SoilWatch

Remote Soil Monitoring
Regenerate Soils
Empower Land Users

Problem

- **Degraded Soils** Worldwide Are a Threat to Global Food Security
  - Soil Erosion, or loss of soil organic carbon from topsoil, is the main cause of soil degradation globally
  - Soil erosion can decrease yield by up to 50%, if not provoke total loss of arable land, leads to Ecosystem Degradation, Reduces Water Supplies, Exacerbates natural disasters and Entails Loss of Livelihoods and Migration (FAO, 2018)

Opportunity

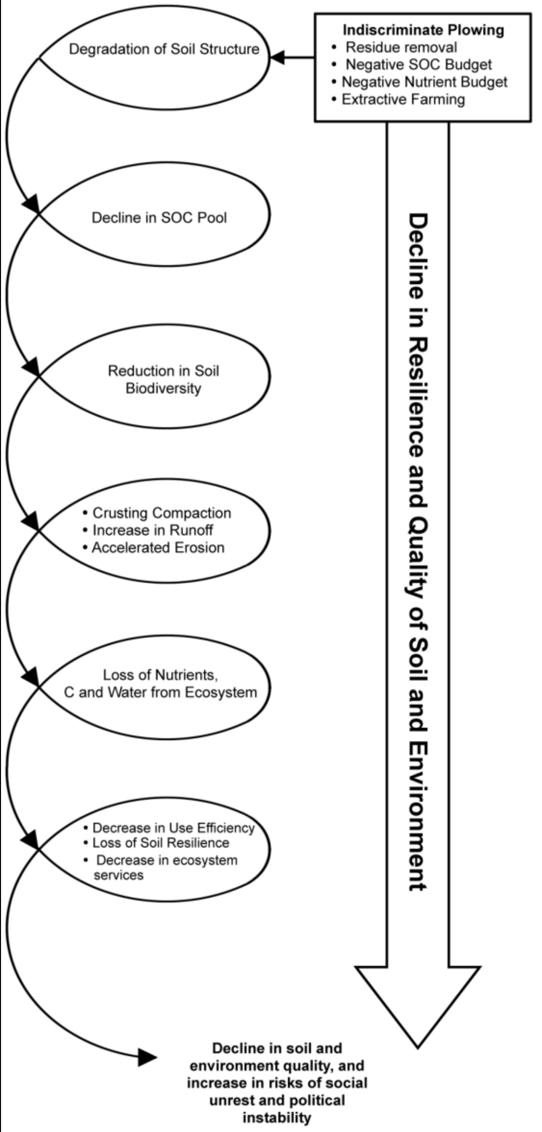
- The **soil's carbon sink capacity** (2500 GT) is larger than that of the **atmosphere** (800 GT) and **vegetation** combined (670 GT)
- 1/3 of World's arable land lost to **land degradation** in the period 1975-2015 (FAO, 2015)
- **Over 90% of Earth's soils** could become **degraded** by 2050 (FAO, 2018)
- Every ton of sequestered soil organic carbon (SOC) per hectare has the potential to **boost yields by 32 Mio Tons/year** in developing countries and **offset CO2 emissions at the rate of 500 Mio Tons** C/yr (Lal, 2006)

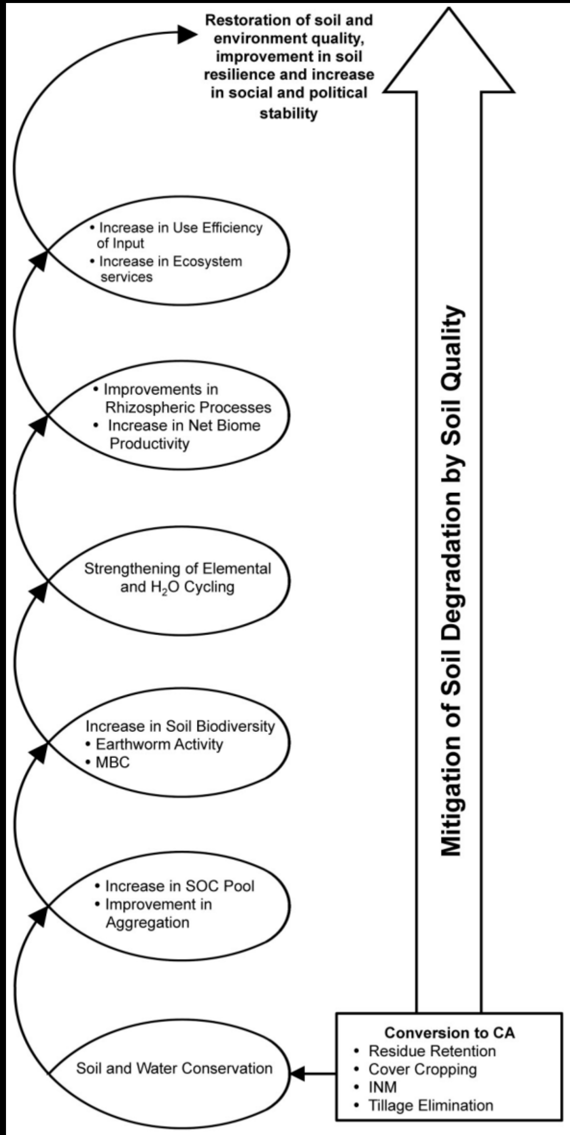
How to Sequester Carbon through NBS?

Source: Lal, 2015

- Mutual **Environmental** and **Social** Benefits of Sequestering Carbon in Soil besides climate change mitigation

- NBS to implement context-specific
  - Land Use (grassland or cropland?)
  - Agro-ecological conditions → SOM breakdown speed (actual removal, or prevention from further degradation?)
  - Soil conditions (loamy, sandy, etc?)





Practical Pain Points

Difficulty to measure soil carbon **accurately** in a **cost-effective** and **scalable** way

- **Current Measurement Methodologies**
  - Too expensive
  - Not scalable

- **Measurement done in practice currently**
  - “Cut corners”
  - Unreliable results
  - Accused of greenwashing

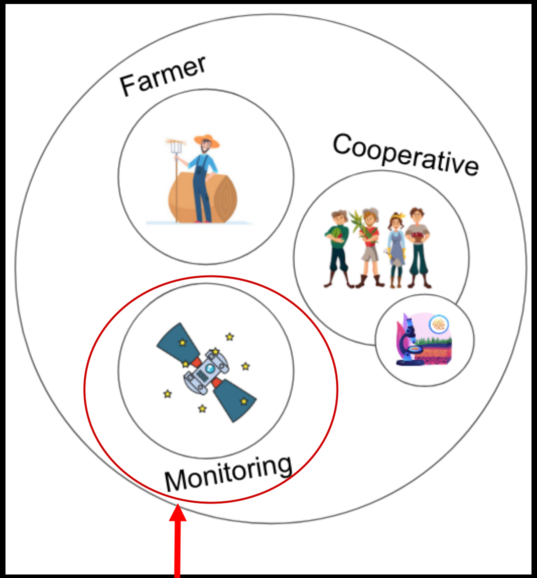
Solution

- A satellite-based **Monitoring, Reporting and Verification** (MRV) system to link **Land Users** with **Climate Financing** and provide evidence for **positive social and environmental** benefits of **Nature-based Solutions** (NBS) projects

Financial Incentive	**CO_2 Sequestration**	**Food Security**
for land users who adopt regenerative management practices	in the soil as a result of sustainable land management to mitigate climate change	through regenerated soils, boosted yields and preserved livelihoods

1 **Project Consortium**

A multi-stakeholder consortium is formed to create a carbon credit



SoilWatch as consortium partner or external MRV solution provider

Consortium applies to a certification body

2 **Certification Body**

E.g. Gold Standard, VCS, CDM

1. Regenerates soils & biodiversity
2. Positive impact on yields
3. Contributes in fight against global warming

3 **Carbon Marketplace OR Carbon Broker**

Once certified the carbon credits are listed

4 **CRS departments OR NGOs**

Two types of carbon credits on sale:
1)Carbon Offsetting: someone compensates your footprint
2)Carbon Removal: net negative emission

Carbon credits implemented and monitored by the Consortium

SoilWatch reduces the NbS project cost and chances of success by using its innovative MRV solution

Product

MRV Tools

- Scoping Areas of High(est) Sequestration Potential
- Optimize Soil Field Sampling Locations
- Estimate Soil Organic Carbon Stocks
- Continuously Monitor Land Management Practices

Technical Consulting

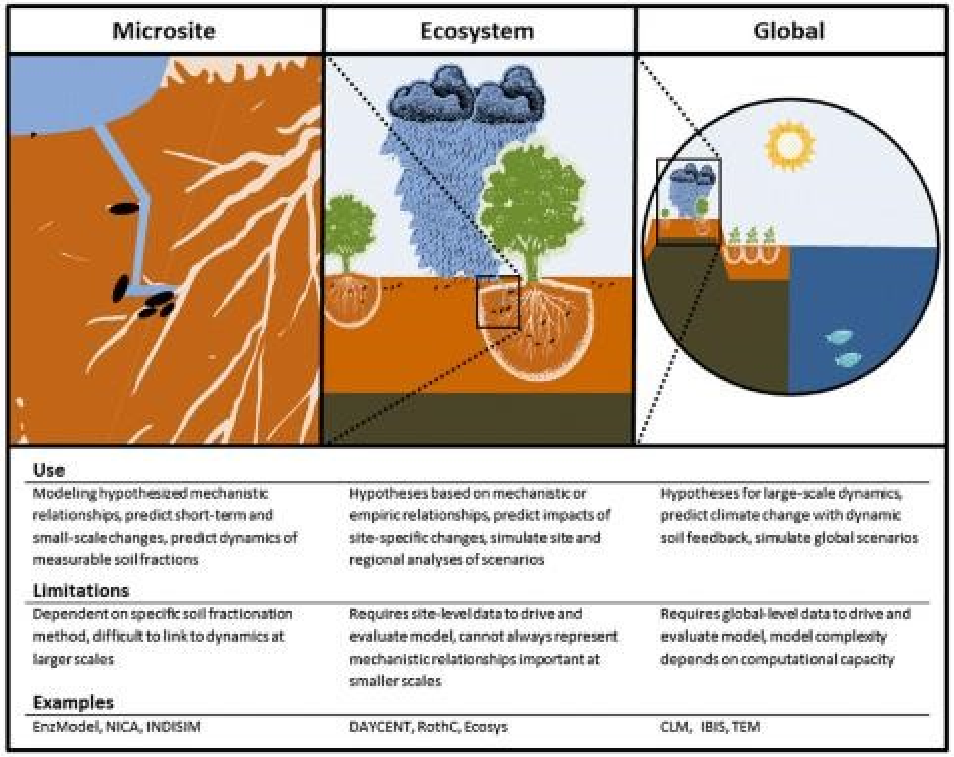
- Onboard concerned land users and match them up with project developers and climate financing option(s)
- Support Project Proposal and Development

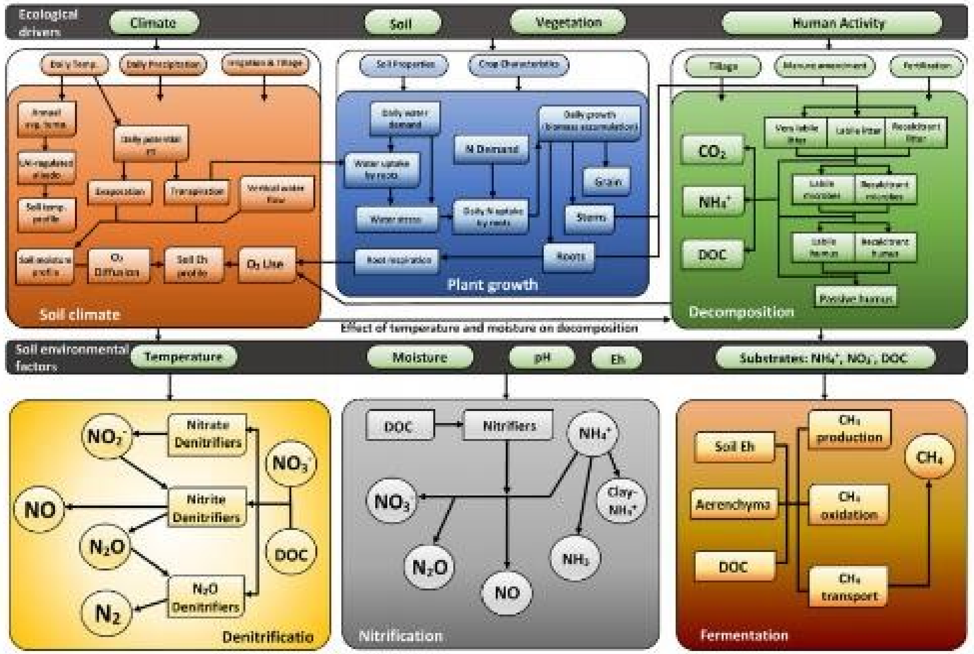
Process-based Models

A Spatial Scale Disconnect

- Process-based models have potential for a broader range of applicability across gradients of soil, climate and management conditions
  - More complex and difficult to use than empirical models
  - Require many more data inputs

- SoilsRevealed used the UNCCD modified Tier 1 method to model global SOC stock change at 250m

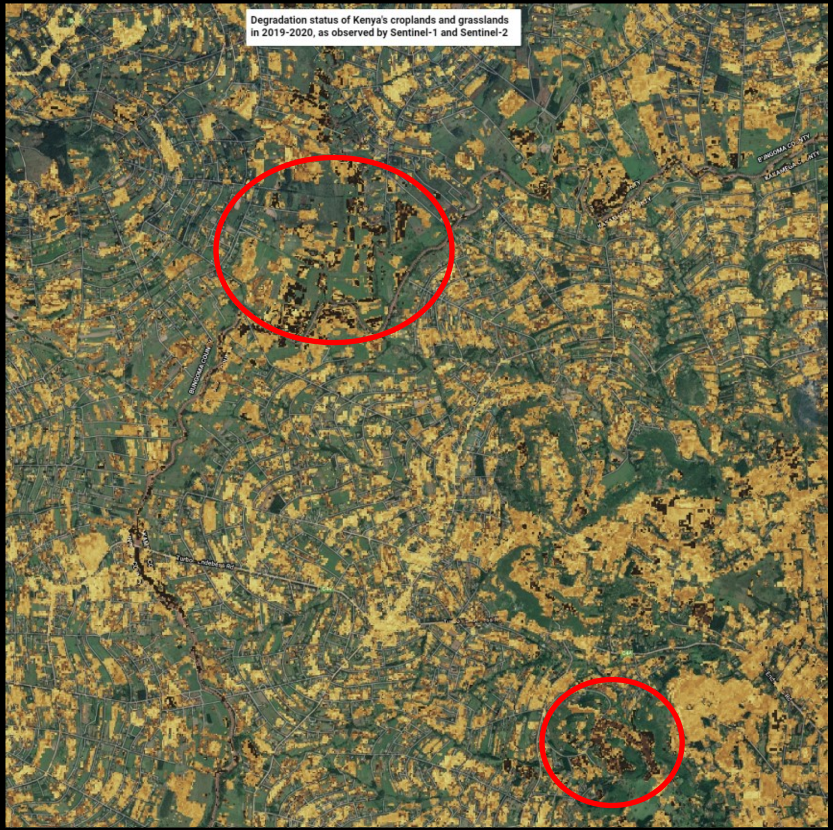


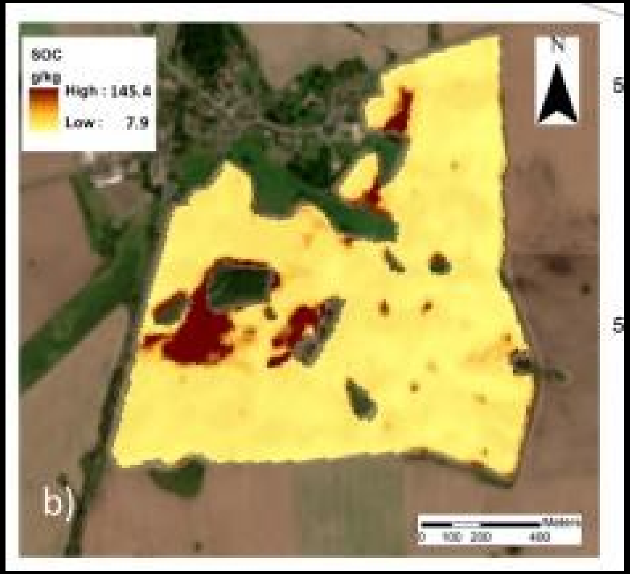


Empirical Models

Spatial Variability Described by Multi-Spectral Remote Sensing

- Empirical models through (machine learning) regression used in process-based models for calibrating certain model inputs
- Spatial distribution empirically modelled by sentinel-2 agrees with process-based models of comparable granularity (wrt. Piiki et al., 2019)
- Need for finer-grained spatial covariates to bring SOC estimates to the field level
    - Global elevation model
    - Multi-spectral sentinel-2 data
    - Land Use/Cover conversion information

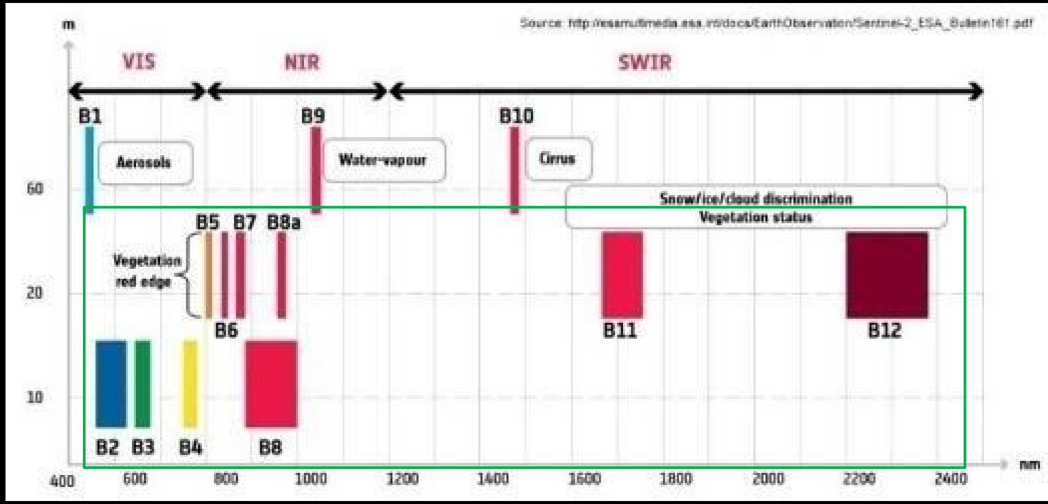


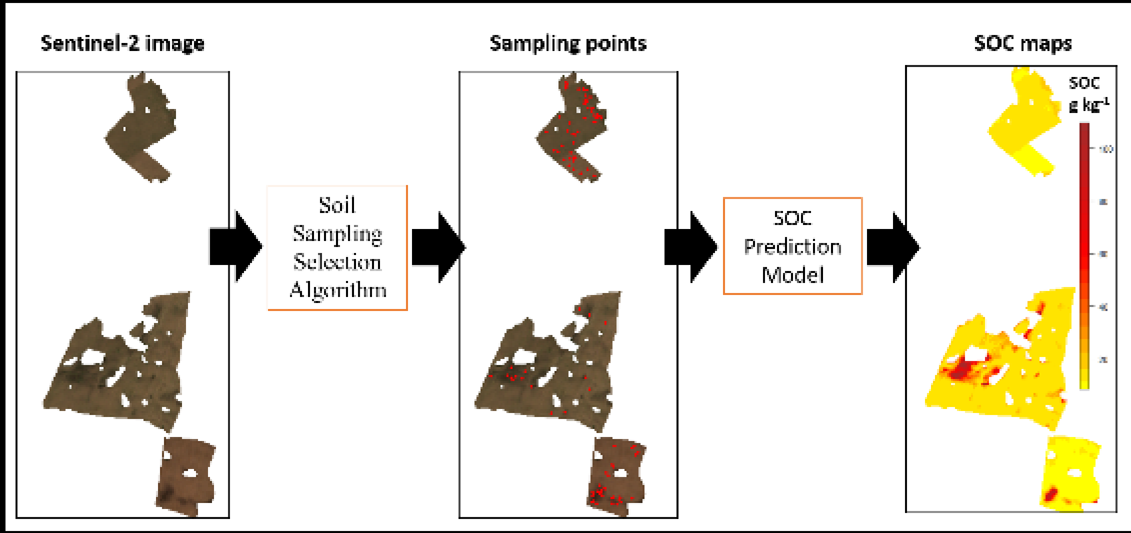


Source: Castaldi et al., 2019

Input Data Source: Sentinel-2

Contextual Spatial Information measurable by Remote Sensing





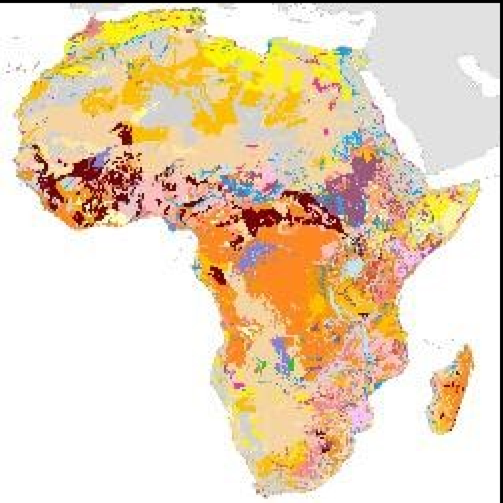
Sentinel-2A & B
(Optical Multispectral)
Resolution: 10/20/60 m
Temporal revisit: 5 days
Available since **End 2016** for Africa
Satellite mission with most potential for field-level yield

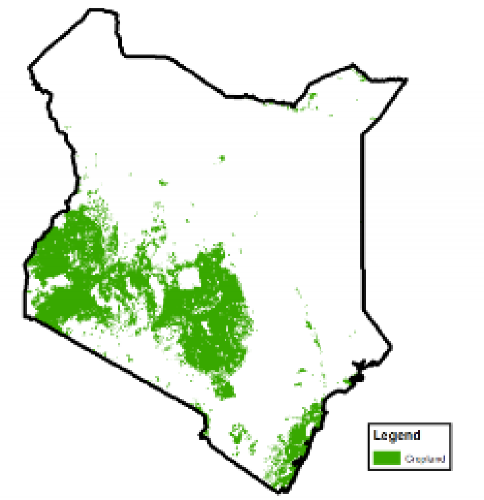
[Sentinel Success Stories: Copernicus Sentinel-2 data to estimate soil organic carbon in croplands]

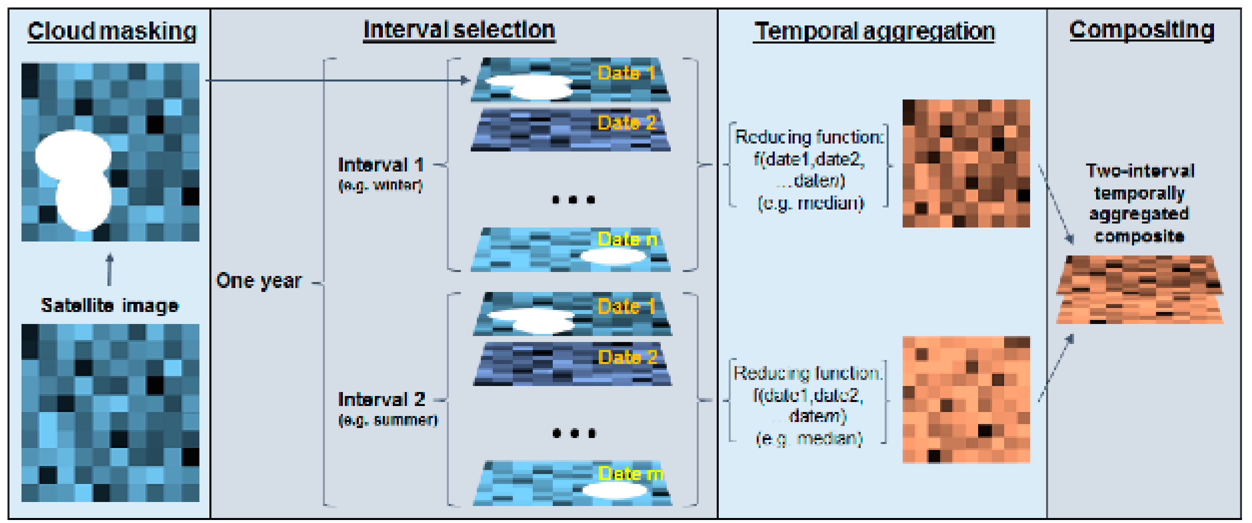
"Laying" the Land

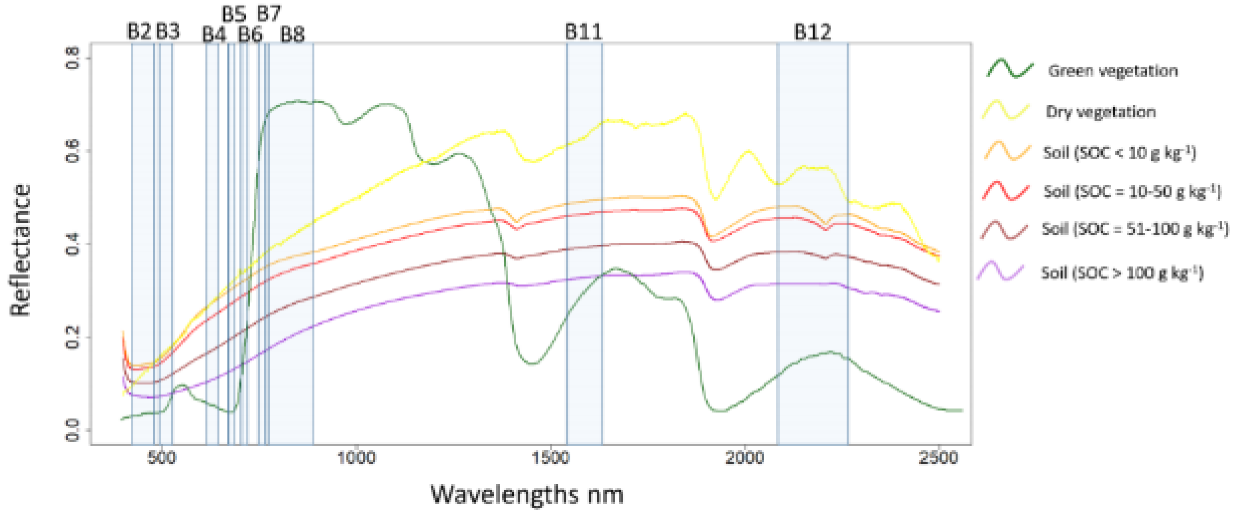
Contextual Spatial Information measurable by Remote Sensing

- Identify plots at time of season when SOC estimation is least affected by external factors:
  1. Crop and grasslands mask
  2. Sentinel-2 Seasonal Composites of the fields when most bare
     - Reduce Crop Residues (tillage practices) effects
     - Reduce Soil Moisture effects (no preceding rainfall)
     - Reduce Surface roughness effects
  3. Stratification According to "Soil Scapes"

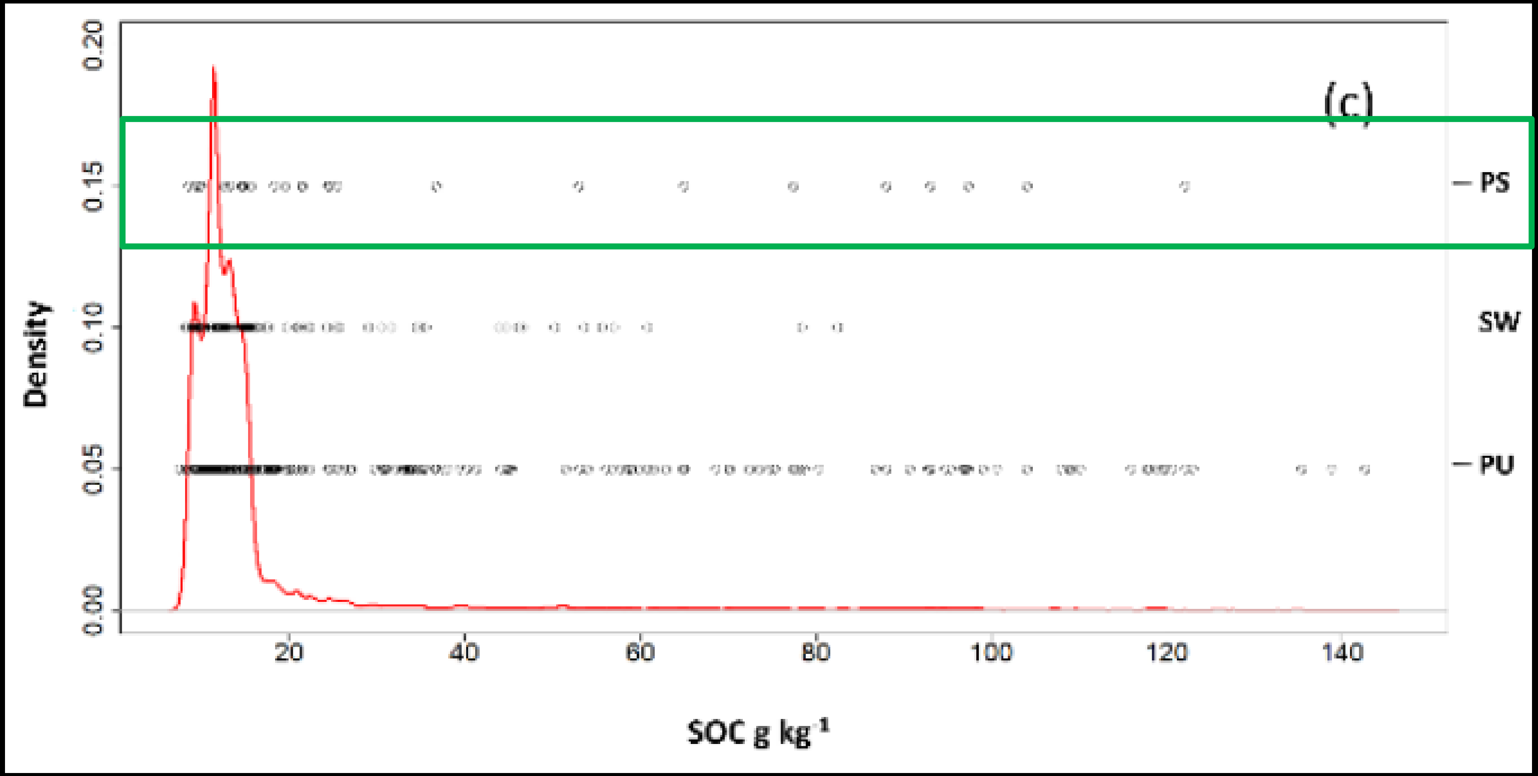








Qualitative Sampling vs Quantitative sampling



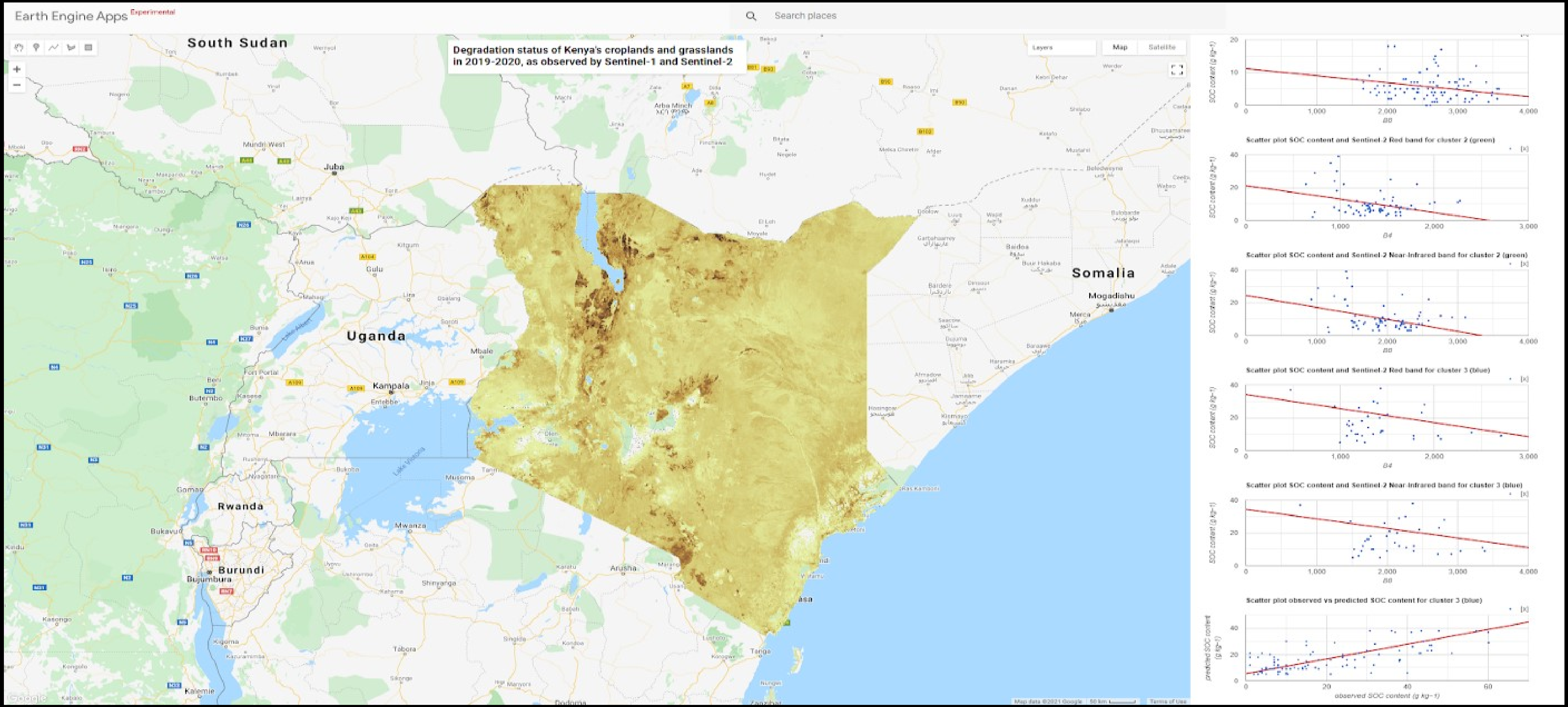
- More important to **sample the full range of SOC variability** in a given region than **sampling a lot inconditionally**
    - Smart sampling based on **Sentinel-2 spectral feature space** to generate regional spread of sampling locations

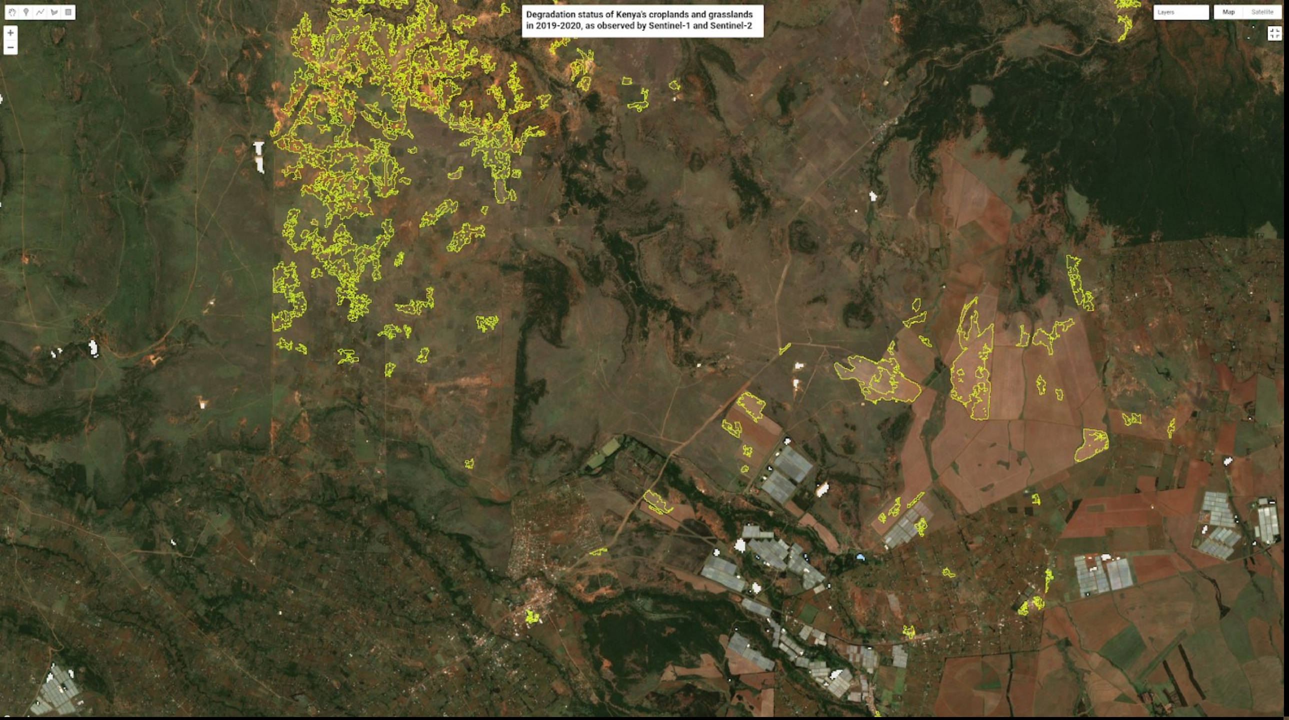
- Very **high correlation coefficient** between the Euclidian Distances between two Sentinel-2 spectra and the differences between corresponding two SOC measurements (Castaldi et al., 2019)

Operational Considerations

1. Measured SOC changes more reliable when there is significant biomass and ground cover decay into topsoil (i.e. regenerative practices)
   - Yearly SOC change estimations of heavily tilled surfaces not statistically significant
   - Measurement intervals of approximately 5 years to obtain statistically significant results (Paustian et al., 2019)
2. Sample full range of SOC variability at the rate of ~**30 samples/1000 Ha**
   - Spectral variability correlated with SOC variability → Remotely assess optimal sampling locations
3. Re-sample at same locations to get yearly ground truth on SOC change
   - Using data from previous years (cross-year training) would require further research
4. An “ideal” (dry, bare, low roughness) cloud-free composite sentinel-2 image as input for SOC modelling and soil digital mapping
   - If “ideal” case not available, quantify the uncertainty of using sub-optimal (e.g. partially vegetated) input

Google Earth Engine App Prototype





Optimizing Soil Sampling Locations

Monitoring of Soil Degradation Status and Management Practices

Meet The Team

William Ouellette:
Earth Observation (EO) Data Scientist at FAO| Land Cover Specialist | Expert in cloud native EO data processing | Data crunching anything with coordinates

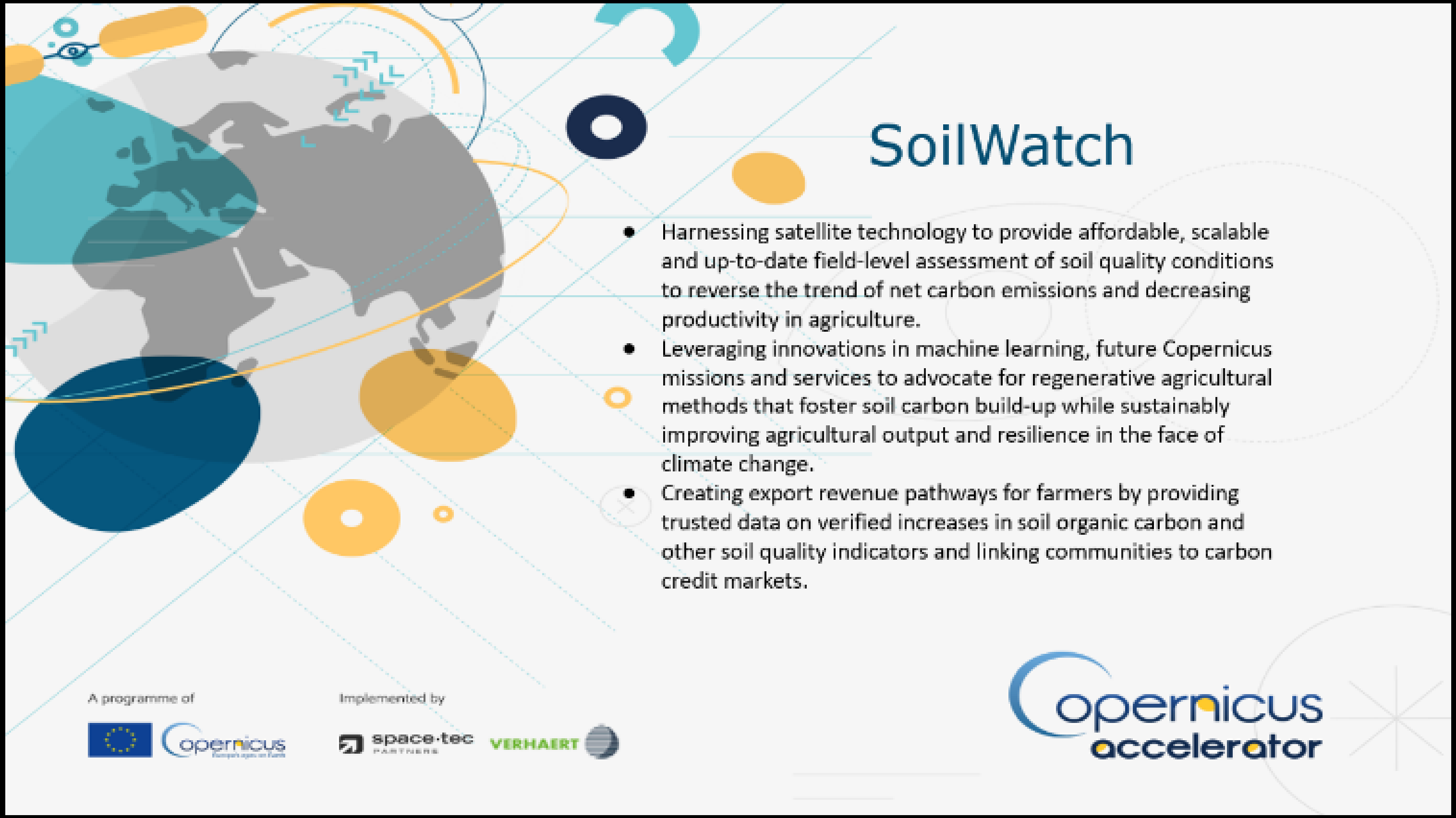
Eero Wahlstedt:
Monitoring, Evaluation & Learning Specialist | Expert in quantitative & qualitative data collection in challenging contexts in Sub-Saharan Africa | Aid sector reformer | Dad rock enthusiast

Joona Mikkola:
Former Manager for an Agribusiness Start-up | WFP M&E Consultant | Regenerative Agriculture Specialist | Hustler & environmentalist | Addicted to mountains

David Morrison:
Project manager | Former FAO Emergency Specialist | Consultant | Climate change and water conflict expert | Communications | Surfer

SoilWatch Part of the Copernicus Accelerator

- 12 months program, including:
  - Coaching
  - Bootcamps
  - Virtual Trainings
  - Access to Earth Observation Network
  - Meeting with Investors
  - Market Validation



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