RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

Evidences

Study #2794

Contributing Projects:

- P432 - Land Restoration Planning and Performance Management

Part I: Public communications

Type: OICR: Outcome Impact Case Report

Status: On-going

Year: 2018

Title: Soil-plant spectral technology guiding soil fertility investments in Africa (WLE-ICRAF)

Short outcome/impact statement:
Seventeen African countries are now using soil–plant spectral technology developed by CGIAR Research Program on Water, Land and Ecosystems (WLE) and partners to restore soils and boost agricultural production. The Africa Soil Information Service (AfSIS) is now being deployed for targeting soil fertility restoration strategies. Ethiopia, Ghana, Nigeria, and Tanzania have established state-of-the-art soil information systems based on the technology. NGOs and the private sector are delivering soil testing services to smallholder farmers and monitor intervention impacts on soil health.

Outcome story for communications use:
New technology aiding soil restoration across sub-Saharan Africa

Seventeen African countries are now using soil-plant spectral technology developed by the World Agroforestry Centre (ICRAF) and the CGIAR Research Program on Water, Land and Ecosystems (WLE) to restore soils and boost agricultural production, food security and livelihoods.

About 40% of soils in sub-Saharan Africa are low on nutrients. Widespread soil degradation hampers food production and leads to erosion and desertification. Globally, restoring just 12% of degraded agricultural land could increase smallholder incomes by USD 35-40 billion. However, African governments and other decision makers have long had little knowledge of where to implement what kind of restoration measures.

That's why ICRAF, WLE and other partners, through the Africa Soil Information Service (AfSIS), has developed and shared technology that can quickly and cheaply measure and map soil and plant properties as well as match soil problems with appropriate solutions. This facilitates better targeting of soil management measures.

The Soil-Plant Spectral Diagnostics Laboratory has helped 14 government institutions, three private sector labs and one development agency to adopt the technology. Data has been used to create soil property maps of Africa at 250 m resolution (SoilGrids). The maps are being used by research and development agencies to guide land management decisions and by the World Soil Information organization to develop fertilizer recommendations for West Africa.

At national levels, AfSIS has helped develop state-of-the-art soil information systems based on spectral technology in Ethiopia (EthioSIS), Ghana (GhaSIS), Nigeria (NiSIS), and Tanzania (TanSIS). Nongovernmental organizations are also using the technology: One Acre Fund has established a rural spectral lab in Kenya, while Conservation International, Technoserve and The Nature Conservancy have commissioned spectral analysis services. The World Bank Living Standards Measurement Study piloted soil spectral technology in Ethiopia and Uganda. In addition, ICRAF has provided advisory services to private companies now deploying spectral technology in 22 countries.

The technology is also helping smallholder farmers benefit from soil- and plant-testing services, through satellite-based data, mobile laboratories and handheld devices. A low-cost, handheld, spectrometer was developed and tested, and it has potential to provide a quantum leap in accessibility of the technology for smallholder farmers, helping them solve soil challenges right on their farms.

Over the past four years, ICRAF has trained over 1000 people from 17 countries on the technologies. More African and Asian countries plan to adopt the technology.

Photo 1: http://blog.worldagroforestry.org/wp-content/uploads/2015/04/Soil-samples-copy.jpg Soil samples awaiting infrared scanning at the CGIAR?s Soil-Plant Spectral Diagnostic Laboratory based at ICRAF. Keith Shepherd/ICRAF (no consent necessary)
Photo 2: http://blog.worldagroforestry.org/wp-content/uploads/2016/10/scanning_soil_samples.jpg

Scanning soil samples with an infrared spectrometer. Keith Shepherd/ICRAF (no consent on file)
Photo 3: https://www.flickr.com/photos/waterlandeco/47665468081/in/album-72157679997279158/
Preparing soil samples for spectral analysis at the soil lab in Addis Ababa, Ethiopia. Mulugeta Ayene/WLE (no consent on file but maybe not necessary)

For related links please see "Communications Materials" in the field below. For a version of this story with embedded links, please contact WLE: a.hunt@cgiar.org

Links to any communications materials relating to this outcome:

- https://www.isric.online/explore/soilgrids
- http://wle.cgiar.org/
- http://africasoils.net/
- https://tinyurl.com/yxe6lmrf
- https://www.ata.gov.et/highlighted-deliverables/ethiosis/
- https://oneacrefund.org/blog/sharing-our-2017-annual-report/
- https://tinyurl.com/rcch5lw
- https://tinyurl.com/yysxmq9j
- https://www.isda-global.org/national-soil-services/
- http://worldagroforestry.org/
- https://tinyurl.com/y5au2qfh
- https://www.mdpi.com/2071-1050/7/6/6523/htm
- https://tinyurl.com/y6kpptxx
- https://tinyurl.com/yyojgwmn

Part II: CGIAR system level reporting

Link to Common Results Reporting Indicator of Policies : No

Stage of maturity of change reported: Stage 2

Links to the Strategic Results Framework:
Sub-IDOs:

- Land, water and forest degradation (Including deforestation) minimized and reversed

Is this OICR linked to some SRF 2022/2030 target?: Too early to say

Description of activity / study: Nutrient and organic matter depletion and soil erosion in African croplands are significant land degradation processes. This work is contributing to the restoration of degraded croplands by measuring and mapping soil properties, and plant nutritional responses, to different soil management interventions, thus enabling the refinement and better targeting of soil management measures.

Geographic scope:

- Multi-national

Country(ies):
- Nigeria
- Tanzania, United Republic
- India
- Uganda
- Ethiopia
- Malawi
- Nepal
- Kenya
- Ghana

Comments: <Not Defined>

Key Contributors:
Contributing CRPs/Platforms:
- WLE - Water, Land and Ecosystems
- FTA - Forests, Trees and Agroforestry

Contributing Flagships:
- F1: Restoring Degraded Landscapes (RDL)

Contributing Regional programs: <Not Defined>
Contributing external partners:
- ISRIC - International Soil Reference and Information Centre
- Rothamsted Research
- The Earth Institute, Columbia University
- One Acre Fund
- iSDA - Innovative Solutions for Decision Agriculture
- Bruker Corporation

CGIAR innovation(s) or findings that have resulted in this outcome or impact:
The World Agroforestry Centre (ICRAF) has developed soil-plant spectral diagnostic protocols for rapid and low-cost analysis of soil properties and plant nutrients using only light (infrared, x-rays). This low cost technology allows soil and plant analysis to be conducted faster, and at much wider scales, than was previously possible, as samples can be quickly and cheaply analyzed from many georeferenced sites. This in turn permits digital mapping of soil properties and the measurement of nutrient constraints faced by different crops in multiple agronomic trials over large areas [1-5]. The technology is also enabling soil and plant testing services to be delivered to smallholder farmers, through satellite laboratories, mobile laboratories, and handheld devices.

Innovations: <Not Defined>

Elaboration of Outcome/Impact Statement:
Through the Africa Soil Information Service (AfSIS) and other projects, such as FoodAfrica, and with WLE support, the Soil-Plant Spectral Diagnostics Laboratory has helped 14 government institutions, three private sector labs and one development agency to adopt the technology. New soil spectral data generated across sub-Saharan Africa have been combined with legacy soil profile data to create soil property maps of Africa at 250 m resolution (SoilGrids). The maps are being used by research and development agencies to plan soil sampling campaigns, site crop trials, and guide land management decisions, for example by various CGIAR projects in eastern Africa, and by the World Soil Information organization (ISRIC), for fertilizer recommendations in West Africa [6].

At national levels, AfSIS has helped develop state-of-the-art soil information systems based on spectral technology in Ethiopia (EthioSIS), Ghana (GhaSIS), Nigeria (NiSIS), and Tanzania (TanSIS). The Ethiopian Agricultural Transformation Agency and the Tanzanian Ministry of Agriculture have sent strong letters of support, and ICRAF has also shared other impressive testimonials [7].

There has also been uptake by NGOs and the private sector. One Acre Fund established a rural spectral lab in Kakamega, Kenya [8]. Conservation International, Technoserve and The Nature Conservancy have commissioned spectral analysis services. The World Bank Living Standards Measurement Study piloted soil spectral technology in Ethiopia (here) and Uganda in partnership with national statistics agencies. ICRAF has provided advisory services to private companies now deploying spectral technology in 22 countries.

ICRAF with WLE support has conducted extensive capacity development in use of spectral methods for targeting land restoration. Over the past four years ICRAF has provided exposure training in the new methods to 1,059 people; intensive training to 178 people (30% women) from 17 countries; and supported 31 MSc/PhD students. We over-performed by 167% on our 2018 milestone to train and support 60 national scientists (20% women) in applying low cost soil and plant health measurements using dry spectroscopy for targeting and monitoring land restoration in eight countries (Ethiopia, Ghana, Kenya, India, Malawi, Nepal, Nigeria, and Tanzania).

In partnership with Global Good (a collaboration between Bill Gates and Intellectual Ventures) a prototype of a low cost, handheld, near infrared spectrometer for developing countries was developed and tested which has potential to provide a quantum leap in accessibility of the technology for smallholder farmers.

References cited:

Hengl T.; Leenaars, J.G.B.; Shepherd, K.D.; Walsh, M.G.; Heuvelink, G.B.M.; Mamo, T.; Tilahun, H.; Berkhout, E.; Cooper, M.; Fegraus, E.; Wheeler, I.; Kwabena, N.A. 2017. Soil nutrient maps of Sub-Saharan Africa: Assessment of soil nutrient content at 250 m spatial resolution using machine learning. Nutrient Cycling in Agroecosystems 109:77?102. https://link.springer.com/content/pdf/10.1007/s10705-017-9870-x.pdf. DOI 10.1007/s10705-017-9870-x.

1. Towett, E.K.; Shepherd, K.D.; Drake, B.L. 2016. Plant elemental composition and portable X-ray fluorescence (pXRF) spectroscopy: quantification under different analytical parameters. X-Ray Spectrometry 45: 17?124. DOI 10.1002/xrs.2678.

2. Nocita, M.A.; Stevens; Wesemael, B.; Aitkenhead, M.; Bachmann, M.; Barth&#65533;s, B.; Ben Dor, E.; Brown, D.J.; Clairotte, M.; Csorba, A.; Dardenne, P.; Demattê, J.A.M.; Genot, V.; Guerrero, C.; Knadel, M.; Montanarella, L.; Noon, C.; Ramirez-Lopez, L.; Robertson, J.; Sakai, H.; Soriano-Disla, J.M.; Shepherd, K.D.; Stenberg, B.; Towett, E.K.; Vargas, R.; Wetterlind, J. 2015. Chapter Four - Soil Spectroscopy: An Alternative to Wet Chemistry for Soil Monitoring. Advances in Agronomy 132, 2015, Pages 139-159. https://doi.org/10.1016/bs.agron.2015.02.002

3. Shepherd, K.D.; Shepherd, G.; Walsh, M.G. 2015. Land health surveillance and response: A framework for evidence-informed land management. Agricultural Systems 132 (2015) 93?106. http://dx.doi.org/10.1016/j.agsy.2014.09.002

4. Tittonell, P.; van Dis, R.; Vanlauwe, B.; Shepherd, K. 2015. Managing Soil Heterogeneity in Smallholder African Landscapes Requires a New Form of Precision Agriculture. In: Lal, R and Stewart, B.A. (eds) Soil-Specific Farming: Precision Agriculture. Advances in Soil Science, CRC Press. Pages 199-224. http://www.crcnetbase.com/doi/abs/10.120/b18759-9

5. ISRIC. 2017. Taking fertilizer recommendations to scale for major crops in West Africa. https://www.isric.online/projects/taking-fertilizer-recommendations-scale-major-crops-west-africa.

6. Land Health Decisions: Testimonials. http://www.worldagroforestry.org/sd/landhealth/soil-plant-spectral-diagnostics-laboratory/testimonials.

7. One Acre Fund. 2017. Annual Report (pages 20-21). https://oneacrefund.org/blog/sharing-our-2017-annual-report/

Quantification: <Not Defined>

Gender, Youth, Capacity Development and Climate Change:
Gender relevance: 0 - Not Targeted
Youth relevance: 0 - Not Targeted
CapDev relevance: 2 - Principal
Main achievements with specific **CapDev** relevance: Providing both exposure and intensive training in the use of the technology, as well as supporting MSc/ PhD students has been a major investment
Climate Change relevance: 1 - Significant
Describe main achievements with specific **Climate Change** relevance: Identifying soil health issues and ways to ameliorate them strengthens the resilience of smallholder farmers in the face of climate change impacts

Other cross-cutting dimensions: No

Other cross-cutting dimensions description: <Not Defined>

Outcome Impact Case Report link: Study #2794

Contact person:
Keith Shepherd, Leader of Research and Development Theme on Land Health Evaluation, Restoration and Investment Decisions, World Agroforestry Centre (ICRAF), and co-leader of WLE FP 1, RDL, k.shepherd@cgiar.org.