

Innovations in Soil Health Monitoring: Combining Systematic Field Assessments with Spectroscopy and Earth Observation

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#Research2Resilience



RESEARCH
PROGRAM ON
Water, Land and
Ecosystems



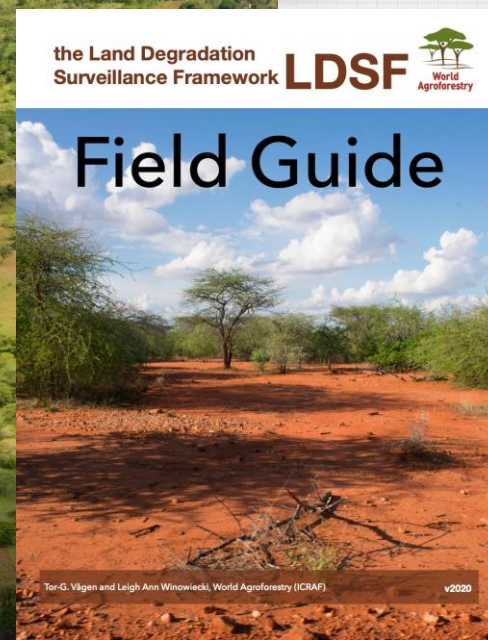
UNITED NATIONS DECADE ON
**ECOSYSTEM
RESTORATION**
2021-2030



Understanding the multiple dimensions of soil health for ecosystem restoration, climate change and food & nutrition security

- 1) Application of a systematic sampling framework
- 2) Use of innovative methods for soil analysis
- 3) Coupled with statistical analysis to generate predictive maps

<http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/>



LAND HEALTH INDICATORS

COLLECTED BY THE LAND DEGRADATION SURVEILLANCE FRAMEWORK (LDSF)



VEGETATION COVER

- Tree density
- Shrub density
- Vegetation structure and distribution
- Tree biodiversity
- Shrub biodiversity
- Herbaceous cover type and density
- Rangeland module
 - Grass species richness and abundance
 - Grass perennial to annual ratio
 - Distance measurements for perennial grasses



LAND DEGRADATION

- Soil erosion prevalence
- Root-depth restrictions



SOIL HYDROLOGY

- Infiltration capacity



LAND MANAGEMENT

- Agricultural and rangeland management strategies
- Land cover classification
- Land use
- Landform designations
- Impact on habitat
- Soil and water conservation

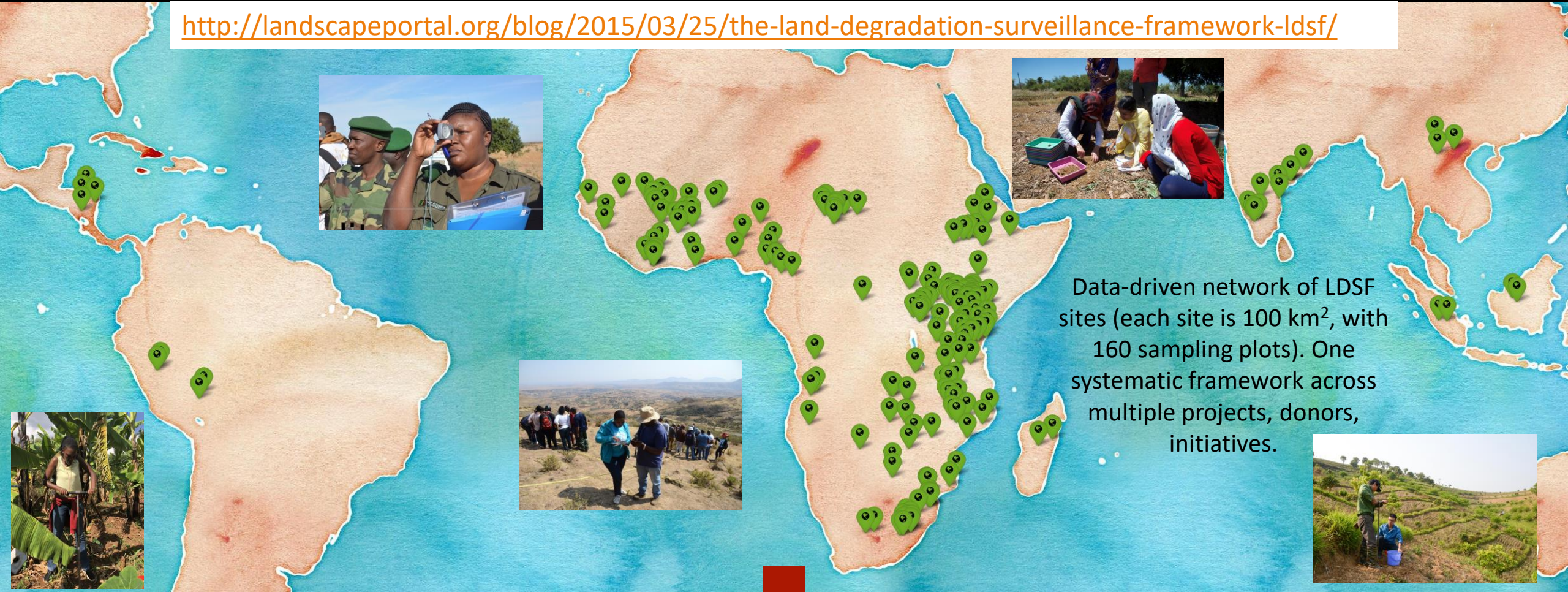


SOIL HEALTH VARIABLES

- Organic carbon (OC)
 - Concentration
 - Stocks
- Acidity (pH)
- Total Nitrogen (TN)
- Base cations (Mg²⁺, Ca²⁺, K⁺, Na⁺)
- Soil texture (% sand, silt and clay)
- Soil biology module
 - Mycorrhizal spores
 - Macroinvertebrates
 - Earthworms

Robust and rapid monitoring systems across diverse landscapes: The Land Degradation Surveillance Framework (LDSF)

<http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/>



Data-driven network of LDSF sites (each site is 100 km², with 160 sampling plots). One systematic framework across multiple projects, donors, initiatives.

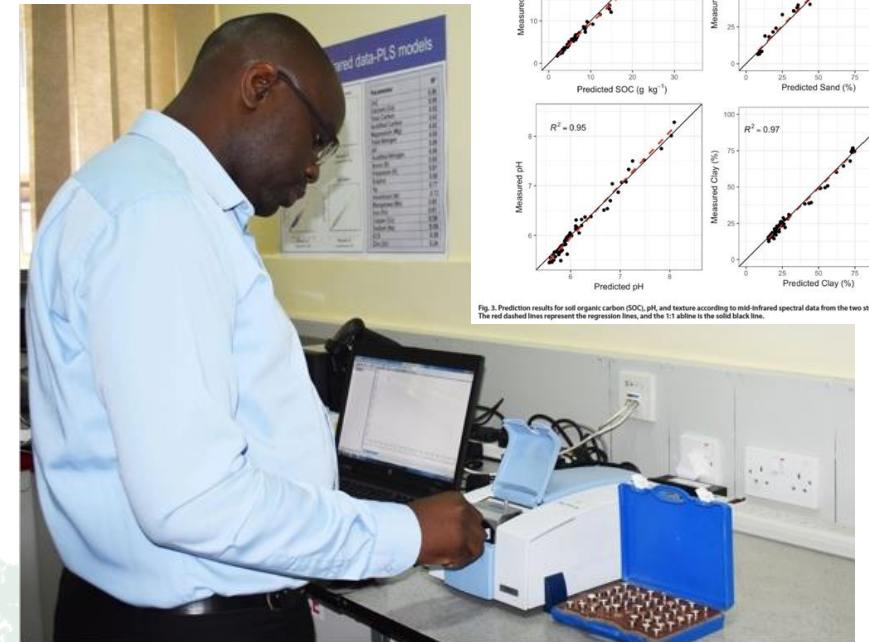


Shining a light on soils for land restoration

- MIR spectroscopy for accurate, robust, low-cost analysis of multiple properties, simultaneously
- Can be used to analyze plants, compost, manure, fertilizers, liquids and yes soil!
- Enables landscape scale sampling- which was previously limited by costs of analysis
- This has transformed research and requires NEW skills of soil scientists
- ICRAF has invested >20 yrs to build a consistent spectral library (database) for a number spectrometers
- Investment in spectral data analytics

<http://worldagroforestry.org/blog/2020/08/13/data-streaming-spectrometer-new-dawn-soil-assessments>

<https://wle.cgiar.org/solutions-and-tools/science-driven-solutions/shining-a-light-on-soils-for-land-restoration/>



Elvis Weullow of the ICRAF Soil and Plant Spectroscopy Lab demonstrating how to use the Spectrometer. Photo: World Agroforestry/Ann Wavinya



Spatially explicit assessments of priority areas for restoration: SOC + Erosion

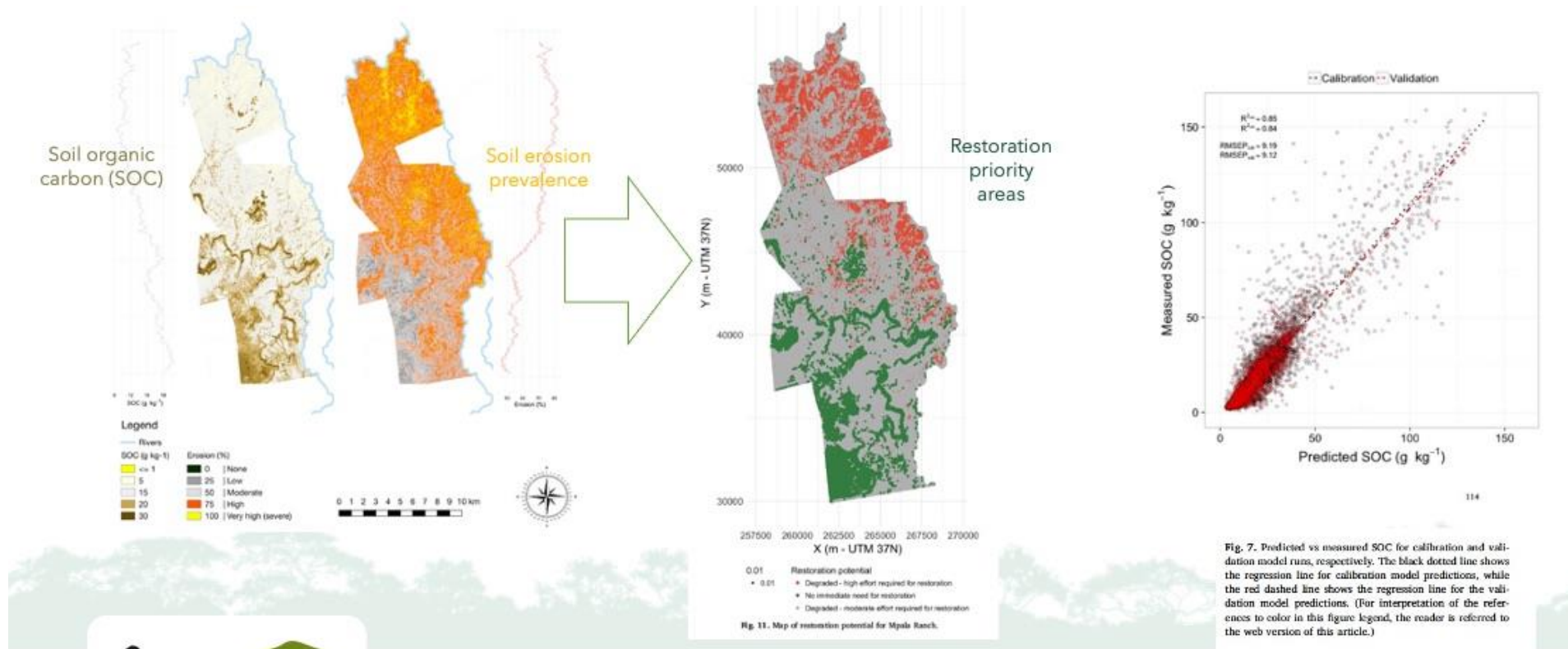
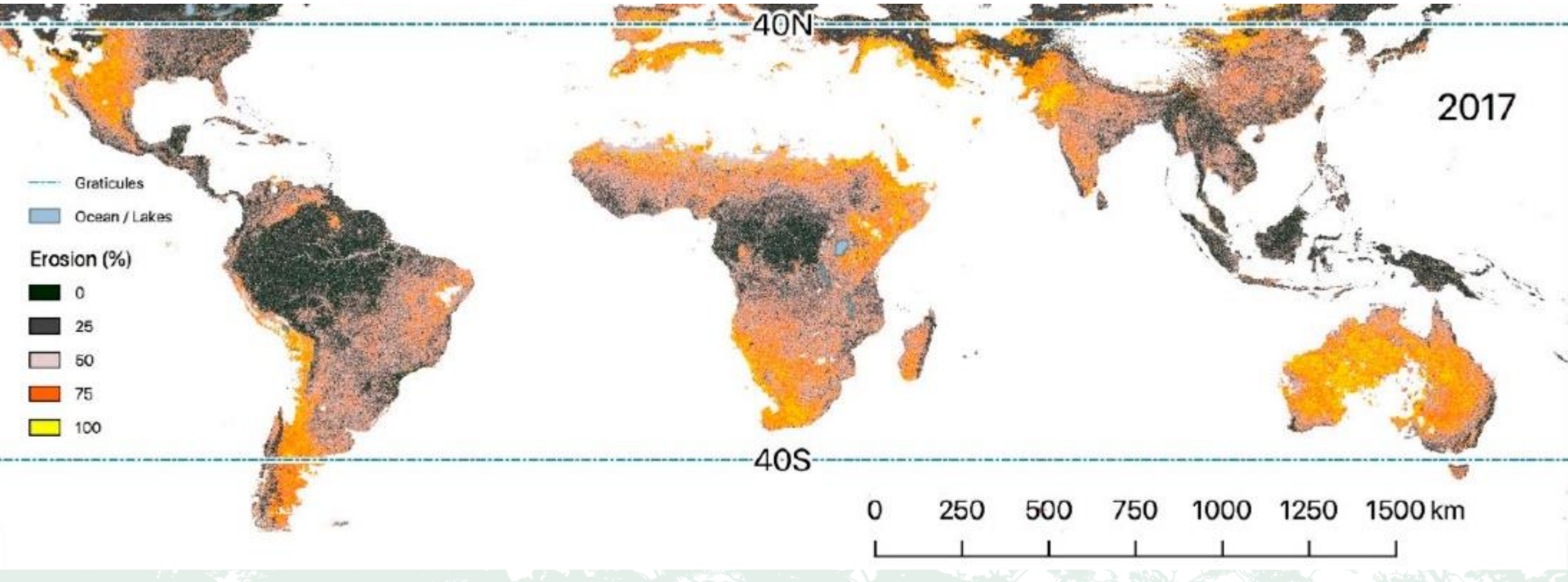


Fig. 7. Predicted vs measured SOC for calibration and validation model runs, respectively. The black dotted line shows the regression line for calibration model predictions, while the red dashed line shows the regression line for the validation model predictions. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Winowiecki, LA., Vågen, T-G., Kinnaird, MF, TG. O'Brien. 2018. Application of systematic monitoring and mapping techniques: Assessing land restoration potential in semi-arid lands of Kenya. Geoderma.

<https://www.sciencedirect.com/science/article/pii/S001670611830510X>

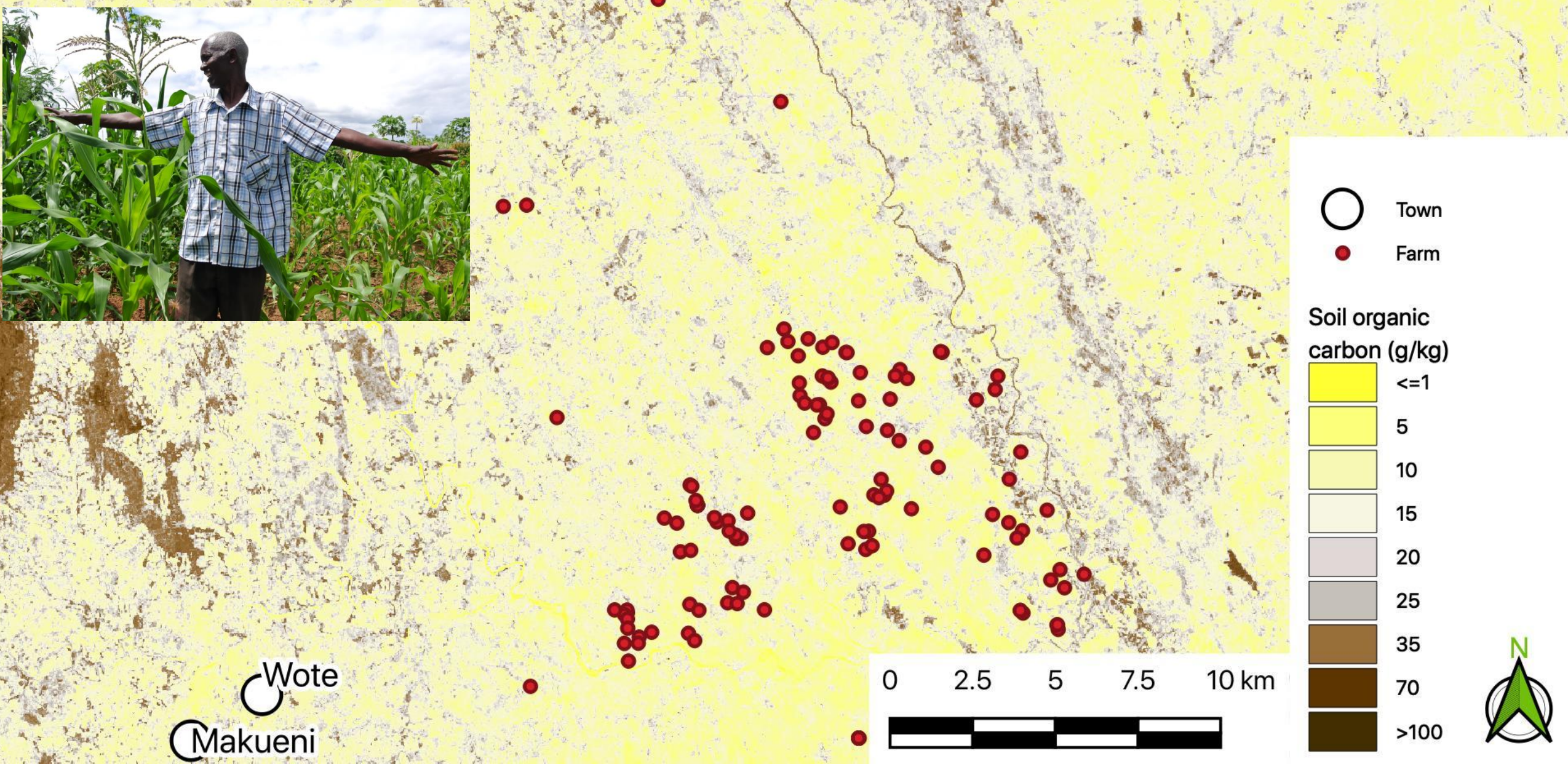
Soil erosion is a key indicator of land degradation: Spatial assessments enable targeting and tracking over time and demonstrate the urgency



At the Global Level:

Vågen, T.-G.; Winowiecki, L.A. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. *Remote Sens.* **2019**, *11*, 1800. <https://www.mdpi.com/2072-4292/11/15/1800>

Farm-level assessments at 30 meter resolution to track what is happening at the farm/household level – impact of restoration/ management options on SOC



Key messages

- We have the tools and methods to measure and track changes in soil health at scales relevant to multiple stakeholders
- Monitoring frameworks must capture the complex processes of degradation and restoration
- These frameworks must be able to track performance of options overtime as well as inform decision making
- Developing capacity to conduct assessments as well as to interpret and interrogate the results/data is critical
- Investment in long-term and consistent monitoring is key to building the evidence base



Thank you!

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Check out CIFOR-ICRAF Soil and Land Health Webpage for videos, brochures, and more:

<https://worldagroforestry.org/landhealth>

Video: Scaling ecosystem restoration in agricultural landscapes:

<https://youtu.be/qvf0drWdTq4>

AlJaZeera Earthrise special: <http://youtu.be/vFMSEHV7Ap4>

cifor.org | worldagroforestry.org

foreststreesagroforestry.org | globallandscapesforum.org | resilientlandscapes.org

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