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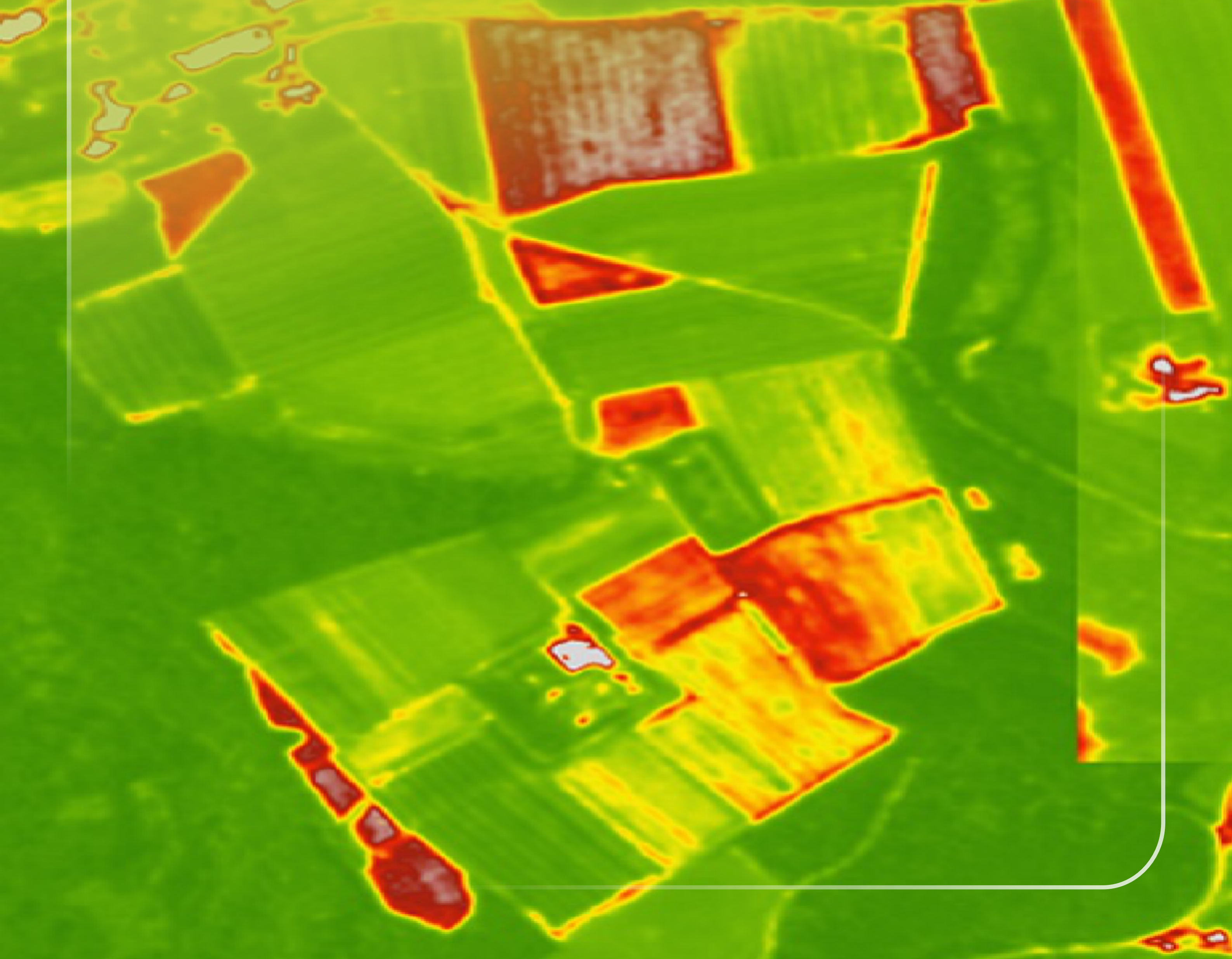
Project Fact Sheet

SATELLITE-BASED DIGITAL SOLUTIONS FOR CLIMATE-FRIENDLY AGRICULTURE IN KENYA & INDIA



Satellite-Based Digital Solutions for Climate-Friendly Agriculture in Kenya & India

The Project was implemented by the Fund for the Promotion of Innovation in Agriculture (i4Ag) and part of the Special Initiative "Transformation of Agricultural and Food Systems" (SI AGER).

Name of the Project	**Satellite-based digital solutions for the valorisation of climate-friendly agriculture**
Name of the Global Fund	Fund for the Promotion of Innovation in Agriculture (i4Ag)
Commissioned by	Federal Ministry for Economic Cooperation and Development (BMZ)
Project Region	India, Kenya
Implementing Partners	Agricultural Ecosystem Services Trading Initiative (aESTI), VAA-Impact, Spatialise, Earth Analytics India (EAI), Partners in Prosperity (PnP)
Duration	10/2021 - 07/2024

The Challenge

Including smallholder farmers in the business of validating, protecting, and up-building of soil organic carbon (SOC).

Small and medium-sized farms are severely affected by soil degradation and the effects of climate change. At the same time, agricultural practices, such as the burning of crop residues or deep cultivation, exacerbate the release of greenhouse gases and the degradation of soils. Climate-friendly, soil-conserving cultivation methods such as minimal or no-plow tillage, the addition of mulch and organic fertilizers or application of cover crops can help stop soil degradation and secure productivity in the long term. As these practices increase carbon sequestration in the soil, they directly contribute to lowering the concentration of carbon dioxide equivalents (CO_2 - eq) in the atmosphere.

The Challenge

Rapid rate of soil degradation and climate change demand urgent and immediate action.

25% of the earth's surface is already degraded. To limit global warming to below 1.5 °C, global greenhouse gas emissions would have to be drastically reduced by 2030.

However, there is a slow uptake of regenerative agriculture practices.

This is due to the absence of affordable and easily accessible tools for ensuring adequate soil nutrition based on soil health.

Traditionally established methods of soil sampling and SOC monitoring are expensive and time consuming.

To obtain robust soil data, these methods rely on regular collection and validation of soil parameters and information on agricultural activities through visits to the field and complex laboratory tests.

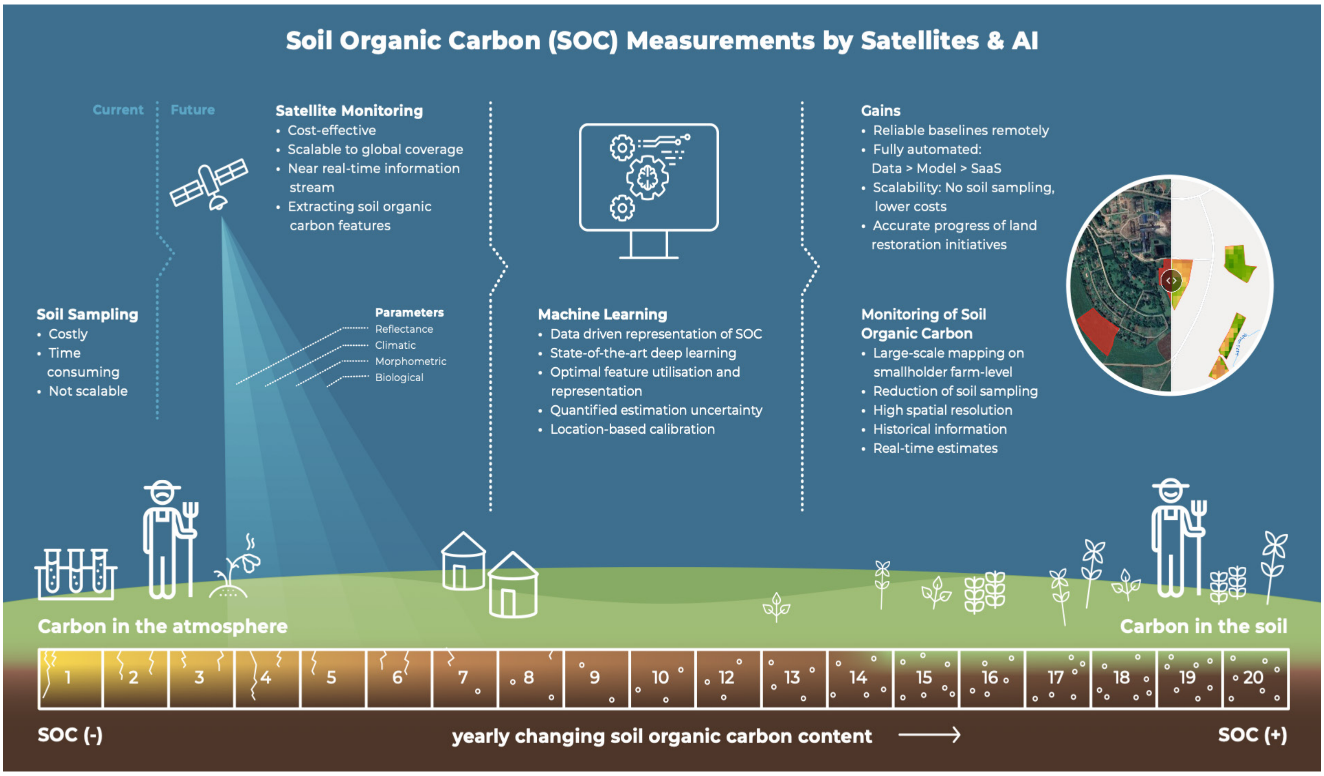
Soil organic carbon (SOC) refers to the carbon component of soil organic matter. It is an indicator of soil health and productivity. Regenerative agriculture practices that retain and increase the amount of SOC, improve soil productivity, by increasing its water and nutrient retention capacity, and also sequester atmospheric carbon.

The Main Objective

To design and test out open-source digital remote sensing and satellite-based monitoring approaches (algorithms) for capturing organic carbon stored in the soil, along with regenerative agriculture practices for climate change mitigation.

Major Achievements of the Project

- An open-source algorithm for satellite-based monitoring of soil organic carbon (SOC) and regenerative agriculture practices on the field level.
- 80% -90 % reduction in the cost of measuring soil carbon build-up per hectare of agricultural land with the digital satellite-based method, compared to established methods.
- A digital control platform to automate the recording and administration of carbon dioxide equivalent (CO_2-eq) savings.
- Outreach to more than 14.000 smallholder farms and medium-sized enterprises, 65% of which are run by women, around training on potentials of regenerative agriculture practices, soil organic carbon and carbon credits.
- 8 use cases relevant for public and private sector stakeholders.
- Technical documentation of the innovative technology submitted for accreditation, to recognized standard-setting organizations in Voluntary Carbon Markets.
- 23 events to share learnings and experiences among relevant actors in the target countries.
- 13 high-profile communication materials for disseminating knowledge and information among the stakeholders.



The Innovation

Reliable, affordable, and openly accessible capturing of soil organic carbon and regenerative agriculture practices, through remote sensing and satellite-based data and digital machine learning.

Conventional soil sampling and measurement of soil organic carbon (SOC) and regenerative agricultural practices is not only expensive but also time consuming. To overcome this barrier, an open-source tool was developed with the objective to integrate non-invasive remote sensing technologies and innovative machine learning approaches.

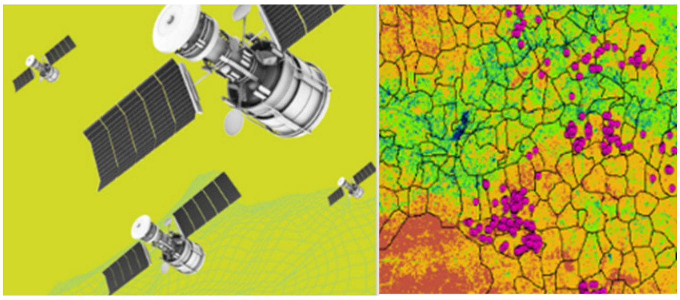


FIGURE 1: Monitoring SOC Using Satellite-Based Machine Learning Platform.

Key initiatives and activities of the project

Development of an Open-Source Algorithm for Satellite-Based Monitoring of Soil Organic Carbon (SOC)

The project focuses on the development of an open-source algorithm for satellite-based monitoring of soil organic carbon (SOC) at field level. The collection of soil samples and their in-depth analysis is a prerequisite for measuring the carbon stored in soils using remote sensing technologies. Ground truth data in the form of soil samples and laboratory analyses were collected in the intervention areas and served as reference points for calibration and adjustment of the satellite monitoring tool. At the same time, other historical data points were collected, analysed, and verified by the project partners and used to complement the ground truth data.

Leveraging satellite data and machine learning technology, an open-source algorithm was developed to utilise free satellite-based data (Sentinel-2 satellites, among others) for measuring soil carbon content and other soil parameters, such as soil type, nutrient level, and soil moisture in agricultural soils.

FIGURE 2: Sentinel-2 Satellite Utilised For Data Collection.

In both India and Kenya, extensive testing in selected geographies of partners at different levels has been conducted to test the efficacy of digital approaches in monitoring soil carbon build-up and agricultural practices on field level. Data accuracy and reliability are highly dependent on the quality and quantity of soil data (sample size) available for verification and ground truthing.

TABLE 1: Soil sample collected and accuracy level in India & Kenya

Project component	Sample size	Reliability/ Accuracy level
Africa Pilot (Including larger dataset of Africa Soil Information Service AfSIS)	~ 100,000	approx.. 80%-85%
India Pilot	~ 4000	60% - 65%

Development of an Open-Source Algorithm for Satellite-Based Monitoring of Regenerative Agriculture Practices

In addition to soil organic carbon, an open-source algorithm was developed to capture and quantify regenerative agriculture practices that lead to build-up of soil organic carbon namely tillage, cover cropping, crop residue/ biomass burning, crop health and crop type.

Tillage practices influence soil properties and surface roughness, affecting the spectral response of fields observed by satellites. Sudden backscatter value lowering was observed in certain regions when analyzed using

Sentinel-1 SAR, indicating land surface change. Therefore, these regions were classified as tillage.

The analysis of Sentinel 2 time series data indicated low health vegetation growth in the intermediate time frame between rabi and kharif seasons. This shows the presence of cover crops, as indicated in the images by green colour. A false colour image was provided for reference, showing vegetation cover in bright red.Temporal analysis was performed by using spectral bands from remote sensing technologies to accurately identify and map the extent of and changes in cover crops, in the study area.

The extent of crop residue burning in the study area, was monitored through remote sensing using normalised burn ratio (NBR) index. The Normalized Burn Ratio (NBR) index, with a 10-meter resolution, was validated through the integration of data from various sources including NASA's Fire Information for Resource Management System (FIRMS), MODIS (Moderate Resolution Imaging Spectroradiometer) active fire data, and VIIRS (Visible Infrared Imaging Radiometer Suite) data for burnt areas at a 375-meter resolution. This multi-source validation approach enhanced the reliability and accuracy of the NBR index, thus leveraging the strengths of each dataset to provide a comprehensive understanding of fire events and their impacts.

Crop health assessment using the Normalized Difference Vegetation Index (NDVI) was conducted. NDVI provides insights into vegetation vigor and health.The Sentinel 2 NDVI dataset was employed to monitor crop health, specifically during the flowering and fruiting stages when crops set and develop fruits.

Remote sensing technology plays a pivotal role in identifying and classifying crop types over large agricultural areas. A supervised classification method was used to develop a crop type map with Sentinel-1 SAR imagery. In the examined study area, a significant presence of crops like paddy, maize, and cotton was observed during the kharif season, and these findings were thoroughly corroborated with ground truth data.

Cost Reduction in Measuring Soil-Carbon Build-Up

The project aimed to achieve 50 percent reduction in the cost of measuring SOC build-up per hectare using a digital satellite-based method compared to established methods. A study conducted in both India and Kenya to compare the cost of different methods of soil sampling and analysis shows promising results that monitoring of soil carbon using Remote Sensing could reduce the cost of soil analysis by more than 80 to 90 per cent, depending on the ratio between on-ground soil data, remote sensing analysis and levels of accuracy. The graphs show a comparison of soil sampling and analysis using the different methods in both India and Kenya.

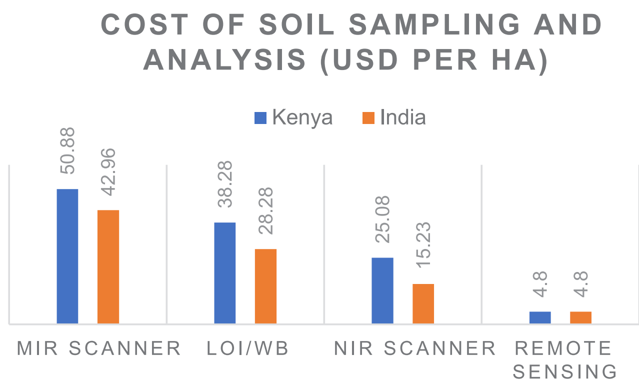


FIGURE 3: Cost of Soil Sampling in Different Methods.

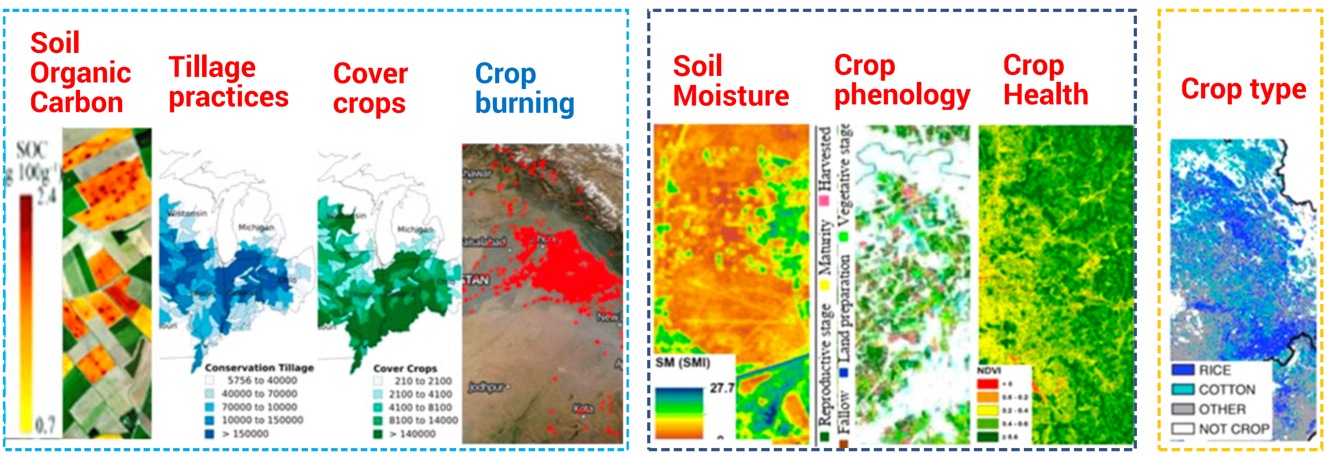


FIGURE 4: Regenerative Agriculture and other Practices Monitored using Remote Sensing.

Remunerating Farmers for Sequestering Carbon

The goal is to renumerate farmers for adopting regenerative agricultural practices. Monitoring carbon sequestration of soil would help generate carbon credits, that not only offset carbon emissions but also provide an income for smallholder farmers.

Raising Interest of International Standard-Setting Organizations

To remunerate smallholder farmers with resources from the voluntary carbon market, the assessment of carbon sequestration to generate carbon credits requires a very thorough and trustworthy monitoring tool. The monitoring and recording of soil carbon parameters using satellite-based technologies is currently not recognized by any of the standard-setting organizations in the voluntary carbon market. A concept note describing the technical documentation of the innovative technology was developed and submitted for review to the standard-setting organization "Regen Network". Along with Regen Network, consultations, meetings, and communications were also established with other standard-setting organizations and carbon credit registries such as Verra, Gold Standard, Plan Vivo among others.

Knowledge Dissemination through Multi-Stakeholder Engagement and Events

During the project period, GIZ and other partners have organized and participated in 23 different knowledge events in India, Germany, and other parts of the World to share the learnings, experiences, challenges, and technical breakthroughs with a diverse range of stakeholders including multilateral agencies, carbon credit setting organizations and registries, the scientific community, private sector players, civil society organizations, research institutions and farmers.

Outreach to Farmers for Awareness of Regenerative Agriculture Practices and Carbon Credit Mechanism

To raise awareness among smallholder farmers on soil health, regenerative agricultural practices and carbon credit projects, training sessions were held for farmer groups in India and Kenya. More than 14.000 farmers were sensitized on carbon credits generated on farmer-owned land through the adoption of regenerative agricultural practices.

In addition, master trainers were trained to support the dissemination of regenerative agricultural practices to project farmers in India. To ensure that women farmers benefit from incentive schemes, including the monetization of soil carbon storage, special effort was made to promote their participation in training and decision-making processes on regenerative agriculture.

FIGURE 5: Training of Master Trainers for Dissemination of Regenerative Agriculture Practices in India.

FIGURE 6: Training on Carbon Rights Transfer in Bungoma County, Kenya.

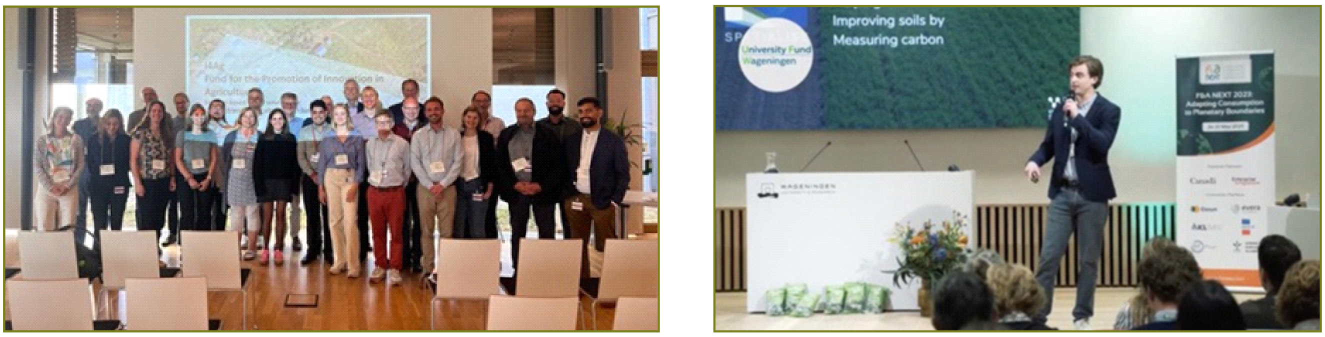


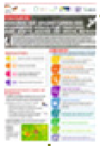
FIGURE 7: aESTI team pitching for a large audience during the Feike Sijbesma Sustainable Innovation Award and Workshop held in Bonn on Digital Solutions for Climate-friendly Agriculture in Asia and Africa.

Research Papers and Knowledge Documents

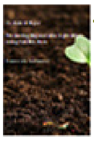
Sharing the learnings and experiences has been one of the main approaches during the project. In total, 13 knowledge documents and high-profile communication material were developed and shared with appropriate stakeholders. These knowledge documents include concept notes, high-end research studies, research papers, use cases, user guides and newsletters. Use cases were developed along with government institutions and civil society organisations to investigate and scale up the use of geospatial-based monitoring, reporting and verification (MRV) tools for regenerative agricultural practices and carbon sequestration.

8 Use case capturing different applications of satelite based soil health monitoring.

Multiple Research reports to stregthen to support and validate the innovation.



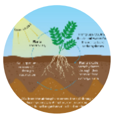
User guide detaling the key steps and process for public stakeholders.



Technical papers and concept notes on technology for dissemination among the scientific community and other stakeholder.

Use Cases for Satellite-based Digital Solutions For Climate-friendly Agriculture

1 Promoting circular sugarcane production, by developing high quality, low-cost solutions for measuring soil organic carbon of agricultural soils and enabling smallholder farmers to participate in carbon credit markets.



2 Supporting state governments in India for planning and implementing State Action Plan on Climate Change, by building their understanding on carbon sequestration potential from agriculture, and measuring year-on-year changes in carbon biomass.

CARBON CREDIT

3 Collaborating with NABARD's JIVA programme on natural farming to improve the reliability of the MRV tool for measuring soil organic carbon and regenerative agriculture.

NET ZERO

4 Developing monitoring tools to measure the carbon storage potential of forests and soils so as to encourage an increase in the uptake of nature based solutions in India's Nationally Determined Contributions.

5 Streamlining certification of sustainable cotton production by supporting global procurers and certifiers of sustainable cotton in their first mile of cotton supply chain, to verify soil and water related parameters with the help of geospatial data.

6 Supporting Ministry of Agriculture and Farmers' Welfare, India to ensure high quality and updated soil data while reducing cost, time and labour, and provide integrated advisories to farmers based on soil health.

7 Collaborating with Space Application Centres for driving sustainable soil monitoring and environmental monitoring.

NGO

8 Supporting NGOs to enhance uptake of regenerative agriculture, by measuring impact at both output and outcome levels, using geospatially integrated digital tools.

Sustainability and Scaling-up Strategies

One of the project's objectives was to translate the learnings generated during the project into products that can be offered to market participants both for-profit and non-for-profit business models. The sustainability of the platform developed during the project would be achieved if the developed solution is being used and accepted by a range of stakeholders. Additionally, the cost-saving benefits of the digital satellite-based method for measuring SOC build-up could attract agricultural actors, civil society organisations and government institutions seeking affordable solutions for monitoring soil health and carbon sequestration.

Substantial efforts were initiated to integrate the tool with government schemes and other programs by facilitating state governments to utilise the tools and implement them at the scale.

Exploring Opportunities to Collaborate

PHASE 1: Pilot to monitor Soil Health Card jointly with Soil and Land Use Survey of India (SLUSI): GIZ India is in discussion with the Ministry of Agriculture and Farmers' Welfare (MoAFW) to pilot and establish scalable model/s for open-source digital and remote sensing-based solutions for enhancing efficiency and use of soil health information at the national scale, aligned to achieving green and sustainable development in India, through integration with the Government's Soil Health Card Scheme.

To kickstart the process, GIZ proposes to conduct a pilot test to gauge the accuracy of the tool. This test would aim to conduct a comprehensive breakdown of parameters and activities relevant to the MoAFW. Based on the insights garnered from this pilot, a Remote Sensing-based portal would be developed. Technical experts from MoAFW would play an active role in this developmental phase. Throughout this process, GIZ would provide support to integrate the tool into the MoAFW system and ensure its smooth operation for an additional two years. The purpose of this extended support would be to facilitate ongoing enhancements until the tool seamlessly transitions into a fully managed internal process within MoAFW. By harnessing remote sensing technology, this initiative would aim to enhance the accuracy and reliability of soil testing while simultaneously driving down costs. Ultimately, the goal would be to make soil testing accessible and affordable to a vast number of farmers across India.

PHASE 2: Efficient use of soil health information and integrating advisories for farmers: GIZ proposes to collaborate with technical experts from MoAFW to develop a Remote Sensing-based portal. This platform would leverage the existing soil data collected by MoAFW and other associated government agencies. Initially, this data would be utilized to train the AI algorithms, and subsequently, it would be continuously used for algorithm improvement and reference checks.

Once the portal is established, it would efficiently utilize satellite-based data to gather soil health information. This information would then be utilized to provide precise agricultural advisory services to farmers.

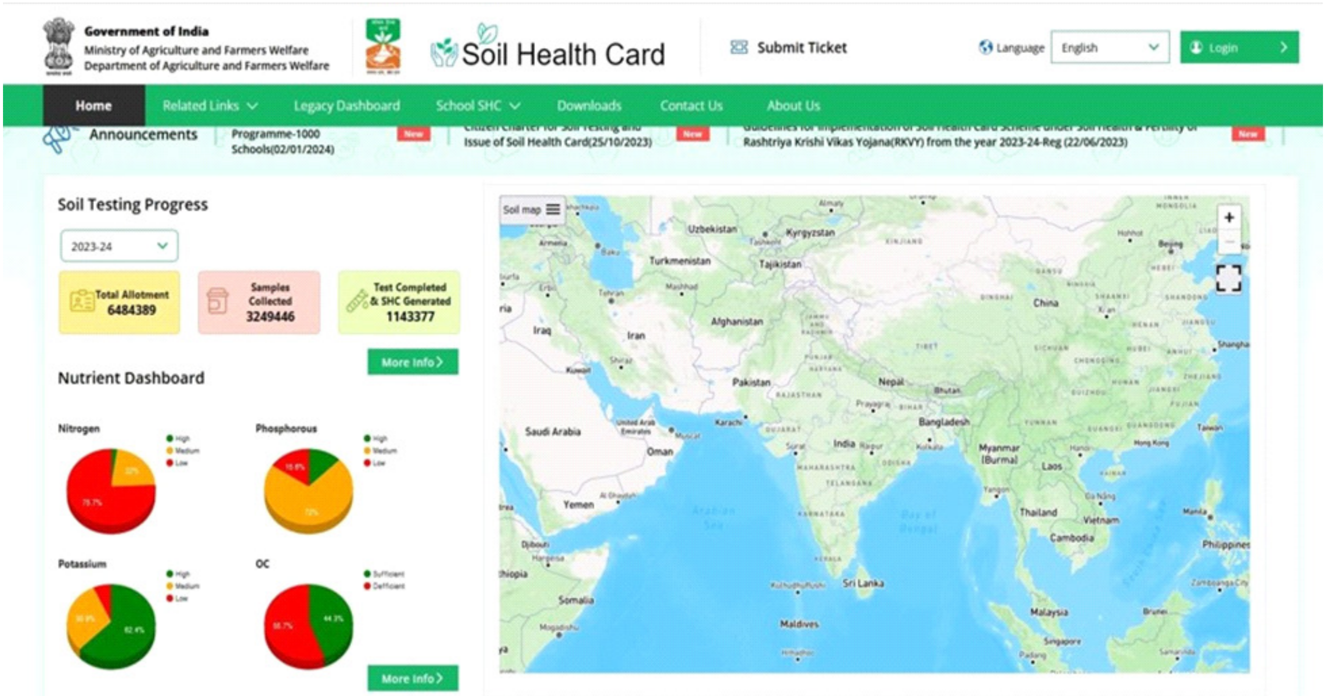


FIGURE 8: Soil health card database of GoI

Supporting State Government in Developing Climate Action Plan

GIZ and Project Partners are also in discussion with Governments of Maharashtra and Telangana among others, to understand the carbon sequestration potential from agriculture using remote sensing-based technology and measuring year-on-year changes in carbon biomass. Measuring of the carbon sequestration potential from different agriculture practices can support state Governments in developing an informed climate action plan for their respective states

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