SOIL HEALTH: THE BEDROCK FOR INTEGRATING AGRIFOOD SYSTEMS INTO THE RIO CONVENTIONS

CGIAR Environment and Biodiversity Impact Platform

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1. KEY HIGHLIGHTS

Promoting sustainable soil management is essential for achieving the Rio Conventions' goals and enhancing food security, biodiversity, and climate resilience.

Leveraging innovative and sustainable soil management practices like Integrated Soil Fertility Management (ISFM) and conservation agriculture is crucial for restoring and sustaining soil productivity and ecosystem health while aligning with the UN Sustainable Development Goals.

Decision-making tools, technological innovations, and investment in carbon farming initiatives offer pathways to link farmers to carbon markets, driving sustainable practices that support both soil health and climate resilience.

Multi-sector partnerships are critical for expanding access to sustainable soil management practices, fostering innovation, raising awareness, and ensuring progress toward global environmental objectives, including the UN Sustainable Development Goals.

2. BACKGROUND

Soil health is a cornerstone for achieving the goals of the Rio Conventions [United National Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD), and United Nations Convention to Combat Desertification (UNCCD)] by supporting food security, biodiversity, and climate resilience. However, global soil degradation, affecting about 33% of soils, threatens agricultural productivity and ecosystem services, putting 3.2 billion people, especially in vulnerable regions of the Global South, at risk. Soil degradation—through erosion, salinization, and organic matter loss among others—could reduce global crop yields by at least 56% by 2050, significantly impacting agrifood systems, global food security, and ecosystem health. As the largest terrestrial carbon reservoir, soil stores approximately 2,500 gigatons of carbon, more than the atmosphere and vegetation combined, making it crucial for climate regulation. Yet, when soils degrade, they release this carbon, intensifying climate change.

Soils also host over 25% of Earth's biodiversity, essential for nutrient cycling, disease suppression, and ecosystem resilience, aligning with the CBD's objectives. Land degradation and desertification, exacerbated by poor soil management, are critical challenges to achieving UNCCD goals, affecting 1.5 billion people in arid regions and accelerating productive land loss. Sustainable soil management practices, including optimized use of synthetic inputs, can boost global food production by 58%, strengthening agrifood systems and resilience. With each dollar invested in sustainable land management yielding a fivefold return, directing resources to soil restoration can advance the Rio Conventions' objectives and create resilient, sustainable food systems. Thus, prioritizing soil health acts as a bridge between global environmental objectives and local agricultural sustainability, ensuring that the challenges of climate change, biodiversity loss, and land degradation are tackled cohesively.

3. SELECTED SOLUTIONS TO ADDRESS THE ISSUES BUILDING ON TECHNICAL AND SOCIAL INNOVATIONS BY CGIAR AND CLOSE PARTNERS

CGIAR forges strong partnerships with governments, NGOs, and the private sector to drive knowledge creation, policy influence, and the integration of soil health initiatives with global goals for climate action, biodiversity conservation, and land restoration. To counter the pertinent challenges posed by soil degradation, CGIAR and close partners have spearheaded technical and social innovations that target the key issues impacting soil health—nutrient depletion, erosion, contamination, and carbon loss among others– through sustainable soil management practices that are adaptable, data-driven, and community-focused. A few examples are listed below.

The Africa RISING – Africa Research In Sustainable Intensification for the Next Generation (africa-rising.net) (2011-present), led by the International Institute of Tropical Agriculture (IITA), applies Integrated Soil Fertility Management (ISFM) to rejuvenate soils of smallholder farms across sub-Saharan Africa, promoting balanced organic and inorganic inputs that improve nutrient use efficiency.

In South Asia, the Cereal Systems Initiative for South Asia (CSISA) (2009-present), spearheaded by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with the International Rice Research Institute (IRRI) and the International Food Policy Research Institute (IFPRI), uses conservation agriculture practices like minimal tillage and crop rotation to reduce erosion and retain moisture in farming systems across India, Bangladesh, Nepal, and Pakistan.

In North Africa and Latin America, Conservation Agriculture for crop livestock-system (CLCA) project led by the International Center for Agricultural Research in the Dry Areas (ICARDA) (2014-2022), supported scaling of conservation agriculture in Mixed-crop livestock system for improving productivity, reducing soil erosion, and improving soil fertility.

Agroforestry innovations are also making strides through the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF's) EverGreen Agriculture Partnership (2012-present), which integrates trees into crop and livestock systems in Africa and South Asia. By improving soil organic carbon, stabilizing soil structure, and supporting biodiversity, EverGreen Agriculture has empowered over a million smallholder farmers to adopt practices that contribute to both ecological health and agricultural productivity.

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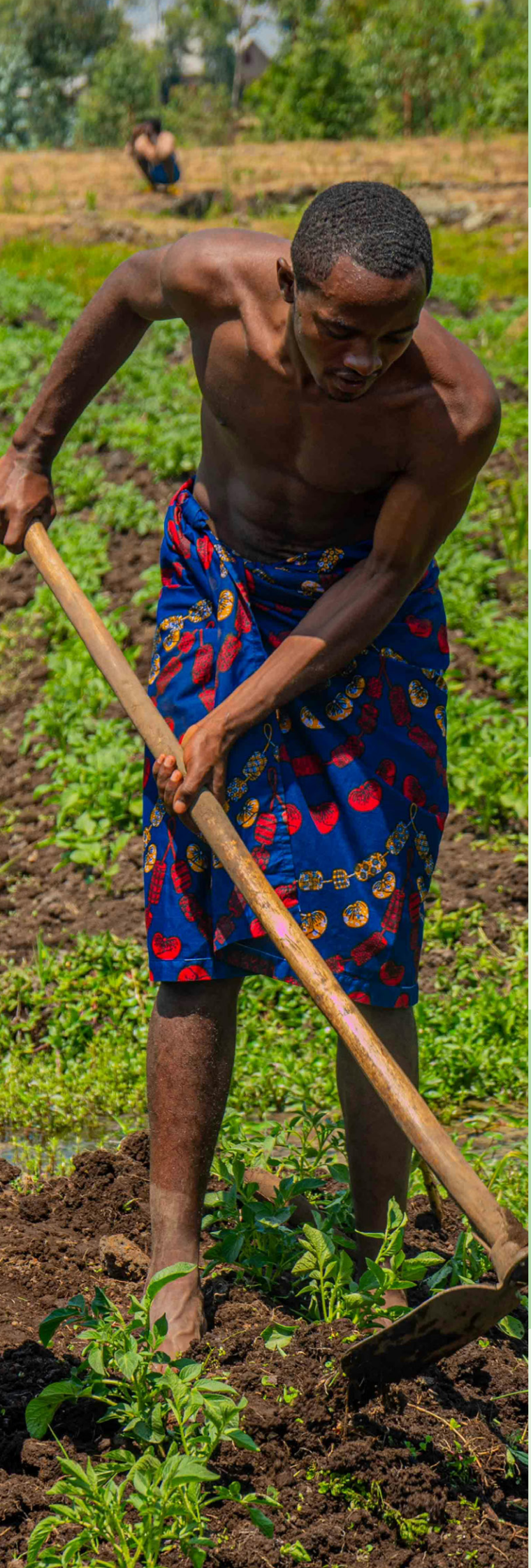

To enhance precision in soil management, the Alliance Biodiversity and CIAT's SoilGrids250m 2.0 (2013-present) offers high-resolution soil maps across Latin America, Africa, and Asia, allowing farmers and policymakers to make informed decisions about soil nutrients and water management.

CGIAR Excellence in Agronomy (EiA) **initiative (2022-present)**: a global platform (Africa, Asia, and Latin America and the Caribbean) for empowering smallholder farmers, especially women and youth, with scalable, inclusive agronomy solutions to enhance soil health, efficient fertilizer use, and climate resilience, driving sustainable productivity and food security by 2030. For example, EiA is supporting the government of Morocco to reach one million ha under conservation agriculture. Through field schools and peer learning, this initiative equips farmers with knowledge and tools for locally adapted and sustainable agronomic practices.

The Transforming Agrifood Systems in South Asia - CGIAR (TAFSSA, 2021-2025) program promotes carbon farming practices that sequester carbon while improving soil health, connecting smallholders to carbon credit markets and incentivizing soil-friendly agricultural methods.

In collaboration with Government of India, ICARDA implemented Precision Agriculture for optimizing input (2021-2024) with aim to provide real-time agro-advisory services using mobile application improved crop productivity by 15-20%, reduced production cost by 15%, improved water and fertilizer use efficiency and soil fertility compared to the farmer's practice.

In heavy clayey soils in Egypt, ICARDA's new leaching technique is to change the microtopography of farmlands by installing an internal network of ditches and drains inside the field. The water from the external canal is carried onto the field by a series of internal ditches, surrounded by internal drains, before being discharged into the main external drain. ICARDA has proven the concept of this practice in experimental fields in Port Said and Kafr El Sheikh governorates. This approach shows great promise to effectively leach salt-ridden farms.

ICARDA demonstrates biochar/nano-biochar with both clayey and sandy soils for soybean, tomatoes, and wheat in many farmer fields across Egypt governorates. The water productivity was enhanced under saline and non-saline conditions, when biochar/nano-biochar was applied.

CIMMYT and partners implemented **Digital Soil Mapping (DSM)** in Bangladesh to benefit decision-making on land-based resources and agricultural development. DSM has supported the data collection on different soil types and texture, soil organic matter content, soil pH, soil fertility, as well as moisture. Integrated with digital data on topography, climate, vegetation, and land use, users can then create high-resolution maps of soil properties and characteristics to support land-related planning and decision-making. In collaboration with Cornell University and in the International Soil Reference and Information Centre (ISRIC), CIMMYT implemented similar work in a few states of India to leverage the Soil Health Card scheme to provide precise spatial soil information for targeted agricultural action.

Through digital agriculture, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with various partners has used web/value chain approach and digital technology to enhance agri-food systems in the drylands by developing digital technologies such as The Intelligent Agricultural Systems Advisory Tool (ISAT), The Sowing App, STARS-One Android App, MRIDA, resulting in Digital soil health mapping over 10 million hectares and agro-advisory on precision nutrient application that benefited more than 5 million farmers with economic benefit of US$ 453 million.

Responding to the lack of systematic methods to assess and monitor soil and ecosystem health at landscape level as well as track progress of indicators under all three conventions, researchers at CIFOR-ICRAF have published the science-based field protocol The Land Degradation Surveillance Framework (LDSF) | Landscape Portal. LDSF now forms one of the largest global geo-referenced databases of soil and land health indicators. Land health typically indicates the degree to which the integrity of the soil, vegetation, water and air, together with ecological processes, are balanced and sustained.

Together, these examples of ongoing initiatives of CGIAR and close partners offer science-based, scalable solutions to improve soil health and sustainable agricultural practices globally. Through targeted approaches to soil fertility, conservation agriculture, agroforestry, and carbon farming, CGIAR helps align agrifood systems with the Rio Conventions' environmental goals, strengthening socio-ecological resilience and supporting climate-smart agriculture.

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4. OPPORTUNITIES AND CHALLENGES TO SCALE THE INNOVATIONS

Scaling innovations developed by CGIAR and close partners in soil health presents immense opportunities that align with global priorities in climate action, biodiversity conservation, and sustainable food systems, creating a favorable environment for expansion. Supportive national, regional, global policies are essential, as they can facilitate widespread adoption of the most innovative solutions mentioned above. For instance, the Soil Initiative for Africa and the Africa Union's 10-Year Action Plan for Fertilizer and Soil Health , informed by research and innovations from CGIAR and close partner collaboration, present critical frameworks for scaling soil health solutions across the continent. They represent significant opportunities to leverage CGIAR innovations in achieving the Rio Conventions' goals, with a focus on soil restoration, climate resilience, and sustainable agrifood systems across Africa.

However, adopting soil health solutions comes with a cost, which could be prohibitive for resource-constrained end-users, particularly smallholder farmers. This challenge could result in low demand for some of the innovations, therefore reducing the availability in the locations where they are required. While technical solutions are key for soil health, social innovations are equally critical to empower the end-users of the technical solutions, of which access to financing and supporting policies is key. Importantly, most of the innovations require capacity strengthening for the end-users, which often represents another layer of challenge in geographies where extension services are not strong enough.

5. CALL FOR ACTIONS FROM VARIOUS ACTORS OF THE RIO CONVENTIONS

Foster demand-oriented R4D that drives advancements in sustainable and profitable agronomic practices with positive outcomes for soil health, biodiversity and ecosystem resilience.

Prioritize policies that support sustainable soil management, incentivize conservation practices, and strengthen soil health monitoring to advance scalable soil solutions, including policy coherence.

Establish partnerships between governments, the private sector, financing institutions, the academia, national agricultural research and extension services, CGIAR, and other development partners for capacity sharing on issues related to soil health and sustainable soil management to jointly deliver on the Rio conventions.

Pursue innovative financing models, including for instance payment for ecosystem services and carbon credits, to support soil health initiatives.

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