bouma, J. 2014. "Soil Science Contributions towards Sustainable Development Goals and Their Implementation: Linking Soil Functions with Ecosystem Services." *Journal of Plant Nutrition and Soil* Science 177 (2): 111–20.

Brogan, J. C., P. Lemos, and R. E. Carlyle. 1965. *A Survey of Soils Laboratories in Sixty-Four FAO Member Countries*. FAO Soils Bulletin 2. Rome: FAO.

Cherlet, M., C. Hutchinson, J. Reynolds, J. Hill, S. Sommer, and G. von Maltitz, eds. 2018. *World Atlas of Desertification*. Luxembourg: Publication Office of the European Union.

Dotterweich, M. 2013. "The History of human-Induced Soil Erosion: Geomorphic Legacies, Early Descriptions and Research, and the Development of Soil Conservation—A Global Synopsis." *Geomorphology* 201: 1–34.

FAO and ITPS. 2015. Status of the World's Soil Resources: Technical Summary. doi:ISBN 978-92-5-109004-6.

Fey M., ed. 2004. "SSSSA Golden Jubilee Reviews of South African Soil Science." *South African Journal of Plant and Soil* Special Issue: Volume 21.

Gibbs, H. K., A. S. Ruesch, F. Achard, M. K. Clayton, P. Holmgren, N. Ramankutty, and J. A. Foley. 2010. "Tropical Forests Were the Primary Sources of New Agricultural Land in the 1980s and 1990s." *Proceedings of the National Academy of Sciences* 107 (38): 16732–37.

Grove, R. 1989. "Early Themes in African Conservation: The Cape in the Nineteenth Century." In *Conservation in Africa: Peoples, Policies and Practice,* edited by D. Anderson and R. H. Grove. New York: Cambridge University Press.

GSP/FAO (Global Soil Partnership/Food and Agriculture Organization of the United Nations). 2015. "NENA Soil Partnership Conference: Towards a Regional Implementation Plan on Sustainable Management of Soil Resources." *Status of Soil Resources and Priorities towards Sustainable Soil Management.*

———. 2016. *Regional Implementation Plan for the African Soil Partnership.* Food and Agriculture Organization of the United Nations, Rome, Italy.

———. 2018a. "Report of the Fourth Near East and North African Soil Partnership Workshop," June 13, 2018, Food and Agriculture Organization of the United Nations, Rome, Italy.

———. 2018b. "Third Meeting of the African Soil Partnership," June 13, 2018, Food and Agriculture Organization of the United Nations, Rome, Italy.

Hall, R., I. Scoones, and D. Tsikata. 2017. "Plantations, Outgrowers and Commercial Farming in Africa: Agricultural Commercialisation and Implications for Agrarian Change." *The Journal of Peasant Studies* 44 (3): 515–37.

Keesstra, S. D., J. Bouma, J. Wallinga, P. Tittonell, P. Smith, A. Cerdà, L. Montanarella, et al. 2016. "The Significance of Soils and Soil Science towards Realization of the United Nations Sustainable Development Goals." Soil 2 (2): 111–28. doi:10.5194/soil-2-111-2016.

Marsh, G. P. 1864. Man and Nature: Or, Physical Geography as Modified by Human Action. New York: Charles Scribner's Sons.

Montanarella, L., D. J. Pennock, N. McKenzie, M. Badraoui, V. Chude, I. Baptista, T. Mamo, et al. 2016. "World's Soils Are under Threat." Soil 2 (1): 79–82. doi:10.5194/soil-2-79-2016.

Montanarella, L. and R. Vargas. 2012. "Global Governance of Soil Resources as a Necessary Condition for Sustainable Development." *Current Opinion in Environmental Sustainability* 4 (5). Elsevier B.V.: 559–564. doi:10.1016/j.cosust.2012.06.007.

Muchena, F. N. and R. M. Kiome. 1995. "The Role of Soil Science in Agricultural Development in East Africa." *Geoderma* 67 (3-4), 141–57.

Mutsaers, H. J. W., D. Coyne, S. Hauser, J. Huising, A. Kamara, G. Nziguheba, P. Pypers, G. Taulya, P. van Asten, and B. Vanlauwe. 2017. *Soil and Soil Fertility Management Research in Sub-Saharan Africa: Fifty Years of Shifting Visions and Chequered Achievements*. Earthscan studies in natural resource management. London: Routledge.

Sanchez, P. A. and M. Swaminathan. 2005. "Hunger in Africa: The Link between Unhealthy People and Unhealthy Soils." The Lancet 365 (9457): 442–44.

Vanlauwe, B., A. H. AbdelGadir, J. Adewopo, S. Adjei-Nsiah, T. Ampadu-Boakye, R. Asare, F. Baijukya, et al. 2017. "Looking Back and Moving Forward: 50 Years of Soil and Soil Fertility Management Research in Sub-Saharan Africa." *International Journal of Agricultural Sustainability* 15 (6): 613–31.

Whitlow, R. 1988. "Soil Conservation History in Zimbabwe." *Journal of Soil and Water Conservation* 43 (4): 299–303.

Appendix 1. Commentary by the Respondents to the World Bank–Sponsored Survey of Human Capital in Soil Science in Africa (presented verbatim)

1. Algeria

Pour ce qui est de mon pays d'énormes travaux de caractérisation selon les nouvelles normes WRB sont à engager de manière urgente, vu l'espace a couvrir c'est un chantier qui durera plusieurs année et devant engager plusieurs spécialistes de la pédologie sur ces différentes facettes.

The soil science remains the least developed discipline in most African countries and requires a lot of attention to ensure the life of future generations.

Soil science is an important key for agricultural and economic development in African countries

La science du sol est un domaine délicat, en Afrique il était avec les événements, actuellement il a besoin d'efforts concertés au niveau locale et régional pour les promouvoir en coopération avec les institutions et les organisations mondiales

Il y a beaucoup à faire.

Je ne connais pas les autres pays africains que l'Algérie. Dans mon pays, la science du sol est un domaine connu des institutions administratives activant dans l'agriculture et l'environnement. Beaucoup d'études sur les sols, avec la création de 2 bases de données (Nord et Sud du pays), mais il reste encore à faire malgré les différents programmes de cartographie.

2. Benin

L'Afrique regorge de spécialistes de Sciences du sol qui, malheureusement, travaillent de façon dispersée. Une initiative regroupant les spécialistes des Sciences du sol pour aborder ensemble le grand problème de la dégradation des terres en Afrique, sera salutaire. Deux des grands problèmes à résoudre sont -i- la qualité de la matière organique en vue de son stockage dans les sols tropicaux de l'Afrique et -ii- l'utilisation des microorganismes du sol (plant growth-promoting rhizobacteria).

Le principal problème des sciences du sol aujourd'hui en Afrique est la fiabilité des résultats d'analyse dans les laboratoires, la qualité des équipements de laboratoire ce qui amène à collaborer avec certaine Université du Nord. La formation et le renforcement de capacité des cadres et techniciens aux nouvelles méthodes d'étude des sols.

Les sciences du sol ont un grand défi à relever en Afrique Sub-Saharienne surtout en ce qui concerne la baisse de la fertilité des sols et du niveau de rendement des cultures. La principale cause est la baise du taux de matière organique. Le développement des stratégies sur la base d'une approche participative pour le développement des technologies de gestion intégrée de la fertilité des sols s'impose afin d'améliorer l'efficience de l'utilisation des nutriments par les cultures.

Le sol étant le garde-manger de toute production végétale et animale, tout agronome devra s'intéresser à ce domaine. Auparavant, il y a beaucoup de spécialistes de sol et beaucoup d'ateliers, de symposium (corrélation des sols par exemple) y étaient organisés avec l'appui de la FAO. De nos jours, ces activités ont diminué considérablement et on observe aussi que les jeunes agronomes d'aujourd'hui n'aiment pas du tout cette matière. Il importe que des dispositions visant à inciter les jeunes à s'intéresser aux sciences du sol soient entreprises. Il faut que les anciens encadrent les jeunes d'aujourd'hui pour assurer la relève. Maître de Recherche en fertilité des sols et nutrition des plantes et ancien Directeur du Laboratoire des Sciences du Sol, Eaux et Environnement, je suis prêt à contribuer à une dynamisation de sciences du sol en Afrique

La science du sol est une spécialité de l'agronomie au service de l'agriculture africaine. Pour passer de

l'état actuel d'agriculture ''minière'' épuisant les sols à celle intensive durable et protectrice de notre environnement , nous devrons œuvrer pour la maitrise des aspects physiques, chimiques et aussi biologiques de la fertilité et de la conservation de nos terres. Cette science du sol a encore beaucoup de défis pour la promotion de l'autosuffisance alimentaire de notre continent et de l'exportation des produits agricoles tropicaux vers les autres continents.

3. Botswana

We have to work towards the creation of soil science awareness in Africa. A lot of interference in soil science works from other professionals who know very little about soils. Should be regulated.

4. Burkina Faso

Soil matters are forgotten by investors; while we are seeking sustainable development. See my Twit @ clinisols: we need a Marshall plan for soils in Africa!

We should use the current revival of soil science in Africa to create more impact and thus to prove relevance. (PS. country of residence is The Netherlands).

Soil science in Africa didn't know by the government. They didn't take care the information and the results of soil science to promote sustainable agriculture. that is the difficulty ho have meet soil scientist in Africa.

Il faut renforcer et augmenter le niveau de formation en sciences des sols. Ceux qui sont bien formés partent à la retraite alors que la relève n'est pas assurée. Il faut trouver des moyens financiers pour valoriser les expériences des anciens qui vont à la retraite.

L'histoire de la science du sol dans mon pays été marquée surtout par la cartographie des sols par l'ORSTOM. Puis l'on s'est intéressé à la l'utilisation des engrais minéraux puis agro minéraux pour améliorer les rendements. La gestion intégrée de fertilité des sols est l'approche actuellement utilisée. Les questions de la biologie des sols, de la séquestration du carbone, de mise au point de formules de fumure équilibrées sont d'actualité.

La science du sol est mal comprise par les décideurs et les pédologues sont très mal employés. les résultats de recherche sont peu et mal utilisés. Les analyses d'échantillon ne sont faits parfois.

Il faut un plan pour promouvoir la science du sol et surtout le renforcement des capacités des pédologues. Nous souhaitons que les projets de développement au niveau de l'agriculture intègre systématiquement les pédologues au niveau national pour l'exécution des projets

5. Cabo Verde

La science du sol a toujours existée en Afrique, dans la mesure où, les africains ont toujours maintenu un lien étroit et de respect par rapport au sol et les autres composants du sol. Malheureusement, l'état actuel de la science du sol est nettement en-dessous du niveau qu'elle devrait avoir. Compte tenu de la qualité des laboratoires en Afrique, du niveau de formation de la majeure partie du personnel qui y travaille et également des salaires nettement en dessous de la qualité des spécialistes et chercheurs qui évoluent dans ce domaine. Au delà de ces aspects, on peut citer aussi, des liens pratiquement inexistants entre les chercheurs et spécialistes du sol Africains.

6. Côte d'Ivoire

La science du sol en Afrique existe il y'a bien longtemps déjà, à ce jour il y'a d'énormes progrès dans ce domaine et son avenir est prometteur.

Sans vouloir refaire une histoire approuvée, la science du sol a fait des progrès considérables sur le plan scientifique et académique. Cependant, c'est une discipline qui est restée trop attachée a ses principes de base comme le veut son histoire: elle est peu adoptée par l'utilisateur surtout en Afrique ou se sont des personnes peu éduquées qui devraient l'utilisée. Cette situation crée une letargie de l'essore

de cette discipline car émaillée par des méthodes sophistiquées.

Pour rendre plus opérationnelle cette discipline, il faudra la rendre plus accessible au grand public.

A cet effet, des études de corrélation régionale devraient être conduire pour traduire les données analytiques en indicateur biophysique et promouvoir l'ethno-pédologie.

Les utilisateurs attendent de nous des recommandations après 30 mn – 1h de visite de terrain et non après échantillonnage et analyse en laboratoire. D'ailleurs cette approche est trop onéreuse pour les praticiens africains.

La science du sol est sous-estimée en Afrique

Nombreux sont les agro-industries qui s'intéressent véritablement à l'importance qu'a la Pédologie dans la bonne marche de leur structure. Dans l'avenir, nous devons d'abord amener ces structures à beaucoup s'intéresser au sciences du Sol. Ensuite, amener les entreprises de construction à consulter un spécialiste des Sciences du Sol avant tout travaux de construction afin, d'éviter tout effondrement. Enfin, du moment où tout commence par la terre et fini par la terre, nous pensons que les Sciences du Sol sont très promoteur car incontournable dans nombreux domaines.

Encore à l'état de balbutiement

Alors que plus des trois quarts des pays d'Afrique tire l'essentiel de leurs ressources de la mise en valeur du sol, très peu de moyens(surtout financiers) sont consacrés aux travaux destinés à une bonne connaissance des sols. De plus, la plupart des cartes d'inventaire et de répartition des sols disponibles sont largement dépassés (échelles trop petites, couvertures parcellaires des territoire, etc.)et gagneraient à être actualisées. Les laboratoires capables de faire des analyses d'échantillons de sols sont en nombre très insuffisants et généralement sous équipés, ce qui, non seulement rallonge les délai de mise à disposition des résultats, mais aussi et surtout, favorise le coût élevé des déterminations.

Qui parle de la science du sol, parle de la vie. On dira d'une évolution de la science du sol en Afrique mais beaucoup reste à explorer avec la dégradation du sol et l'utilisation des intrants non homologués

Juste signaler que les sciences du sol sont les parents pauvres du domaine de l'agronomie en Afrique

Pendant longtemps, la science du sol est restée l'affaire des seuls spécialistes dans mesure où l'agriculture elle-même était un secteur réservé aux personnelles qui n'avaient pas pu avoir de quoi faire pour se prendre en charge. Aussi les gens cultivaient partout où ils le pouvaient et se contentaient du peu qu'ils pouvaient récolter pour se nourrir et survivre en espérant recevoir des aides de leurs enfants ou parents travaillant dans d'autres secteurs. On pratiquait alors l'agriculture extensive, les cultures itinérantes sur brûlis, etc. Mais aujourd'hui, avec le retour des jeunes à la terre par la réduction de l'embauches des diplômés et la hausse du coût de la vie urbaine par rapport aux salaires distribués, certains agriculteurs, notamment ceux qui veulent y faire fortune, tout comme les petites et moyennes entreprises agro-industrielles font recours à la science du sol avant et pendant les mises en valeur des terres à leur disposition ou à acquérir. De par le nombre très croissant des agriculteurs et celui très décroissant de la disponibilité des terres cultivables, le recours à la science du sol avant et pendant les mises en valeurs des terres à leur disposition ou à acquérir se fera sans hésitation par tous les utilisateurs de sols.

Face aux changements climatiques et à la pression foncière, de nouvelles approches des activités des sciences du sol doivent être conçues et mises en œuvre. En effet, la connaissance des parcelles cultivées doit être approfondie en vue d'apporter des solutions appropriées. L'accent doit être mis sur l'agriculture biologique.

Les sciences du sol en Afrique ont démarré, selon nos connaissances, sous l'autorité des occidentaux avec comme schéma directeur, la cartographie des sol et la fertilisation des cultures principales (industrielles et vivrières). Contrairement à cette époque où les activités des sciences du sol étaient bien coordonnées,

aujourd'hui il est observé des activités isolées dans le cadre de divers projets. Ce qui fait craindre parfois, la conduite de mêmes études dans les mêmes domaines, avec un risque d'inefficacité certain. L'une des solutions est la création d'une base d'information accessible à tous les pédologues d'Afrique, même si les moteurs de recherche sur internet y contribuent pour déjà.

Progressivement l'intérêt des sciences du sol est reconnu et cette disciple sera de plus en plus indispensable pour une gestion optimale et durable des ressources dans le contexte actuel de changement climatique et d'agriculture biologique. Les spécialisations de plus en plus poussées dans le domaine des sciences du sol et également à saluer."

Le principal défi de l'Afrique en matière de Science du sol demeure la Gestion Durable du Sol, face à la nécessité de l'augmentation de la production agricole pour nourrir une population en forte croissance, tout en tenant préservant l'environnement.

Le manque de laboratoires et d'équipements ne permet pas à nous chercheurs en sciences du sol de travailler effacement au service des communautés or les sols sont dans un état de dégradation avancés

Soil scientists in seem to work each one in his corner or in small laboratory or country level groups. More broad collaborations and Knowledge sharing are needed

7. Democratic Republic of Congo

In the province of Katanga or in Tropical Africa, in general, the decline in agricultural production seems to be the consequence of the irrational management of land, due to the lack of adequate and appropriate information for each of the units of soil, thus leading, so Inescapable to their degradation. And yet, this had already been pinned down in 1948 during the African Soil Conference, held in Goma where it was recommended to treat tropical soils very differently from those in Europe, under penalty of their sterilization (Chevalier, 1948). Because, soil erosion by runoff is very higher. This is, the case today, the situation of many soils in the agricultural zone of Upper Katanga, which is the basis of the low productivity of agricultural land leading to the food scarcity, which forces the province to use the importation of foodstuffs of First necessity to support its population, despite its immense resources in the land. Soil Science is the key to improve life by raising and conserve soil productivity for the new generation.

Les sols africains sont très diversifiés étant donné leur pédogénèse, beaucoup de potentialités agricoles. Actuellement, des conflits fonciers récurrents suite à l'utilisation inadéquate des sols. Nécessité d'un travail systématique de cartographie et affectation de terres

Le sol occupait moins d'importance dans nos sociétés africaines, actuellement le se situe au cœur des problématiques de développement humain de notre temps; il est particulièrement au centre des préoccupations alimentaires et environnementales que connaît le monde d'aujourd'hui. Sur ce, il s'avère donc indispensable de sensibiliser pleinement la société civile et les décideurs à l'importance cruciale des sols pour la vie humaine. En perspective, il serait envisageable d'instruire le public sur le rôle crucial que jouent les sols dans la sécurité alimentaire, l'adaptation au changement climatique et l'atténuation de ses effets, les services écosystémiques essentiels, la réduction de la pauvreté et le développement durable.

La connaissance des sols en R.D. Congo remonte des travaux de la Belgique au cours de la décennie 1950 – 1960 à travers l'INEAC qui est devenu, à ce jour, l'INERA. Ces travaux n'avaient couvert que 15 % du territoire national. Les travaux qui ont suivi après sont sporadiques et peu denses. Les besoins de caractérisation des sols et d'élaboration d'une planification adéquate de leur utilisation dans le but d'un développement durable et propre suppose sont importants. Il y a nécessité d'appuyer l'équipement des laboratoires en capacités d'analyses physicochimiques, minéralogiques et en matériels de cartographie numérique et télédétection ainsi que la formation des ressources humaines plus jeunes pour la relève.

La science du sol a connu des moments de succès et de baisse.

1. Succès: Pendant l'époque coloniale, par ce que les investisseurs dans le domaine agricole devraient maîtriser le comportement des sols africains qui est différent des sols européens. Ex: en RDC, création de laboratoire de pédologie au sein de l'INEAC (Institut National d'Étude Agronomique au Congo).

2. Baisse: Après les indépendances la recherche scientifique est et surtout agronomique est presque laissée au second plan par les décideurs. le sol étant considérée comme ce qu'on foule au pied, les questions le concernant ont également été foulées aux pieds, càd, abandonnées. En RDC, par exemple, à par les données anciennes des sols de Yangambi, il n'existe presque pas de données sur les différentes unités pédologiques suivant les provinces ou les régions.

3. Avec l'éveil de conscience actuelle, suite aux impacts de l'homme sur l'environnement, la science du sol parait un domaine incontournable pour solutionner plusieurs questions touchant l'humanité entière et particulièrement et plus sévèrement, l'Afrique. La biologie, fertilité et santé des sols en Afrique doit attirer les chercheurs Africains.

Les sols des pays d'Afrique subsaharienne ont un faible niveau de fertilité intrinsèque (Anonyme, 2003) lie a des contraintes naturelles spécifiques a chaque zone agro écologique. Ces déficiences sont des facteurs déterminants de la production. Elles sont mal connues si bien que de faible rendements. Les éléments nutritifs exporter par les récoltes, dans des sols déjà pauvres, ne sont pas restituer de manière adéquate. En général, l'utilisation des engrais minéraux et organique dans les cultures vivrière, en milieu rural, reste insignifiante compte tenu du faible pouvoir d'achat du paysan. Et comme perspectives cette recherche a besoin d'une autre voie de recherche, celle d'évaluer la synergie entre l'amélioration des stocks de carbone et la dynamique de fertilité tant chimique, physique que biologique du sol ainsi que son impact sur la production agricole d'une part et autre part d'élargir la gamme de culture a évaluer les potentialité en vue d'augmenter les alternatives dans le processus d'adaptation et atténuation climatique et la sécurité alimentaire dans les zones les plus vulnérable tel est le cas des régions tropicale.

Merci bien, le problème de la gestion rationnelle de la fertilité du sol est toujours d'actualité dans les tropiques humides. Il s'intègre de plus en plus dans un ensemble de réflexions sur les schémas méthodologiques à mettre en œuvre pour juguler la fertilité fragiles des sols tropicaux soumis à une forte pression démographique pour répondre aux besoins alimentaires sans cesse croissants des populations tropicales nombreuses. L'identification et la caractérisation des sites de références à vocation agro-environnementales constituent, et comme perspective l'établissement d'un référence des paramètres de la fertilité et des contraintes du sol peut conduire a celui des carte de gestion des ressources naturelles.

8. Egypt

Soil Science in Africa is good status right now, because there are some countries interesting organizes scientific conferences and exchanges graduate and under graduate students and the experiences of researchers and scientists.

We need more advanced laboratories in our department

I think it needs more experts

I wish to establish a data base about soil scientists in Africa and network for most of science branches

9. Equatorial Guinea

Lack of soil data for drawing maps, etc.

10. Eswatini (formerly Swaziland)

Africa has a fair share of both acidic and alkaline soils. Salinity problems are also experienced in several parts of the continent. Do to continuous crop production without optimum replenishment of nutrients removed

using fertilizers most of the soils have reduced fertility and are degraded.

11. Ethiopia

I am an Emeritus Professor at The Ohio State University. For about the past five years, I have been working with a group of people in Ethiopia to start a private agricultural university named "Bethel Environmental and Agricultural University and Training Center." We have a registered board in both Ethiopia and in North America. We have obtained 30 acres of land and will be moving into Phase 2 shortly. We are seeking partners to help us with this vision.

I think soil science has long history in Africa, but it was not applied in a way that can bring sustainable change on crop production. Most production constraints are now related to soil (Acidity, alkalinity, water management, lack of fertilizer recommendation etc). Due to this, currently soil issues are becoming the main agenda for governments. But still it requires more effort and emphasis.

Soil Resource is among a precious natural capital for Africa. Nowadays, to some extent there is improvement on the concern of soil in Africa as compared to the past. However, the advancement of research and laboratory for expertise in the field is not satisfactory Most of the expertise and researchers in the area mainly depend on depend. In most countries researchers conduct different useful researches to solve certain problems and they report it in a language in which farmers cannot understand. (i. e even farmers are not getting the research outputs).

Soil matters – soil security is a requisite to feed this ever-growing African population!

12. Gabon

fort potentiel d'amélioration

Il faut redoubler d'efforts des nombreux pays africains manquent des données sur les sols en général et la séquestration du carbone en particulier

13. Ghana

It looks great particularly under climate change with agroecology outlook

African soils are neglected, the science of the soils are not applied

There is limited capacity building and support of the acquisition state of art tools & equipment for soil studies.

With the predominantly low inherent nutrient level of soils of the sub-region and declining yields of the sub-region there is the urgent need to resource Soil Scientist to improve yields to feed the increasing African population

The vigour required for the study of Soil Science is low. A serious and proactive approach must be adopted to boost interest in the study of the subject. (2) Students would wish to strongly know the job prospects. (3) The study of Agriculture right from the Basic level has not been given due recognition, thus interests in pursuing the various fields of Agriculture (e.g. Soil Science) at the higher (tertiary) levels have dwindled.

Soil science is only a partial expertise of what is needed to understand and support farmers. We need more interdisciplinary trained scientists and should not worship specific biophysical disciplines.

Soil Science is dying. We need to reinforce the interest of people through outreach and farmers engagement, stakeholder consultation and education.

in west Africa knowledge of soils is low, interest in soil analysis and interpretation is low, leading to misuse of the (few) fertilizers available.

Main priorities: nitrogen applications, rates, timing, forms – micro nutrients deficiency – increasing and preserving Organic Matter content, very low in most areas, by application of O.M. rich raw material and conservation practices."

Poor attention and coordination

Soil science in Africa is receiving much attention in the present than in the past

Agricultural soils in Africa is going down and we need a lot of soil scientists to come up with solutions to help improve the status of soil.

The soil in the past was largely considered as medium for plant growth and the Science was dependent on Agricultural Science. The trend is however changing as the soil is regarded more and more as a non-renewable resource that needs to be protected. It centrality in mitigation and adaptation to climate change has renewed the interest in many soil scientists in Africa.

Compared to the developed world, we still lag behind both in terms of technology, creativity and human personnel. For the past decade, the trend has been changing with more post-graduates being trained to fill in the void (about 30 PhD soil scientists has being trained in my Institution for the past 4 years alone).

Scarcity of funds has limited research in several ways. Young scientists are unable to think independently and must conform to the system to progress. Little collaboration exists among soil scientists, and with other disciplines (e.g. engineers, computer scientists). Young soil scientists must dare to think independently and creatively to tackle the challenges of our time.

Could Institutions engage in profitable ventures to fund their own research? Can we creatively engage with other disciplines to build technology devices to enhance both field study and laboratory analysis? I believe the Science has many job opportunities to offer if we dare to encourage creativity and take advantage of technologies.

Soil science is Africa is making good progress

Progressing steadily

GREAT PROSPECTS IN THE FUTURE.

High prospects but requires recognition and financial inputs.

14. Kenya

I am professor research in cacao nutrition, production and management

I am working in my laboratory of soil physics and research with my team about relationship in soil plant physiology and weather

The soils are primarily acidic due to over use of synthetic fertilizers, with erosion (And other) hotspots throughout agricultural farms. There is rehabilitation potential with green manure cover crops on the farms to reduce soil loosening and exposure to erosion agents, and biological engineering for cross slope barriers in steep gradients.

Soil science in Africa has been underfunded, therefore the basic infrastructure needed is still limited. Several initiatives such as AFSIS are changing the landscape but investments are needed to improve tools to better understand African soils. The prospects must be bright as soil science is the basis for sustainable land use—a critical need due to population expansion.

I would like to work as a soil consultant in Africa.

Still a huge gap.

I am deeply concerned that the interest to study Soil has significantly declined. Agriculture transformation agendas now focuses on markets, financing, seeds but pays less attention to soil health.

Been neglected before, used broad crop Nutrition recommendations that were not evidence-based. Currently strongly recommended to understand soil before managing it. Will be basis and driver for wide range of farming practices.

Importance of Soils is slowly gaining popularity in Kenya. Soil Scientists are however, not very much recognised.

Africa soil scientists should look forward to rapid, cheap and non destructive light based analytical spectral methods coupled up with paired soil and

plant tissue sampling to be able to provide near real time soil functional properties maps and as well be able to address soil and plant nutrient uptake challenges.All the this informationcan be collated and backed up and be extrapolated with use of satellite imageries.

Lots of capacity building on spectral analytical techniques is required in both academic and research institution to cater for the upcoming generation of soil scientists now and in future.

Africa needs up to date soil status information coupled with robust analytics and empowered scientist to be able to better their decision making process and influence policies on agriculture such as fertilizer applications and blending to better improveyields and productivity and reduce perennial hunger.

The future is promising; if and only if there is sufficient creation of awareness to the larger Agribusiness community, relevant County Government and National Government officials. This also involves continuous campaign on the need to embrace precision farming services and Good Agricultural practices for every farmer, small, medium and large-scale level to realize profits. All farmers to embrace KenGAP and Global GAP where applicable. Most importantly, the mainstay for most households being agriculture ensure our practices respect nature.

Soil science is relatively a new field in Kenya. We lack quorum in classes in the university as most students prefer more lucrative jobs. University of Eldoret started teaching soil science in undergraduate level in 2005. All other universities had it as subsidiary units. Most universities authorities are yet to understand that soil science is a broad subject and increase the quorum in undergraduate degrees.

However, the rate of unemployment in Kenya is quite high. Even with graduate papers, acquiring jobs seems so hard. As for me I do farming so that I can practice all the knowledge I gained.

Land degradation is a major problem affecting agricultural production in most parts of Africa. The major problem has been the management of African soils, which vary from very acidic in the highlands to saline in the lowlands. Several research on soil health has been carried out in different areas, findings disseminated and adapted by farmers. However, the research carried out, disseminated and adopted captures only a small percentage of the continent. Most areas of the continent remains untouched. Despite plant nutrition challenges in African soils, the pool for soil science researchers in Africa remains low, with the number of women in soil science research remaining significantly low.

There is, however, green light on the future of soil science in Africa, with many organisations such as AGRA coming up to support soil health in the continent.

Despite the support, soil health is still lagging behind and there is need for practical empowerment of soil science experts and structures in Africa.

Gleam…

Very few research due to lack of funding and very little has been done on soil classification, which is very basic in understanding other aspects of the soil. To mitigate climate change and also improve food production and make Africa food secure soils has to be given the attention they deserve in terms of research. more so in the role of soils in climate smart agriculture

In Most cases soil science based research has not been given much focus in Africa a case study in Kenya because of less number of trained soil scientists. Soil science as a course offered in Kenyan Universities is commonly marked with low number of student admission less than 200 countrywide because many people fear risks of unemployment.

Progressive

The governments in Africa have really neglected the aspect of soil Science, which ought to be the most crucial in agricultural production.

Historically Soil science in Kenya (my view) has been championed by all sorts of people masquerading

as soil scientists who have misled, provided poor results tainting the image of what soil science is all about. This was made worse by instructors at university who made it difficult, through their teaching methods, for students to embrace soil science. Also, surprisingly 99% of my lecturers and fellow senior Scientists are trained in the west and yet they have made no effort to set up quality labs to support their results and generate data to influence policy. The lack of quality laboratories and research infrastructure is very frustrating for any soil scientist born, trained, living and working in Africa, a reality I faced when conducting my PhD in Soil Science in Africa! And the list can go on. The situation has however improved as the need for evidence-based research for public policy formulation has put pressure on scientists who are making all efforts to collaborate and seek funding for meaningful research. The future is bright, and I believe that as more inspired for change scientists emerge they will make efforts to develop tools, methods, protocols, design products that are suitable and relevant to the land users. Soil Scientists in Africa need to stand up and be counted.

There is still alot to be done, In many cases, the Soil Science aspect has been left or forgotten and emphasis put on crop improvement rather than on Soil improvement.

Soil Science is neglected by all major stakeholders, just like all research. very low funding and promotion, low enrolment of soil science students, inadequate infrastructure e.g. laboratories and overreliance on external support and expertise.

15. Lesotho

There is lack of research institutes in Lesotho and fewer experts in soil science. There is also a need for soils councils in place to assist the alleviation of food insecurities and promote agricultural production.

The rate of land degradation is increasing due to climate change

I think its importance is not well recognized

16. Liberia

Soil Science in Africa requires more investment as the demand for agricultural commodities increases proportionally to global population. Appropriate investment in soil resources with much emphasis on soil conservation and soil health will save the environment.

17. Libya

Most of the African countries are still behind in the technology, We should create a soil science database in Africa, Also, I really encourage to have A soil science society of Africa.

Maybe we can also have creative practices like what is called Soil Judging in the USA. I have tested this project in Libya in two different universities and most of the Participants liked the idea.

Adaptation of Soil Judging to Libya (https://scisoc.confex.com/crops/2015am/webprogram/Paper91217.html)

18. Madagascar

Les grandes études sur la cartographie des sols à différentes échelles disponibles datent encore de la période de colonisation et effectuée par les instituts de recherche français. Très peu de nouvelles études pédologiques ont été effectuées depuis. L'absence de financement pour la recherche fait partie des principales contraintes dans ce domaine et le manque de spécialistes engagés. L'importance des sols en Afrique est d'une manière générale et souvent reliée à des notions de fertilité. Pourtant, de grands chantiers nous attendent dans la lutte contre la dégradation des sols qui commence à prendre de l'ampleur. Le rôle des spécialistes en sciences du sol est donc plus important que jamais.

19. Malawi

Unlike some decades back, when virgin land was plenty and micro fauna population was still high, and the soil was healthy and productive, in recent years there has been a remarkable increase in human population in most part of the Sub-Saharan African region. Hunger and poverty have become endemic. While, soil degradation caused by combined social and climate factors has reached the level of acceptance. Its economic impact has affected many regional developments as it touched the national and international financial budgeting. As a result, poor soil quality, declined soil fertility and environmental quality have decreased food production and economic profits in the entire African region. Crop production depends fully on quality of soil and its fertility It is the highest priority of soil science to improve and promote the understanding of soil and it function for economic crop production. Unfortunately, soil scientist continues to be side-lined in the development agenda. This is because everybody thinks soil is dirty when actually it is life. If African nations can start giving Soil Scientist room in their agricultural development agenda, crop productivity would increase significantly.

20. Mali

L'état des sols se dégradent de plus en plus en Afrique et est vulnérable aux menace de dégradation des ressources naturelles et pour cause la pression d'une population croissante. la forte dépendance des pluie est une sensibilité aux variation climatique (changement climatique).

Les terres arables sont des plus en plus touché par l'érosion hydrique et éolienne sur tout en Afrique sub-saharien; salinisation, déforestation et désertification.

Les sols Africain ont tendance à perdre leur capacité physique à cause des mauvaises pratique culturelles (compostage, labour, jachère .....etc).

La productivité des ressources et fondamentalement liée à la qualité physique des sols ; cette productivité est en déclin et ceci met en danger la sécurité alimentaire et accrois la pauvreté.

Par ailler pour mécaniser ces différents faits, la comité scientifique des gestion des sols Africains doit élaborer des méthodologies de recherche pédologique et climatique (sol, climat, culture) et développer des techniques des gestion durable des terres Africains.

Créer une base de donné qui contient les enregistrements de chaque sol (paramètre physicochimie) du continent Africain.

J'ai effectué mes études en ex-URSS pour venir travailler dans mon pays en tant qu'Ingénieur Pédologue. De ma sortie à maintenant, notre gouvernement n'a jamais su qu'il a des ressources compétentes formées et ne s'est jamais adressé à nous. Je suis un des rares à frayer seul mon chemin. Dans mon pays on ne se soucie pas des sols, il n'existe aucune couverture complète du pays, il y a bien sur des données cartographiques réalisées par TAMS Ingénieur (USAID) au 1/500.000 è en 1987. Plus rien encore en matière de cartographie des sols. Le personnel formé ces derniers temps s'occupe surtout de la fertilité des sols (ce sont surtout des ingénieurs agronomes), donc pas qualifiés pour ce travail des cartes qui sont les documents de base de la planification locale, régionale ou nationale. Dans l'indifférence, nous avançons comme ça, aucun souci jusqu'aujourd'hui. J'ai aimé conduire, organiser et réaliser les études en sols (étude et cartographie des ressources en terres, études d'état de surface ou études des ressources en terre en vue de leur mise en valeur agricole ou de leur conservation, étude d'évaluation environnementale) et réaliser les études et faire des cartes des sols au 1/200.000è, 1/50.000è pour tout le pays, en plus justement des études ponctuelles.

C'est un domaine ancien qui n'est pas beaucoup exploré en Afrique surtout. Mais avec les innovations de la nouvelle Technologie, la science du sol peut devenir un domaine incontournable pour le développement du Continent Africain.

Dans l'histoire, les sols ne demandaient pas de soutient organique pour donner un rendement important, mais aujourd'hui ils sont appauvries en matière de matière

organique. Cette situation est fonction de pression démographique.

De 1977 à 2000, des études portaient sur l'érosion hydrique des sols en Afrique de l'Ouest (Roose, 1997; 1994; Diallo, 2000; Diallo et al, 2011, etc.). En 1995, on assiste à l'émergence de l'aménagement des champs en courbe de niveau (Traoré K, 1998; Gigou et al, 2006). Actuellement les études sur l'érosion des sols et le développement des aménagements en courbe de niveau sont en cours au Laboratoire Hommes Peuplements Environnement du Mali. En perspective, le laboratoire Hommes Peuplements Environnements entreprendra des études sur les propriétés des sols et la vulgarisation des aménagements en courbe de niveau sur l'ensemble du Mali.

21. Morocco

Faiblesse du potentiel humain

Les sols africains sont dégradés ce qui nécessitent un renforcement de capacité technique et scientifique pour améliorer la qualité des sols

Soil research is still at juvenile stage. Great efforts are needed to develop soil sciences in Africa.

22. Mauritania

C'est la science la plus négligée et la plus utile en Afrique. La sécurité alimentaire, la lutte contre la désertification, le réchauffement climatique en dépendent. En Mauritanie, cette ressource naturelle est laissée à la merci des aléas. Ce service écosystémique mérite une évaluation et une valorisation. Comme je suis biologiste des végétaux, je prends beaucoup de temps à faire comprendre au différent acteur le rôle que joue le sol comme service de support comme également la pollinisation. Or en Milieu subdésertique comme le nôtre l'entomologie et la pédologie ne figurent pas dans les préoccupations réelles des décideurs car les enjeux ne sont pas éclatants et très éloquents .Je pense que ce sont des domaines sur lesquels la banque mondiale doit se focaliser pour relever les défis de la faim, de la désertification et de la maladie.

Je trouve que la science de sol c'est un élément essentiel pour le développement des pays et surtout en Afrique où se trouve des sols très fertiles, et en même temps nous avons beaucoup de problèmes tel que la salinisation des sols, l'ensablement et l'érosion … etc.

23. Mauritius

Apart from soil, mapping, soil science is close to nil in Africa. It therefore does not have a history worth noting, the current state is poor and therefore the prospects for imparting knowledge of soils in Africa is bright

I can only comment about the sugarcane industry where I work. My impression is that there is insufficient knowledge on soils in the industry in Africa and there is scope for improvement, the more so as there are new challenges in terms of climate change, soil conservation, etc. We need to better communicate with the farmers on these and other soils-related issues.

24. Mozambique

There is a potential but need strong coordination, leadership and funding

i THINK WE NEED TO GIVE A LOT OF TECHNICAL ASSSITANCE TO AFRICAN COUNTRIES IN SOIL, AGRICULTURE, RURAL EXTENSION, RURAL DEVELOPMENT, SOCIAL DEVELOPMENT AND MANY OTHERS.

ainda em estado incipiente em Mocambique. Precisa-se de mais capacitacao e formacao de recursos humanos na area de ciencias do solo

Parece não haver cooperação quanto a cientista do solo de África se comparados com Brazil e Estados Unidos de América. Será que existe uma sociedade de pesquisadores e cientistas de solo em África?

During the period 1986 to around 2000 there was an intensive focus on soils, Then was ignored the development agencies and governments put attention on crop science, biotechnology, Computer science, Business management. The consequence is poor adherence of students in soil subject. Luckily, the Global Soil Partnership is advocating and building awareness of the Soil in supporting the sustainable development Goals.

25. Namibia

moderate

Soil science is a neglected field in Africa despite its importance in agriculture. Today all African countries appear to have taken leap in introducing more soil related institutions in their universities or research centres. With an alarming rate of soil depletion and world awareness of global issues such as climate change and greenhouse gas emissions, soils are playing pivotal role.

26. Niger

Most of the soils of Africa are characterized by the poverty of original material in nutrients. The main limiting factors are low clay and organic carbon content and low exchange capacity. This is associated with overexploitation and high pressure on cultivated soils and lands resources with the quick growth of population and the demand for food. Maintaining soil fertility and land resources is a big challenge. Since the paradigm of "external input" in the 1960s and 1970s, to the latest concept of integrated soil fertility management, most of the approaches remain crop oriented or livestock oriented with less attention to local communities, which are at the heart of land resource management. There is a need to rethink our approaches of management of soils and lands resources in Africa.

We suggested a new integrated and holistic approach that involves local communities in a dynamic process of participative management of lands as providers of services for the entire community (can see publication: https://doi.org/10.1016/bs.agron.2018.02.001)

Good progress been made so far.

Discipline peu sollicitée pour le développement agricole et la gestion des ressources naturelles

Dans le domaine de la recherche, je pense qu'une avancée significative a été réalisé. Cependant, beaucoup de chose reste à faire dans le domaine la cartographie des sols et de l'évaluation des la dégradation des sols particulièrement au Niger.

Il y a beaucoup de choses à faire dans le domaine.

La science du sol est très peu embrassée par les jeunes africains et ceux qui se sont engagés ne se connaissent pas bien car ils ont très peu de programmes de recherche en commun. Chacun évolue de son côté. Compte tenu de l'état de dégradation des sols africains, il est impératif que les pédologues s'unissent (création d'un réseau des pédologues africains) pour réfléchir ensemble afin de trouver des solutions adéquates. Aussi, les jeunes doivent être encouragés pour aller vers cette science qui a un rôle capital à jouer car s'occupant de la principale ressource, base des productions en Afrique.

La science du sol a connu de beaux jours avec des formations solides, des spécialistes qui aiment leur métier; aujourd'hui la science du sol n'est pas suffisamment associée dans le processus de prise de décision pour l'utilisation du sol, et les jeunes s'y intéressent de moins en moins car "c'est salissant et c'est mal payé", disent-ils; du coup, les perspectives de la science du sol ne sont pas très prometteurs surtout avec la forte concurrence des forestiers qui s'accaparent le monopole du discours sur l'environnement.

27. Nigeria

Soil science activities in Africa is still in the development stage, obsolete equipment and poor funding affects the sector. Most farmers ignore soil

testing. Modern soil scientific equipment urgently needed and collaboration is also important.

It is in a sorry state and deteriorating. Nothing is available. No mentoring

The future of soil science is bright

Soil Science was not considered as a marketable course in the university and this can be confirmed through the statistics of students' enrolment in the last three decades. The scenario is however changing perhaps due to increasing need for experts in new universities, fertilizer (organic, mineral, biological) and stimulant industries, commercial agriculture, pollution control, etc. Soil science will be very relevant in the growth and development of Africa.

Soil Science is gradually gaining recognition in Africa and the future looks bright for young soil scientists as farmers, government and other practitioners now recognize the role soil scientists play in promoting environmental sustainability and sustaining food security.

Africa is just waking up to the challenges of soil science, Kenya, Uganda and some East African Countries are not doing bad, since i have visited some of these countries while Nigeria is just coming up. The prospects of soil science is very high because if Africa is able to get or fix the soil right, every other thing will be well in Africa

Soil Science as a distinct subject started in the 1950s in Nigeria at the Degree level and currently it is being taught in over 100 tertiary Institutions in Nigeria. The affiliation of the soil Science as a subject to Agriculture will have expand into environmental issues in the future.

The history of soil science was very encouraging and inspiring. The current state is however low due to the low utilization of soil science for developmental projects. The prospects of soil science in Africa will depend on better education of the role and significance of soil science in national agricultural and non-agricultural programmes and projects.

Soil Science unlike most other courses was not welcomed with open arms in Africa but recently the story has changed tremendously because of the realization of the importance of soil. This has opened up enormous prospects in soil science.

Soil science is progressing rather slowly due to politics. Never the less soil science has prospects in Africa.

Soil Science in Africa is evolving from a state of being subsumed in Agronomy where the emphasis is greater on the 'end' (crop productivity) than on the 'means' (soil resources) to a state of being recognized as the science that encompasses ecological sciences and whose technology arm is the conservation of other natural resources not just for sustainable crop production but also for addressing the negative impacts of all forms of anthropogenic activities on the environment. Soil Science is still not very popular in Africa probably because of the abundant soil resources in the continent and hence the tendency to take their conservation and management for granted. The profession of Soil Science, however, has a lot of prospects in Africa, considering the long weathering history of the majority of soils in the continent for which they are not so fertile, the ever rising pressure on land for which the traditional shifting cultivation is no longer fashionable, the fragile nature and low resilience of many of the ecosystems, the low level of soil stewardship and hence high level of land misuse, the widespread environmental degradation and associated low agricultural productivity in the continent, as well as the fact that the continent is second to none in terms of vulnerability to the contemporary climate change.

A Lot need to be done to improve the prospects. One way is by first updating the curriculum in universities across the continent. By so doing, better graduates will be produced with a mindset that will improve the prospects of soil science

Soil Science in Nigeria is getting well developed with the establishment and passing into law of the Nigeria Institute of Soil Science. This will complement the trainings at Universities & Agricultural Institutions offering Soil Science courses. The prospects of good

careers as Soil Scientists are quite bright in view of the current Nigerian government policy in promoting Agricultural productivity and Climate Smart Agriculture.

A great deal of exposition and prospects of soil science are still lacking in Africa. Subscription for soil science discipline in Nigerian Universities are still at an all-time low. Working conditions and facilities are nothing to write about in parts of Africa. More work to be done by practicing soil scientists, policy makers and government heads.

Soil science is as old as mankind. Presently, there is the pressing need to improve, manage and sustain the status of the soil in Africa generally due degradation by human activities and climate change. Therefore, soil science stands as the gateway to food sustainability and security in meeting the food demand for humanity presently and in the future to come.

Soil Science in Africa has gained in-road due to the understanding of its agricultural significance particularly; with Soil fertility management. However; interest in soil science education has not responded in the similar vein. There is need for campaigns to promote soil science education among Africa's youths.

I have personally tried to purchase equipment for soil analysis over the last 3years. The companies I find on the internet hardly respond to their mails let alone give you a quotation. This has made me to rely on the available which is so inefficient.

Soil Science has now come on board as farmers are now aware of the importance of soil testing in farming, the role of fertilizers and manure in farming and soul conservation. Soil Science is gaining more ground now in Africa, especially with the introduction of Afnet and other soil related organizations that compile soil inventory in Africa.

Research in soil science is lagging in Africa. There is the need for special equipment, human resources and training.

History not well coordinated and articulated, current state far from expectation, a lot yet to be known about African soils and African soil scientists need to come together genuinely to study our soils for purposes of helping African farmers to achieve the required food security expectation. African Governments must be made to understand this through at least encouraging and offering scholarships to students that opt to study soil science across Africa.

SOIL SCIENCE IS GROWING AT A LOW PACE IN AFRICA.

Soil science in Nigeria my country is yet to get national recognition although effort is being made by the soil science society of Nigeria to put soil science in its right place. Many young school leavers don't see soil science as a course that should be studied due to the low pay and other challenges.

Soil erosion is the serious threat in Africa. Depletion of soil nutrients and organic carbon are the concern.

Soil analysis is being slowly adopted by commercial farmers in Nigeria, but there exist the lack of equipment to undertake this function.

Soil analysis is key to the planning of a sustainable fertigation schedule and the best cultural practices to be adapted for production considering the prevailing climatic and environmental factors.

Promising project this could be

Soil Science was relatively unknown to so many people, I remember when I a gained admission into the university I had no idea there was a course known as Soil Science before then. Soil Science is gaining popularity now with so many students studying the course in the university. With the number of graduates of Soil Science produced every year in Nigerian universities, I see a bright future for this field in Nigeria.

Soil Science in Africa must be given some reasonable attention to promote local production of food, reduce food import and grow the economy. Soil Scientists have a lot of challenges that must be faced with courage. They must insist on functional laboratories with requisite supplies and support staff. Soil

Scientists must effectively support food production and environmental management.

There are still many areas that need to be harmonised. A lot of work has been done in pockets. Soil correlation needs to be carried out on work already done.

Africa soil have been overused thou there is still a lot of virgin soil but due to poverty and urbanization, farm land are over cultivated, farmers now relied more on fertilizers.

Daunting but promising

At past, little or no interest was given to soil in terms of their fertility status and productivity index. But today, farmers are becoming more aware on the importance of Soil fertility and suitability evaluation of their lands before embarking on farming activities.

Much has been done, however there is the need to have comprehensive mapping of African soils, particularly at country levels. There is good prospect for African soil scientists, but funds, equipment and manpower still remain the major problems.

The continent in particular Nigeria is facing emerging challenges but there is possibilities for solving them. Thanks

Soil Sciences in Africa has been slow in development due to lack of high-tech instrumentation to carry out quality research. Funding has been a major problem in many countries

YOUNG AND STILL GROWING BUT TOO SLOW. YOUTHS AND NOT TOO INTERESTED IN SOIL SCIENCE. LOW JOB PROSPECTS

All inadequate

There is a lot of improvement compared to some years back. But a lot of work and attention needs to be focused on African soils, to reduced soil degradation, improved productivity and sustainability and to ensure food security. The focus should be in the area of more infrastructure for research and to have a robust data base that is easily accessible to Scientists. Most African administrators are yet to realize the potentials of soil science as the backbone of Agriculture and environmental protection.

Is improving, bit need state-of-the-art facilities in the major laboratories.

The history is rich, currently well managed and good future prospect

Soil Science is gradually become a popular discipline among Nigerians all there a lot of challenges especially lack of equipped laboratories and experts.

My perception of Soil Science as a viable profession in the fields of Agriculture and Environment is that of an evolving discipline. Future prospects of Soil Science being the pivot for sustainable agricultural, Engineering, Exploration and Environmental services is very bright and should be pursued with vigour.

Soil Science has developed commendably well and has continued to improve in its methodologies. This has been made possible by continuous interaction of Nigerian Scientists with their colleagues within and outside Africa.

Future food security of Africa depends on proper classification, utilization and management of rich and diverse African Soil resources.

Soil science is a relatively young discipline in Nigeria, the prospects are high; but other professionals (crop scientists, horticulturists, geologists, microbiologists, chemists, ecologists, geographers, etc.) are often engaged to carry out assignments that are purely soil science based.

Good but there is room for improvement.

With the current global food security challenges, the role of a soil scientist in solving these problems cannot be over emphasised hence there are greater prospects for those in the soil science field at this present time.

Soil science has developed over time in Africa, however, soil information is still localised making it difficult to transfer soil technologies. Sustainable soil use is been threatened emerging issues such as climate change. These issues make soil science relevant in ensuring food security and alleviate poverty in Africa.

As a recent graduate of Soil Science, who is willing to contribute to Soil Science as it relates to agriculture and environment, I am encountering difficulties getting a placement for out-of-school practical work experience (as a volunteer, intern, or even an assistant to any researcher in any organization). There is little or no regard for B.Agric. holders in Nigeria as a result of limited work places. Why these difficulties after 5 years of education?

Great awareness should be made for individuals, farmers and the government to know that quality soil is life as non could thrive well when the soil is not healthy.

Soil Science is gaining wide acceptance and momentum in Africa, particularly Nigeria where serious attention has been shifted towards Agriculture of which Soil is the base.

Soil Science is the mainstay of the economic development for the sub-saharan African region. Soil science provides support to crop production, raw materials to million industries, water quality for biota, animal and human survival, recycling of abundant dead materials, landscaping for engineering and research purposes, foreign exchange for national income and accommodation for animal and human interactions.

There is need for support to the young scientists and adequate funding for soil based researches

The study of soil in Africa offers solution to the problem of food security.

The prospect for Soil Science has never been better. Africa is experiencing a population surge and high food import bills in the light of dwindling national incomes. The solution to this lies to some extent with improved agricultural productivity, which willbe driven by technology and sustainable soil management. The other major challenge facing Africa is climate change occasioned by greenhouse warming. Carbon sequestration through sustainable soil management will play a major role to play in climate change mitigation.

Lot of way to go due to inadequate funding locally and internationally

Soil scientists have come together in Africa more than before in societies that have annual conferences. These have created platforms for addressing issues of soil management for improved soil productivity and food security in Africa. Soil scientists are beginning to influence policy makers in Africa.

As present, the society of soil science in Nigeria are working vehemently to see to improvement of soil service in the country and it will in turn bring awareness to farmers in my country and by extension to other countries within the continent.

Quite promising. Soil Science is gradually going environmental.

Soil science prospect is vast if effectively harnessed and utilized.... There is much oil to tap from in the future...

The history of soil science in Africa is as old as the age of formal education in the continent. Africans have had early training in soil science and as it is known, bad governance has hindered steady progress in soil research. The non-availability of national/regional soil research coordinating centre and a regulatory body makes studies in soils a job for all. Zoologists, Botanists, Geographers and several other people of diverse background do regularly engage in soil investigations, sampling, analyses and thereafter try to interpret the data without any formal training in the field of soil. Yet, sustainable use of soil resources calls for adequate understanding of their properties, their potentials, capabilities and constraints to specific land use type. Research is an indispensable avenue for finding solutions to social, economic and technology

related problems. There should be adequate training to equip soil scientists with the necessary training to plan and implement research projects. Capacity building for researchers in the areas of research and development should be organized on regular basis. With growth and development strategies as well as efforts to encourage farmers, environmentalists, engineers and others to use soil reports, the prospect of soil science in Africa will be great.

Great Potential

Soil science has contributed greatly to the advancement of agriculture in Africa. The future of the discipline is very bright in Africa.

Soil science was at rudimentary stage before but currently people are now conscious of efficient management and conservation of soil for high and sustainable agricultural productivity in Africa.

The notion about soil science as a background discipline is fast changing in Africa most especially in my home country Nigeria. Many farmers (commercial) now know the value of soil science in their business. Am so optimistic that in the nearest future, soil science as a discipline is going to command important aspect in the development of modern Agriculture in Nigeria and Africa at large.

Soil science in Africa started long ago but development has been very slow. However current trends portray gloomy picture

Soil science in Africa has not yet arrived but we are moving and gradually we will make it.

Soil Science in Africa is a course that needs to be studied at the early stage in schools this is to avoid adverse effects of soil degradation, which is a problem in the continent.

The soil is fertile and if it's well managed, the problem of food security will be solved and death as a result of malnutrition will be reduced to the barest minimal.

Poor

The Soil Scientists in Africa have great prospects and have the wherewithal to compete favourably with other Soil Scientists in the other parts of the world. There are lots of prospects yet untapped for Soil Scientists in Africa.This is widely revealed in many of the international conferences I do attend.The time has come for us also in Africa to harnessed these human and natural resources forour betterment.

Soil science in Africa in 3 decades ago was at infancy because the public and private sectors had no reason for to conserve the soil, believing that soil is inexhaustible. Currently, people have seen reason to protect agricultural lands from extinction. The number of students admitted yearly to study soil science in the department of soil science in a university have increased from tens to hundreds. The prospect in soil science compared to other agricultural courses is incomparable. This is because every land user irrespective of the sectors needs soil scientists

Soil science is a very promising profession that will take the continent to the next level in agricultural production and sustainability

The African continent before now lacked soil specialist to properly analyse soils with regards to its branches, which affect the optimum utilization, amelioration and recommendations of soil use. Current soil scientist have evolved all over Africa and its representatives now have met up with the renowned leaders in soil science, all over the world. Soil science in coming years will become a unique practice, appreciated by almost all fields.

Soil Science is developing but we need state of the art equipment in most of our laboratories

Arise from the food insecurity in Africa, Soil Science in Africa presently is more concern with agriculture and paying less attention to environmental challenges and other soil and land resources.

Soil Science has a long history of sole attachment to Agriculture in Africa but recently, its diverse applications in various fields are been realized which has broaden its horizons in terms of acceptance and use.

There is need to update soil survey data

The knowledge of Soil Science is based on advances in countries where agricultural development has made consistent progress. The application of soil science to agriculture is somewhat low. With the development of appropriate human capital and infrastructure, the prospects for making substantial contribution to incremental yields of crops and ensuring sustainable soil quality are high.

Soil science is emerging and awareness increasing

Very promising

African Soil Science is progressing but yet at an acceptable and globally competitive level. With harmonisation of our resources and well-founded ground breaking researches, Africa will rule the globe.

Not satisfactory yet

The knowledge of Soil Science in Africa has been in existence for at least two centuries and this started along River Nile in Egypt where irrigation started in Africa. As at today, soil science is being taught in many countries in Africa. With the current realisation of the importance of soil to mankind, soil science has a reasonable prospect in the continent.

More Laboratory inputs are required, lack of ICP in my area is a limiting factor for research in Soils.

28. Republic of Congo

Currently I am participating on a Chapter with FAO on SOC management. I have several other papers on phosphorus availability, SOM dynamics in progress on soils of the Congolese coastal plains, the Arenosols beneath natural savannah. These soils are common in Central Africa and span on 6 million hectares in Gabon, Dr Congo and republic of the Congo. So, these publications will be relevant for the large area.

La science du sol en Afrique, et notamment dans mon pays le Congo-Brazzaville, est une science peu pratiquée et peu connue du fait de peu de spécialistes. Je suis actuellement le seul spécialiste en science du sol en activité dans l'unique université de mon pays. Compte tenu des coûts des analyses de laboratoires, la formation des jeunes chercheurs en science du sol en Afrique est une réelle contrainte. Il y a donc nécessité d'aider les pays d'Afrique Centrale à former des chercheurs en science du sol afin qu'ils contribuent à poursuivre les travaux d'inventaires des ressources en terres dans leurs pays respectifs.

29. Rwanda

Most our laboratory in Africa demand a lot of money for analysis even for their employees or students so this can block young generation to do researches

If you look at the history, The African soils was much fertile compared with today, The main change is about how the management of this resource done, therefore, due to over exploitation and traditional farming system without sustainable conservation and management strategies and policies respectively, the soils have come to be degraded, actually, when you look at the future prospective, more researches, awareness, institutional collaborations are required for better sustainable conservation, management and protect of this natural resource from any hazardous disturbances.

Soil science in Africa started since colonial time and continued in the 1970s under bilateral cooperation projects. After this period it collapsed. With serious problems of soil degradation, erosion, infertile soils and low fertilizers adoption, declining of soil organic carbon, endemic poverty and chronic malnutrition due to poor soils etc the soils renaissance in Africa is highly desired.

Soil database need to be updated and availed to serve as basis for planning of developmental interventions.

30. Senegal

Au Sénégal la pédologie est une comme condition indispensable dans les études des grands projets

d'aménagements, l'état a érigé un institut de pédologie qui tarde à prendre son envol par ailleurs on a l'impression que c'est encore un côté délaissé pour la diversification et l'introduction variétale.

En termes de perspectives, il est utile d'organiser des colloques scientifiques sur les thèmes émergents en sciences du sol (Cartographie numérique des sols, Spectrométrie proche infrarouge des sols, modélisation du carbone organique des sols).

La science du sol a pris du recul ses dernières années en Afrique. Difficile de trouver des pédologues. On note un manque de formation dans ce domaine au sein des universités Africaines.

Vu la place actuel et futur que va jouée l'Agriculture dans l'atténuation du changement climatique de part le stockage du carbone dans les sols) les disciplines de sciences du sol pourraient avoir un regain d'intérêt pour les jeunes scientifiques.

31. South Africa

Soil science is vital for the sustainable alleviation of food security in Africa

Prospects is good but the change of actually practicing in soil science is very slim, the companies don't use you for that

Soil scientist not properly trained in basic chemistry, physics and mathematics.

There is such a need for Soil consulting to expand, especially mobile soil testing clinics since extension services for testing are widely unavailable.

I think soil science is growing in our continent, with young scientists emerging.

My company is a new startup and works with the combination of EMI surveys and satellite monitoring services to help our clients better understand their soils and irrigation.As our company grows, we gain more and more acceptance by the local producers, but it is clear there is still a long way to go in terms of trust in the environment. My hope is that focus can be applied to knowledge transfer to the producers and farm managers on available technologies and how and when to apply them. Africa has a long way to go to compete with the rest of the world in this field.

Huge shortage on Soil Scientist majoring in Soil science and Chemistry, oversupply of Pedologists.

The number of students registered and trained in the field of soil science with agricultural background is increasingly falling very low. The implications:

1. Growing number of environmental soil scientists including within the higher education training institutions who lack knowledge of or misinterpretation of agricultural application.

2. Potential negative effects on future land use and management for agricultural purpose, and global food security.

A lot of work needs to be done by experts from various disciplines to encourage rural development to avoid over population of most industrial cities by people of varying economic classes as that creates anger and frustration among the poor leading to protests about service delivery that end up destroying the little poor infrastructure we have.

Soil Science as an employment choice seems to be growing in popularity. Over the last 10 years I have seen changes in the number of people who have studied this at a University level.

In the past, farmers were not really aware of soil inspections, hence their managements were not that too friendly to the environment. Thus, farming imposed too many questions of its practice towards environmental impact. However, a number of farmers who are aware of environmental friendly practices seems to be gently increasing, meaning soil science information is applied throughout Africa. The challenge is a number of soil scientists, which are being produced from academic institutions_ yes, both men and women are produced and soil science in

generally for both genders but its fieldwork is very harsh and at some point it is not applicable for women. However, based on different disciplines and duties, it is of great importance to consider individual will when employing; to ensure that every soil scientist works at his/her best potential for farmers or land users sake.

Its very poor, few students are studying soil science, many universities are not offering soil science courses. Government is not fully providing laboratory services that are adequate. There are limited facilitates for soil science in Africa.

Soil science in Africa has both European and North American heritage. Emphasis has been on Pedology and Chemistry. Comprehensive national soil science education and research programmes a rare and isolated. The discipline is attracting few young scholars. The need for qualified soil scientists and investment in education and research will certainly continue to grow.

Many people do not take it (the field of soil science) serious, after all, they think that know what they want. In the meantime, soils continue to deteriorate and crop yields decline.

Having a scientific degree does not make you a scientist. Following the scientific method does. Advisers/Scientists need to be 1. qualified and 2. accountable to their recommendations, especially when selling the products they are recommending.

New analytical systems should be used focusing on soil organic material and its diversification's with microbes

For as long as smallholder farmers, and District Municipalities are not fully made a part of the equation, what we know, say, or report about Soils in Africa is a guesswork made from extrapolation based on current trends or interpolation made from data that has no quality assurance. There is a need to train more Soil Scientists in data collection and analysis so that we can be a big team that collect correct data about soils, and analyse it accurately for a better decision-making processes. A lot of work still needs to be done. For the part we know, the current state of our soils (soil quality) is not that bad and our current yield as a sign of soil fertility are giving an evidence to my claim. However, we (all of us) still know very little about our soils in Africa. Hence, there is little to no reliable information about African soils except interpolated maps that actually are hard to believe. Ground-truthing exercises defy some of the documented data, just a sign of too much interpolation and very little field work/ground-truthing.

There is a need for a reliable African wide Soil Classification system.

Prospects for soil science in Africa are on the rise due to increased international interest and focus on sustainable agriculture and sustainable soil management. However, opportunities to benefit from these prospects appear to be localized and dependent on personal networks, communication and experience of a select few.

Exiting

Africa has the opportunity to do development right, and therefore there is large scope for soil science services, but the decision makers need to be convinced of that.

Soil science in Africa is a very small and underdeveloped field. Analysis of samples for the purpose of pollution and soil health monitoring is very expensive and good quality laboratories are few. The soil science fraternity in Africa is not well coordinated and the few platforms/fora that exist each seem to pull into their own directions. Africa is in serious need of a focused "African Soil Institute" that can coordinate efforts and work towards proper soil policy/legislation.

There is a need for better training, especially from an in-field perspective.

Though some countries in Africa are still lagging behind in research, South Africa has produced internationally recognized soil scientists with a proven record in scientific research.Given opportunity and funding, African scientist have a good prospect in research and education.

The average small-scale farmer needs more support however, funding and expertise is lacking. There is a need to increase resources for support systems such as extension officers. There is also a need to increase soil information accessibility so more people have access to such information.

In the past intensive soil surveys and classification of soils have been done in South Africa, but not in the rest of Africa.Currently soils and its properties are becoming more important as more and more realize that production is directly linked with soils.Soil science has a bring future in Africa since more realize the importance of soils and land use planning and to use the limited resource more productively in order to ensure food security.

Soil Science is not well-known in Africa, and especially South Africa. Declining in South Africa

There are great prospects for Soil Science in Africa, as there is a great deal of under-utilized agricultural land.

Lately standards are slipping

GeoDASM needs updating, but still valuable when travelling/working through Africa

Used to be very good in the government service but has declined since 1994. Prospects are good with technological advances in GPS/precision agriculture

There is less effort in this area and more needs to be done

Land ownership uncertainty will decimate the agricultural sector. South African agricultural knowledge supports most of sub-Saharan Africa's food production. With it gone most of Africa will fall on hard times.

History – By using what we have learnt in the past, it is probably technically possible for Africa to feed the world (7.6 billion people). Current state – desperate. Prospects – hopeless.

There's an improved disperse of knowledge and there's a need to recruit and train upcoming soil scientists

The prospects is very good.

Soil scientists are not taken seriously in SA, it could be because people do not know what we do exactly, thus most soil scientists struggle to be employed and there is still a lot of racism in the descipline of soil science.

Soil Sciences was the way to go and currently is declining

Africa has very high prospects of growth and contribution by soil science because of the potential it holds to assist the continent in sustainable development and resources management in the wake of globalization and climate change

I feel like Soil Science is no longer viewed as an important subject area. As a woman I have struggled to fit in and be recognised as a scientist.. Many of us end up working in other fields because of lack of recognition, yet in the early 1990s Soil Science was such a prestigious subject area. For example, recently I developed modules for Soil Science in my institution and my work was taken and handed over to PhD students who are not even soil scientists to teach because the institution does not want to employ me full time. I feel like Soil Science is being undermined and diminished in this respect.. Regionally there are a number of established male soil scientists but they keep the doors closed to the women colleagues. There is a lot that we can do in Soil Science, but we lack resources and conducive environments to use our skills.

Can be improved over time.

As a female, when looking for a job in soil science, I was laughed at outside of universities. I spent three years doing part-time/underpaid work mainly in the field of chemical lab analyses, before finding my current job, which still has nothing to do with soil science strictly speaking, but is at least very interesting and challenging.

Huge potential for growth, particularly on the perennial crop side.

Unregulated industry, people with no formal education in the field sell and advise on products and practises (example fertiliser salesmen). SSSSA need to bring soil

scientists together more often to talk about industry trends and set certain standards.

Poor

we are currently losing more soil through erosion

Need better chemical analysis methods and interpretation guidelines

I experience Soil Science as a growing science the past 38 years. Our biggest problem is the increasing amount of pseudo-science practiced by small company's selling strange/new products to do business

Expanding. Available to consult anywhere in Africa or Overseas

Limited work opportunities and soil science has a reasonably low level of recognition as a discipline in many projects

32. Sudan

needs more considerable about land desertification, deforestation, salanization, Arid area

need much time to write about

We are always in need to be in better conditions

Very limited use of the expertise of Soil Science

33. Tanzania

Results of soil analysis are not or minimal used by most of the small holder farmers. This has been the trend and is continuing until more education is provided to these producers

Prospects of soil science is promising as large investors and small scale farmers, politicians and policy makers are nowadays recognizing the importance of doing soil testing and land evaluation prior implementationof such projects.

34. Togo

Les sciences du sol n'ont pas beaucoup permis d'orienter et d'asseoir une agriculture durable en Afrique. Aujourd'hui les problèmes auxquels nos agricultures sont confrontées, notamment la baisse de la fertilité des sols et la dégradation des sols traduisent le fait que les sciences du sol n'ont pas été suffisamment mises au service de nos agriculture. Il faut aujourd'hui que les sciences du sol permettent de mettre à la disposition de nos agricultures des modèles et méthodes de gestion qui préservent les sols et assurent une production durable de nos agricultures.

35. Tunisia

Soil science in Africa is somehow marginalized. We need to build a unified and strong soil scientists community in Africa.

lack of dedicated project, lack of fund despite the huge need for soil survey, mapping and monitoring for agriculture and environmental purposes

Le sol est le cœur de la production végétale. Toutefois peu d'éfforts sont déployés pour les conserver, les compétences en pédologie sont faiblement valorisées. De nombreux pédologues ont changé abandonné la pédologie pour d'autres métiers

En Tunisie la notion de l'analyse du sol n'est pas assez connue avec la non fiabilité des résultats. J'espère que la science du sol soit une culture ancrée dans notre agriculture

C'est un secteur d'avenir surtout avec la prise de conscience internationale sur l'importance de cette ressource non renouvelable et très fragile

36. Uganda

Soil Science is highly ignored by funders yet all crop production/food security issues are simply embedded in improving soil water and nutrient management alone. Limited funding for extension and research

have made soil appear like it is not critical for transformation of man. The prospects are high but more effort is needed in extension, research, capacity building and policy. Soil will remain the mother of all nature though it remains most ignored today. The future is bright for soils.

Great but supportive resources a big hindrance

Previously soil research has been given low priority in Agricultural Research but is now gaining prominence due to declining fertility and associated environmental pollution challenges. The number of students taking Soils Science as a major remains low, some soil scientists now coming from Land management background. Research facilities remain inadequate for state-of-art research frontiers. Investment in laboratory and teaching of Soil Science af a climate mitigation strategy will increase the relevance e of Soil Science in Africa

Low because of low investment in Soil science, yet low soil fertility is a serious challenge to agricultural production

It's much needed more than ever before, The soil science and related units in universities and national ministry of agriculture and irrigation should be equipped and strengthened. e.g. All Ugandan soil labs are ill equipped and not accredited. In some universities in Uganda, the existence of the soils unit is even being fought.

The status of soil science related research is improving in Africa

History: Evidence has it that soil productivity has continuously declined. "Soils in Sub Saharan Africa lack one or more of the major nutrients required for plant growth (Sanchez, et al., 1997)." "We observe that many studies note the declining soil fertility (in Kenya, Uganda and Tanzania), mainly due to soil fertility mining, putting crop production in an unsustainable path, a number of case studies have shown crop yield decline in the region (Bekunda et al., 2004)." "As a result, obtaining yields and profits among farmers in SSA has been hard to achieve (Gao et al., 2009)" because of continuous mining without replenishment.

Current state: There are no recent soils maps for most African countries including Uganda leading to "one size fits all" or "blanket" soil fertility improvement in put recommendations across most areas,soil health is not given adequate consideration in the extension system of most countries including Uganda due to lack of/ limited experts in the field(eg Makerere only produces on average 3 soil scientists with M.Sc. in a year and these take on average 5 years to finish the course – check AGRA Soil Health M.Sc. training records for the University). The governments have also failed to create a gap for the available Soil Scientists to come in to play except in the National Research Institutes where fundings are very limited and cut across the agronomy chain. As a result, most of the already few soil scientists are employed in other general agriculture sectors (including me – doing banana agronomy work) or in non-agriculture fields.

Prospects: There is need to have a deliberate and concerted effort to address the stated problems if the future of agriculture in Africa is to shine. This will have implications on the food security and general development situations in the continent. Therefore, need for training of more soil scientists is not the only area to focus on but also realignment of agriculture/ extension policies to incorporate soil issues as major development issues. To make this work well, the few Soil Scientists need to be facilitated/supported to come under a strong umbrella to be able to mobilize and voice their views in the various African governments for policy considerations.

There has been limited involvement of soil science expertise by farming communities due to the inability to afford or sustain involved costs of the services. However, with the escalating decline in soil fertility, high food demands due to rapid population growth on the constant land resource, a lot of interest is rising. But a lot of opportunity from this field to combat food insecurity and improve on the quality of the environment is being lost due to the limited capacity to effectively facilitate and have the scientist on board.

Not known as a speciality. Often times Agronomists are considered

I am Currently pursuing a masters in soil science. For advanced study and research, I wish to focus on liking plant physiology with soil based stress e.g. drought and nutrient stress; I am particularly interested in high throughput phenotyping techniques and how they can be applied in agronomy.

Previously research and technical work ignored the soil aspect in Africa partly due to the inherent fertility of the soils. Hence, core emphasis was on crop improvement and pest and disease control. The soils now in Africa are now degraded with the increasing concerns about soil resource sustainability, the prospects of soil science as a discipline in Africa are promising and could be the secret to feeding the growing population

Generally, soil science aspects are being over shadowed by crop science.There is a feeling that crop science covers all that are required for plant production including soil management.

37. Zambia

Need for streaming services for increased participation of local scientists and institutions

A lot of areas need attention, especially in the areas of soil survey, financing and equipping the laboratories. There is lack of collaboration among soil scientists in Africa

Soil Science in Zambia has mostly been focused on the agronomic aspect, (i.e. as a means of food production). I feel there is need to expand this to include other equally important roles of soil science such as environmental management, climate change mitigation etc. Another critical problem, at least in the Zambian case, is low investment/support for research which prevents us from doing critical research. Increasing support for research and development should be a priority in the future.

It is a profession in its infancy, very key to environmental resilience yet not able to compete favourably for human capital

soil science is the corner stone for all agricultural production at field level, it cuts across economic as well as environmental management of natural resources. I feel that with more fund to research, soil science can provide answers to many human and animal health problems that have arisen as a result of environmental pollution from various economic activities in Africa and the world at large.

Very high opportunities and challenge. With high expectations for improved sector performance

The field is not supported to the same extent that it as was in the past. For instance, resource inventories through soil surveys are no longer carried out on regular basis. Land degradation is occurring but it is not being monitored and documented in a systematic manner that would allow for archival of the information. Soil analysis are expensive, especially for smallholder farmers who are most vulnerable to the adverse effects of soil degradation.

Prospects for the development of soil science in Africa generally are bright, necessitated by increasing populations that put pressure on limited land resources, requiring agricultural intensification in order to ensure food security."

it has come a long way, but more needs to be done in terms of awareness concerning the science and updating the practice to suit current happenings on the world scene, more facilities and tools are needed to practically train soil scientists, more employment opportunities are needed

Historically no one paid attention to soil as a basic foundation for agriculture. In my country people are slowly becoming aware of the importance of soil and soil science as a profession

38. Zimbabwe

More work needs to be done to characterise African soils. For instance in Zimbabwe, we only have a 1:100,000 soil map. A more detailed soil map is necessary for planning development work in the

country. Key challenges we face in Zimbabwe is poor equipment in soil laboratories.

Limited work that requires soil science expertise is being done. Student enrolment at tertiary institutions in soil science is decreasing

Students are not taking soil science as a major at my university and this is an indication that the future of soil science is not encouraging unless we infuse it in other agricultural programmes like crop science/ agronomy

Need good laboratories to test

Presently there are few soil science jobs available unlike in previous years when there were a number of opportunities available for graduates. If it continues like this soil science is going to become obsolete.

SOIL SCIENCE FIELD REMAINS A KEY COMPONENT TO MEET FOOD SECURITY FROM FARMING SYSTEMS THAT ARE CURRENTLY DEPENDING ON HIGHLY DEGRADED SOIL RESOURCE BASE

Soil science has been growing over the years with a great deal of diversification expected in the future.

Africa has serious soil degradation problems. Its soil scientists are ill equipped to deal with current challenges. Backup laboratories are ill equipped.

Soil science especially soil survey and mapping is often neglected on many developmental projects such irrigation development. Many irrigation engineers see it as not necessary and that they think they can do it when actually its more than just seeing the surface of the soil.

Expertise in soil science in Africa is good but resources to use are limited especially technical support services. A lot of up-to-date machinery and equipment required to support sound soil analysis especially for fertilizer recommendations.

We still have a lot of investments to do especially in funding of research projects. Currently soil scientist are still in the scares skills category but the opportunities to prove our services are so limited and neglected.

Lomonosov Moscow State University

Eurasian Center for Food Security