

Building Carbon-Positive Food Systems Through Soil Health



*Bridging Science, Policy and Practice for the
21st-Century Food System*



Global Policy Report
Prepared by the World Agriculture Forum
August 2026

About This Report

This report is a synthesis of the World Agriculture Forum (WAF) Earth Day Policy Dialogue 2026, convened on 22 April 2026. It distils the keynote address, opening remarks and panel discussion delivered by seven scientists, policy specialists and industry leaders into a single thematic narrative and an actionable set of recommendations.

The report is structured for three primary audiences: policymakers shaping national agricultural and climate strategies; investors, donors and agro-industry leaders seeking credible pathways into soil-health finance; and practitioners, including farmer organisations and extension services, responsible for translating soil-health science into farm-scale outcomes

The report is organised around five themes: the global soil-health challenge, proven pathways for soil restoration, carbon-positive agriculture, financing and policy frameworks, and priorities for collective action through the Global Soil Health Coalition.

Scope and Method

The policy dialogue addressed a central question: what will it take to make soil health the foundation of a carbon-positive food and agricultural system by 2030? Contributions covered the global state of soil resources, the science and economics of soil-organic-carbon sequestration, biological and biostimulant approaches to soil regeneration, climate-stressed and dryland realities, and the African smallholder lens. This report draws on the verified transcript and integrates the speakers' contributions into a single argument with structured recommendations.

A Note on Language

Soil health is the continued capacity of soil, as a living and dynamic ecosystem, to function within natural and managed landscapes while sustaining agricultural productivity, environmental quality and ecosystem resilience. Healthy soils perform five essential functions: regulating water, sustaining plant and animal life, filtering and buffering pollutants, cycling nutrients, and providing physical support for plant growth and human infrastructure. Soil health is assessed through both inherent and dynamic soil properties. Inherent properties develop over long periods through the interaction of climate, organisms, topography, parent material and time, and generally remain stable. These include soil texture, mineralogy, depth to bedrock and drainage class. Dynamic properties, by contrast, respond to land management and environmental conditions and include soil organic matter, biological activity, aggregate stability, nutrient availability and soil structure.

"Carbon-positive agriculture" denotes farming systems whose net carbon balance is negative across the production cycle, meaning they remove more carbon dioxide from the atmosphere than they emit. A glossary of acronyms and technical terms is provided in Annex C.

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The report is intended to contribute to ongoing discussions on soil health, agricultural transformation, climate resilience, biodiversity conservation, carbon farming, and sustainable food systems. While every effort has been made to accurately reflect the evidence, experiences, and perspectives shared during the dialogue, the interpretations and conclusions presented herein are intended to inform discussion and do not necessarily represent the official positions of the World Agriculture Forum, its Board, partners, sponsors, member organisations, or affiliated institutions.

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Chairman's Message

An excellent contribution of WAF to the development and implementation of sustainable production systems and to the conservation and expansion of nature-dominated systems, such that biodiversity increases and world agriculture may guarantee food security and eliminate chronic hunger.

WAF stimulates highly productive agricultural systems at the well-endowed places, such that less-endowed land can be used for nature development, and globally a good balance is found:

sophisticated, productive agriculture at the right places, and nature and biodiversity at the less-endowed places.

Soil health and appropriate land use are leading in the choices that have to be made. Not everything can be done everywhere, but soils, and their present and future convincing characteristics, are setting the scene and defines what is possible where.

That is illustrated very clearly in this report. It paves the way for advanced interventions and is in line with the vision of WAF and its mission.

The report gives a very clear and detailed description of the way soil health should be promoted, and of how that will lead to the introduction of needed changes that enable an urgently needed intervention. In this way, WAF will contribute to debates on a global level, which is urgently needed.



Best regards,

A handwritten signature in dark ink, appearing to read 'Rudy Rabbinge', with a stylized flourish at the end.

Prof. Rudy Rabbinge,

Board Chairman, World Agriculture Forum

Foreword

Soil is no longer a quiet asset. It is now the most under-valued, over-stressed and decisive piece of infrastructure in the global food and climate system, and the World Agriculture Forum is convinced that the next decade will be defined by what humanity does, or fails to do, to restore it.

Over the past sixty-five years agriculture has performed an extraordinary feat. The global population has grown by a factor of 2.7 while cereal production has grown by a factor of 3.3. Per-capita grain availability now stands at around 354 kilograms, an outcome that ranks among the most consequential achievements of modern science and policy. Hundreds of millions of people who would otherwise have starved are alive today because of it. Yet the bill for that performance has come due. Forty percent of the world's land is degraded, and on current trajectories that figure will reach fifty percent by 2050. The food system contributes roughly thirty to thirty-five percent of global greenhouse-gas emissions; one person in ten remains food-insecure and one in four is malnourished. In the soils that produced our success, organic matter, the central indicator of biological function, has been depleted in many tropical and subtropical regions to less than one percent, against an optimum of two-and-a-half to three percent. The soil that fed us is tired.

The WAF Earth Day Dialogue 2026 was convened to confront that fact and to ask a precise question: what will it take to move from an agricultural system that emits carbon to one that draws it down, and to do so without sacrificing the food security of the people who most depend on the land? The contributors did not converge on a single technology. They converged on something more important: a common architecture, with four pillars. First, soil health must become the explicit objective of agricultural and climate policy, embedded in legislation rather than left as an afterthought. Second, finance must reward outcomes, not inputs, and must reach smallholders at the scale, simplicity and certainty that their context requires. Third, science must be matched with practice through extension systems, farmer-led platforms and harmonised regulation of biological inputs. Fourth, equity must be designed in from the beginning, with women, youth and dryland farmers as co-authors of the strategies that will shape their land for the next generation.

The Global Soil Health Coalition is the World Agriculture Forum's response to the coordination problem that all four pillars surface. It is a neutral platform whose purpose is to not to add another voice, but to connect the ones that already exist; to close the gap between global ambition and on-ground reality; aligning knowledge, investment, practice and farmer voices with the global finance landscape. This report is the first formal contribution of the Coalition to the public record. It is offered in the conviction that a carbon-positive future is technically achievable, economically defensible and morally required, and that the decade to deliver it has already begun.

Global Soil Health Coalition Secretariat

August 2026

Executive Summary

Soil health is increasingly recognized as one of the most strategic issues shaping the future of global food systems. It lies at the nexus of food security, climate resilience, biodiversity conservation, water security, public health, and rural economic development. Yet despite its foundational role, soil degradation continues to accelerate worldwide, threatening agricultural productivity, ecosystem stability, and the ability of countries to achieve their sustainable development and climate objectives.

Against this backdrop, the World Agriculture Forum (WAF), through the Global Soil Health Coalition (GSHC), convened the Earth Day Policy Dialogue 2026 under the theme “Building Carbon-Positive Food Systems Through Soil Health”. The dialogue brought together internationally recognized scientists, policymakers, private-sector leaders, researchers, and development practitioners to explore how soil restoration can serve as a catalyst for transforming agriculture and food systems while advancing climate, environmental, and economic goals.

The dialogue took place at a critical moment. Approximately 40 percent of the world’s land is currently degraded, with projections indicating that this figure could rise to 50 percent by 2050 if current trends persist. At the same time, food systems account for an estimated 30–35 percent of global greenhouse gas emissions, while biodiversity loss, declining soil fertility, water stress, and climate volatility continue to undermine agricultural sustainability. Participants emphasized that these challenges should not be viewed in isolation. Rather, they represent interconnected symptoms of a broader erosion of natural capital, with soil degradation emerging as one of the most significant underlying drivers.

A central conclusion of the policy dialogue was that the dominant agricultural model of the past century, while remarkably successful in increasing food production, is increasingly unable to address the complex environmental and social challenges facing modern food systems. The productivity gains of the Green Revolution were achieved through substantial advances in irrigation, mechanization, fertilizers, and crop genetics. However, these gains often came at the expense of soil biological function, ecosystem resilience, and long-term sustainability. Participants argued that the next agricultural transformation must move beyond an input-intensive paradigm toward a soil-centred model that prioritizes ecosystem function, biological health, carbon restoration, and resource efficiency.

Throughout the dialogue, soil organic matter emerged as one of the most important indicators of soil health and one of the most powerful levers available for agricultural transformation. Healthy soils typically contain between 2.5 and 3 percent organic matter in the root zone, yet in many agricultural regions, particularly among smallholder systems, levels have fallen below 1 percent. This decline has far-reaching consequences for productivity, water retention, nutrient cycling, biodiversity, and climate resilience. Restoring soil organic matter was consistently identified as a high-impact intervention capable of generating multiple benefits across agricultural, environmental, and economic systems.

Participants further emphasized the need to reframe soil as a living ecosystem rather than merely a medium for nutrient delivery. Soil supports vast biological communities that regulate nutrient availability, carbon cycling, water dynamics, and plant health. As a result, the future of agricultural productivity will depend not only on improving inputs but on restoring the ecological processes that underpin healthy and resilient landscapes. The dialogue highlighted growing evidence that regenerative and conserva-

tion-based approaches including no-till agriculture, cover cropping, agroforestry, integrated nutrient management, biostimulants, carbon farming, and climate-smart water management practices can improve both productivity and environmental outcomes when implemented within locally adapted systems.

One of the most significant themes emerging from the policy dialogue was the recognition of soil as a strategic climate asset. Beyond supporting food production, soils represent one of the largest terrestrial carbon reservoirs and offer substantial opportunities for carbon sequestration. Participants explored the concept of carbon-positive agriculture, in which farmers are rewarded not only for producing food but also for generating climate and ecosystem benefits through soil carbon restoration. Discussions highlighted the potential for carbon farming, ecosystem-service payments, and innovative financing mechanisms to create new income streams for farmers while accelerating progress toward climate objectives.

The dialogue also concluded that the primary barriers to large-scale soil restoration are no longer scientific. Significant advances have already been made in understanding soil biology, carbon dynamics, regenerative practices, and climate-smart agriculture. Instead, the principal constraints are institutional, financial, and policy-related. Existing subsidy structures often incentivize input use rather than soil-health outcomes. Carbon markets remain difficult for smallholders to access. Extension systems are under-resourced, and regulatory frameworks for biological inputs remain fragmented in many jurisdictions. Participants stressed that future progress will depend on aligning science, policy, finance, and implementation within a coherent enabling framework.

Special attention was given to the realities facing smallholder farmers, particularly in Africa, where soil health is directly linked to food security, poverty reduction, and climate resilience. Participants highlighted the challenges posed by declining soil fertility, limited extension support, insecure land tenure, and restricted access to finance and technology. The dialogue underscored that soil restoration is not solely an environmental imperative but also a development priority, particularly for regions where agricultural livelihoods remain highly vulnerable to climate and economic shocks.

The overarching message from the dialogue was clear: soil health is not merely an agricultural issue. It is a strategic foundation for resilient food systems, climate action, ecosystem restoration, and sustainable development. The decisions taken over the coming decade will determine whether soils continue to degrade or become one of humanity's most powerful assets in building a carbon-positive future.



“The science already exists, and successful case studies are proving what is possible. The next step is bringing science, policy, finance and farmer voices together to scale soil health solutions globally.”

Dr Carla Portugal, Director of Science, Soil Food Web Foundation

Key Messages

1. Agriculture must shift from net carbon source to net carbon sink.

The global food system contributes thirty to thirty-five percent of greenhouse-gas emissions, while soils, plants and degraded landscapes simultaneously hold the largest accessible technical potential for atmospheric carbon removal on land. Realising that potential requires a deliberate shift from input-based to soil-based agriculture, from maximum to optimum yield, and from emissions-neutral to emissions-negative farming systems.

2. Soil organic matter is the central indicator and the central lever.

In smallholder soils across many tropical and subtropical regions, organic-matter content has fallen below one percent (and in the most depleted soils below half of one percent) against an agronomic optimum of two-and-a-half to three percent. Restoring organic matter is the single most consequential action available to agricultural systems, with simultaneous benefits for productivity, water retention, biodiversity, climate mitigation and farm income. Conservation agriculture applied across the world's 1.5 billion hectares of cropland could sequester approximately 2.5 petagrams of organic carbon per year, with a cumulative soil-and-biomass potential to 2100 of around 333 petagrams (equivalent to drawing down roughly 157 ppm of atmospheric CO₂).

3. The known practices work; the missing piece is the delivery system.

Conservation agriculture (no-till with permanent residue cover, complex rotations and continuous living roots), integrated and humic-based amendments, biostimulants used within integrated crop-nutrition programmes, alternate wetting and drying in rice, agroforestry and enhanced rock weathering all have strong evidence behind them. The barrier is not the science; it is the absence of the policy, finance and extension systems that would put these practices into farmers' hands at scale. Direct farm-scale carbon measurement is unworkable due to sampling and depth heterogeneity; payment systems must reward verified practices with periodic spot-check verification.

4. A credible global financing architecture is in the order of US\$100 billion per year.

Compensating the world's 700 million farmers, including 550 million smallholders, at a price of US\$50 per credit (one tonne of CO₂ equivalent) would require approximately US\$70 billion per year for smallholders and US\$30 billion for medium and large farmers. The funds can be drawn from emitting industries, agro-industry, the private sector and consumers. The challenge is one of architecture, not arithmetic.

5. Policy must move from fragmented signals to a coherent legal foundation.

A "trinity of acts" (a Clean Air Act, a Clean Water Act and a Soil Health Act) should anchor environmental governance in every jurisdiction, complemented by subsidies that reward outcomes rather than inputs, harmonised function-based regulation of biostimulants and biological inputs, and secure land tenure that allows farmers to invest in multi-year soil-carbon plans. India's emerging Bharat soil-protection policy and the African Union Fertiliser and Soil Health Action Plan offer working blueprints.

6. Smallholder and dryland realities require differentiated, equity-led approaches.

More than seventy percent of food production in sub-Saharan Africa comes from smallholders cultivating less than two hectares; women produce sixty to eighty percent of food in many African countries. Soil-health strategies that ignore tenure insecurity, weak extension (in Malawi, one officer per two thousand farmers) and the systematic exclusion of women and youth will fail. Carbon-market access for smallholders must be aggregated, simplified and built around cooperative models.

7. The Global Soil Health Coalition is the platform to align the parts.

Most existing initiatives operate well within their own domains, whether science, policy, implementation or advocacy. What is missing is a neutral platform that connects them with the global policy and finance landscape in a unified way. Closing that coordination gap is the work of the Global Soil Health Coalition, and the World Agriculture Forum's organising priority for the decade ahead.

Introduction

The Global Imperative for Soil Health

Humanity faces the unprecedented challenge of feeding a growing global population while simultaneously addressing climate change, biodiversity loss, land degradation, water scarcity, rural poverty, and increasing geopolitical instability. These challenges are deeply interconnected and cannot be solved in isolation. At their foundation lies one of the world's most valuable yet overlooked natural assets: healthy soil.

In January 2025, more than 150 Nobel Laureates and World Food Prize Laureates issued an unprecedented global call for “moonshot” innovations¹ to avert a looming food crisis. Warning that the world must sustainably feed an estimated 9.7 billion people by 2050, the signatories identified climate change, land degradation, biodiversity loss, conflict, water scarcity, and declining agricultural productivity as converging threats to global food security. Their appeal reflected an emerging scientific consensus that the next agricultural transformation must not only increase production but also restore the natural resource base upon which agriculture ultimately depends.

The economic dimensions of this challenge are equally profound. According to the World Bank, global food systems generate approximately US\$5 trillion in annual food production while imposing an estimated US\$6 trillion in hidden environmental and public health costs². Soil degradation, greenhouse-gas emissions, biodiversity loss, water pollution, and diet-related health impacts increasingly demonstrate that food systems must evolve from maximising production alone towards delivering environmental sustainability, human well-being, and long-term economic resilience.

Although soils produce approximately 95 percent of the world's food³, they remain among the planet's most undervalued natural resources. Healthy soils underpin not only crop production but also livestock systems, freshwater resources, biodiversity, and the ecosystem services upon which agriculture depends. Conversely, declining soil health contributes to nutrient losses, reduced water quality, declining fodder production, and wider impacts across interconnected food systems, including fisheries and animal agriculture.

At the same time, agriculture is becoming increasingly difficult to sustain. Across many regions, farmers face declining profitability, rising production costs, volatile markets, labour shortages, and growing climate uncertainty. Agricultural incomes often remain lower and more volatile than those in many other sectors, prompting farming households to diversify their livelihoods while discouraging younger generations from entering agriculture. Building resilient food systems therefore requires solutions that not only restore ecosystems but also strengthen the long-term economic viability of farming.

Environmental pressures continue to intensify these challenges. Land degradation, declining soil fertility, erosion, salinisation, nutrient depletion, biodiversity loss, and diminishing water resources are reducing the productive capacity of agricultural landscapes worldwide. Climate change is further amplifying these pressures through more frequent droughts, floods, heatwaves, and extreme weather events, increasing production risks for millions of farmers who depend directly on healthy soils and reliable water supplies. These trends reinforce the urgency of developing farming systems that improve soil resilience, enhance water-use efficiency, and restore ecosystem functions while sustaining agricultural productivity.

1. *World Food Prize Foundation. Over 150 Nobel and World Food Prize Laureates Call for Moonshot Effort to Avoid Global Hunger Catastrophe. 14 January 2025.*
2. *World Bank. Do the Costs of the Global Food System Outweigh Its Monetary Value?*
3. *Food and Agriculture Organization. Status of the World's Soil Resources (SWSR) – Main Report. Rome: FAO, 2015 (Also supported by FAO's global soil resources publications.)*

Recognising these challenges, governments and international institutions are increasingly placing soil health at the centre of agricultural and climate policy. The United Nations designated 2015 as the International Year of Soils⁴ to highlight the essential role of soils in food security and ecosystem resilience.

The⁴ per 1000 Initiative⁵ demonstrated the global potential of increasing soil organic carbon to simultaneously strengthen climate mitigation and agricultural sustainability. In 2024, the European Union adopted carbon farming⁶ as the cornerstone of its certification framework for carbon removals, while the African Union, through the Africa Fertilizer and Soil Health Action Plan (2024–2034)⁷, established an Africa-led strategy to restore soil fertility, improve agricultural productivity, and strengthen food security across the continent. Collectively, these initiatives signal a growing international recognition that healthy soils are indispensable for achieving climate action, biodiversity conservation, food security, and sustainable development.

Despite this growing scientific understanding and policy momentum, progress on the ground remains uneven. Soil degradation continues to outpace restoration across many regions, while fragmented policies, limited financing, under-resourced extension systems, insecure land tenure, and insufficient coordination continue to constrain large-scale implementation. Increasingly, the challenge is no longer a lack of scientific knowledge but the ability to translate that knowledge into coherent policies, investment frameworks, practical technologies, and farmer-centred solutions capable of delivering impact at scale.

Soil conservation practices after the severe soil erosion and Dust Bowl of 1930s in the Midwest farms in prairie lands led the USDA to establish the Natural Resources Conservation Service (NRCS) to help farmers adopt soil conservation practices. Recently, USDA Secretary Brooke Rollins stated: “However, current conservation programs at USDA have become overly burdensome, and farmers are bogged down with red tape whenever they try to adopt soil health and regenerative agriculture practices”. Even with the improved soil health since the creation of NRCS, USDA data shows that farmers recently reported that 25% of acres had water-driven erosion concerns and 16% of acres had wind-driven erosion concerns.⁸ This experience reinforces a broader global lesson: restoring soil health is not a one-time intervention but an ongoing process that demands collaboration among governments, researchers, the private sector and farming communities.

It was against this global backdrop that the World Agriculture Forum (WAF), through the Global Soil Health Coalition (GSHC), convened the Earth Day Policy Dialogue 2026 under the theme “Building Carbon-Positive Food Systems Through Soil Health.” Bringing together internationally recognised scientists, policymakers, private-sector leaders, development practitioners, and farmer representatives, the dialogue explored how restoring soil health can become a unifying strategy for transforming agriculture and food systems. Rather than viewing soil simply as a medium for crop production, participants examined its role as a living ecosystem, a strategic climate asset, an engine of rural prosperity, and the foundation upon which resilient, productive, and sustainable food systems ultimately depend. The discussions presented throughout this report reflect a shared conclusion: restoring soil health is no longer simply an agricultural objective. It has become a strategic imperative for achieving food security, climate resilience, biodiversity conservation, economic prosperity, and sustainable development. The challenge before the international community is not whether solutions exist, but how rapidly they can be translated into policies, investments, and actions capable of transforming food systems for future generations.

4. *Food and Agriculture Organization. International Year of Soils 2015. Rome: FAO.*

5. *4 per 1000 Initiative. The “4 per 1000” Initiative: Soils for Food Security and Climate.*

6. *European Commission. Commission welcomes political agreement on first EU-wide voluntary framework for certifying high-quality carbon removals. 20 February 2024.*

7. *African Union. Africa Fertilizer and Soil Health Action Plan (2024–2034). Adopted at the African Union Fertilizer and Soil Health Summit, Nairobi, May 2024.*

8. <https://www.usda.gov/about-usda/news/press-releases/2025/12/10/usda-launches-new-regenerative-pilot-program-lower-farmer-production-costs-and-advance-maha-agenda#:~:text=Mehmet%20Oz%20announced%20a%20%24700,America's%20food%20and%20fiber%20supply>.

1. The State of Soil and Agriculture

1.1 Sixty-Five Years of Progress, and Its Costs

Between 1961 and the present, the global population has grown from approximately 3.1 billion to 8.3 billion, a multiplier of 2.7. Over the same period, global cereal production has risen from approximately 880 million tonnes to roughly 3.0 billion tonnes, a multiplier of 3.3. Per-capita grain availability now stands at around 354 kilograms. By any reasonable accounting, this is one of the most consequential achievements of modern science, policy and farming practice. Professor Rattan Lal, in his keynote, attributed the achievement to what he called the Borlaug effect, in honour of Norman Borlaug and the system of public agricultural research, breeding and extension that the Green Revolution catalysed.

The performance was not free. It was driven by a steep increase in inputs. From 1961 to 2019, nitrogen fertiliser use rose by a factor of 9.2; phosphorus by a factor of 5; potassium by 4.8; pesticide use by 5.2; and the irrigated land area from 144 million to 350 million hectares, a multiplier of 2.4. [1] The global food system today consumes roughly two quadrillion gallons of water (2×10^{15} gallons) and around two hundred million tonnes of fertiliser per year.

It is also unequal. The world average for fertiliser application is approximately 100 kilograms per hectare. In Asia, where most of the productivity gain has been concentrated, application is around 158 kilograms. In Europe, it is 56 kilograms. In Africa, where the productivity gap remains the largest, application is below 20 kilograms. The Green Revolution has been, in this sense, a regional revolution that has not yet reached the continent that most needs it.

Headline Indicators, 1961–2025

<i>Indicator</i>	<i>1961</i>	<i>2025</i>	<i>Multiplier</i>
Global population	<i>3.1 billion</i>	<i>8.3 billion</i>	×2.7
Global cereal production	<i>0.88 billion t</i>	<i>3.0 billion t</i>	×3.3
Per-capita cereal output	<i>n / a</i>	<i>≈ 354 kg</i>	n / a
Nitrogen fertiliser use	<i>Baseline</i>	<i>Up sharply</i>	×9.2
Irrigated area	<i>144 Mha</i>	<i>350 Mha</i>	×2.4

Table 1. Selected headline indicators of agricultural performance, 1961–2025. Source: Lal, keynote address; FAO statistics.

1.2 The Hidden Bill: Land, Water, Climate and Hunger

These gains were achieved at the cost of significant environmental and social externalities. Approximately fifty percent of the world's land is now degraded, with that figure projected to reach fifty percent by 2050 if current trajectories continue. [2] The drivers are well established: water and wind erosion, salinisation, organic-matter depletion, acidification, elemental imbalance, declining soil structure and the so-called drought syndrome that follows.

Almost forty percent of the terrestrial land surface is now used for agriculture. [3] Of that, seventy-five percent (about 3.7 billion hectares) is allocated to raising animals. Seventy percent of global freshwater is used for irrigation. Agriculture and the food system together contribute thirty to thirty-five percent of global greenhouse-gas emissions. [4] Yet the system has failed to end hunger. One person in ten remains food-insecure; one in four is malnourished. Hidden hunger, the deficit of micronutrients in diets that may be calorically adequate, has in many places been aggravated by the productivity gains rather than relieved by them.

"The current food system has not provided adequate nutritious food, healthy diet and safe food. It has degraded soils, polluted water, aggravated global warming, eroded biodiversity and altered landscapes." Professor Rattan Lal, Ohio State University.

1.3 *The Soil Organic Matter Crisis*

At the heart of the diagnosis lies the depletion of soil organic matter. The agronomic optimum, in most production systems, is between two-and-a-half and three percent organic matter in the root zone. In the degraded soils of smallholder farms across the developing world, organic matter is often generally low [5] Maggie Munthali-Nkosi, in her panel contribution, reported that in many African regions soil organic matter is below one percent, far below the productivity threshold.

Soil organic matter is not a marginal indicator; it is the operating system of soil function. Professor Ray Weil, drawing on a recent National Academy of Sciences review, observed that fifty-nine percent (well over half) of life on Earth lives in the soil. Organic matter is what feeds and sustains that biology, and it is the principal substrate from which water-holding capacity, nutrient cycling, aggregate stability and the suppressive properties of healthy soils are built. Its depletion is, simultaneously, the cause of the productivity ceiling that input-based agriculture is now hitting and the largest available lever for change.



"Fifty-nine percent, well over half, of life on Earth lives in the soil. Soils are reservoirs of life and of resources we have barely begun to understand."

Professor Ray Weil, University of Maryland

2. The Paradigm Shift Required

2.1 From Input-Based to Soil-Based Agriculture

If the diagnosis of Section 1 is accepted, the implication is structural. The Green Revolution of the twentieth century was input-based: it improved varieties, supplied them with fertiliser and irrigated them at scale. The Green Revolution of the twenty-first century, Professor Lal argued, must be soil-based, ecosystem-based, knowledge-and-science-driven, and built on soil-carbon sequestration as its bedrock.

Operationally, this means a shift from maximum to optimum yield. The maximum-yield orientation produces the input intensity, environmental footprint and soil degradation we observe today. The optimum-yield orientation, by contrast, recognises that the soil itself is the productivity ceiling, and that beyond a certain threshold additional fertiliser, pesticide, irrigation and tillage become not merely unnecessary but counter-productive, leaking into the environment, suppressing biological function and accelerating degradation.

The challenge of closing the yield gap is therefore no longer only a question of increasing external inputs. Climate change, land degradation, and environmental stresses are increasingly constraining crop performance. Future productivity gains will depend on restoring the underlying functions of soil, its

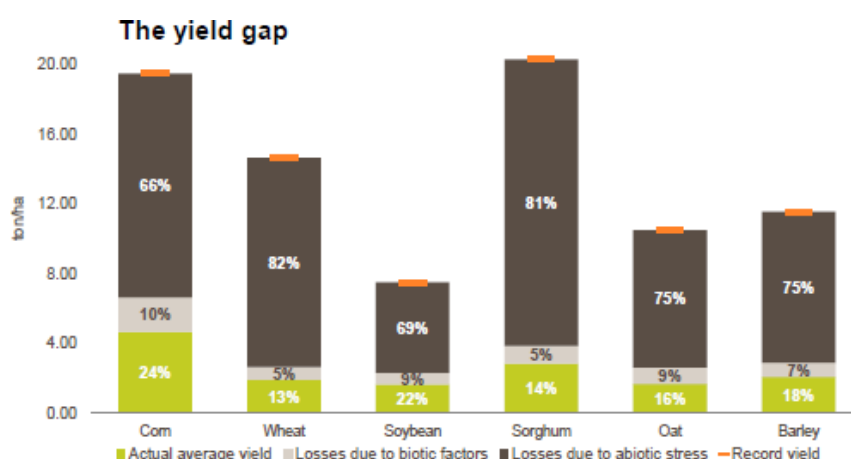


Figure 1. Traditional Farming Practices Face Increasing Limitations in Closing the Yield Gap

Source: Buchanan, Gruissem, Jones, Blohmeyer and *Molecular Biology of Plants*, American Society of Plant Physiologists, 2000. Presented by Antonis Angelakakis, Director of Biostimulants at Yara International

biological activity, water-holding capacity, nutrient cycling and resilience.

2.2 Agricultural Revolution 4.0

Building on the historical sequence (the first agricultural revolution of settlement and domestication, the second of mechanisation, the third of the Green Revolution), the keynote framed the present moment as Agricultural Revolution 4.0. It is driven by artificial intelligence and cyber-physical systems, beginning around 2010, and it carries with it a clear operating principle: produce more from less. Less chemical, less fertiliser, less water, less energy, even less land, while still producing enough food for the 8.3 billion people of today and the 10 billion of mid-century.

The technological vocabulary of Revolution 4.0 includes precision agriculture, the nexus approach, nutrition-sensitive farming, soil-less and robotic systems, plants engineered to emit molecular stress signals that can be detected remotely, and targeted intervention. But the technological surface should not obscure the substantive shift underneath, which is to make farming carbon a central agronomic and economic activity, on a par with farming food.



"Carbon can be a new crop. It is a crop just like wheat, corn, soybean or cotton, because it can also bring income." —

Professor Rattan Lal, Ohio State University

2.3 *The One Health Imperative*

Underpinning the paradigm shift is the One Health concept: the health of soil, plants, animals, people, ecosystems and the planet is one and indivisible. If the health of soil declines, the health of everything dependent on it is jeopardised. One Health is not a slogan; it is the operating logic of regenerative agriculture and a guard against the false economy of optimising one part of the system at the expense of the others.

Regenerative agriculture, in this framing, is a philosophy more than a single practice. It is inspired by eco-innovation, powered by non-carbon energy, driven by a circular economy and green infrastructure, and supported by the decarbonisation of the terrestrial biosphere. It includes, but is not reducible to, no-till plus residue cover, complex rotations, cover crops, integrated nutrient management, agroforestry, drip fertigation, biostimulants, humic amendments, biochar and enhanced rock weathering. Each of these is examined in Section 3.

3. What Works

This section examines the principal interventions identified as having the greatest potential to restore soil health while advancing climate, productivity and food-security objectives. The evidence suggests that meaningful progress will require integrated systems approaches rather than isolated technologies, with emphasis placed on practices that rebuild soil organic matter, improve ecosystem function and enhance long-term resilience.

3.1 Conservation Agriculture: No-Till, Residue Cover and Living Roots

Professor Ray Weil set out the foundations clearly. The first principle is to stop tilling, or to till as little as possible. Tillage is profoundly unnatural; in unmanaged systems soils are not mixed, and horizons differentiate precisely because they are not disturbed. The most common reason that no-till field trials underperform, he argued, is that they are run with residues removed for roofing, fodder or other uses. No-till without a residue cover is a disaster; what is required is that all plant residues not present in the harvested product are spread evenly over the soil so that it is both physically undisturbed and blanketed, as it would be on a natural forest floor.

The second principle is to keep living roots in the soil at all times. Plants are the link between solar energy and the dark biological world below ground. They channel chemical energy into the rhizosphere through both root growth and root-exudate flow, with thirty to forty percent of photosynthate typically routed to soil microbes around the roots. Roots also turn over continuously: the root system observed at the end of a growing season is only a small fraction of the roots that were produced and recycled during it. A regenerative agronomy is an agronomy that stimulates this process, not one that interrupts it.

The third principle is diversity. Most farmers cannot grow ten or twenty cash crops, but they can introduce equivalent biological diversity through cover crops chosen explicitly for soil-biology effects rather than for sale. Modern conservation-agriculture systems plant cover crops into still-maturing main crops and plant the next main crop into the living cover, terminating it with a roller-crimper or spray. In Maryland, where Professor Weil is based, this approach has been adopted at scale, partly as a result of state-level policy and payments tied to water-quality outcomes in Chesapeake Bay.



"No-till without a residue cover is a disaster. The soil should always be covered by plant residues, just as the soil under a forest is always covered by leaves."

Professor Ray Weil, University of Maryland

To these foundations, the panel added several complementary approaches. Complex rotations and the integration of perennials extend the temporal diversity of the system. Agroforestry adds a third architectural layer above the soil and produces the dense, prolific subsoil root systems that are critical for deep-profile carbon storage. Drip fertigation, where applicable, ensures that nutrients and water are absorbed by plants rather than leaking into the environment. Organic amendments, including manure and compost, are valuable for soil function but on a whole-system carbon basis are best understood

as redistributing carbon rather than adding net to the global pool, since the carbon they contain was originally accumulated by plants growing somewhere else. They are properly used as a complement to, not a substitute for, photosynthesis-led carbon capture in situ.

3.2 Carbon Farming with Humic Amendments

Among the approaches presented during the dialogue, Dr. Daman Walia, President and Chief Executive of Arctech Inc., introduced the Actosol carbon farming model as an integrated strategy for restoring soil health while advancing climate mitigation and agricultural productivity. He argued that carbon farming should not be viewed solely as a means of sequestering carbon, but as a comprehensive soil-management approach capable of generating environmental, agronomic and economic benefits simultaneously.

According to Dr. Walia, the Actosol approach is based on an organic humic amendment derived from coal that is designed to improve the biological, chemical and physical properties of soil. He explained that, biologically, the amendment stimulates root development and plant growth, thereby increasing photosynthetic carbon capture and contributing to the gradual accumulation of soil organic matter. Chemically, he reported that the material enhances cation exchange capacity and nutrient chelation, improving the uptake of applied nutrients while mobilising phosphorus that has become fixed within the soil. Physically, he stated that sustained improvements in soil organic matter enhance soil aggregation, water infiltration, moisture-holding capacity and overall soil structure, strengthening resilience under drought and salinity stress.

To illustrate these outcomes, Dr. Walia presented observations from a fifteen-year field application on a former tobacco farm in Virginia, United States, characterised by heavy red-clay soils. According to the results presented, soil organic matter reportedly increased from below one percent to between six and seven percent over the study period, accompanied by an increase in crop yields from approximately fifty to one hundred bushels per acre. He further reported that annual increases in soil organic matter corresponded to an estimated sixteen tonnes of carbon dioxide sequestered per acre, or approximately ten tonnes per acre after applying a thirty percent leakage adjustment.

Drawing on additional examples, Dr. Walia stated that field applications in several countries had reported soil carbon sequestration ranging between five and ten tonnes of CO₂ per acre annually under the Actosol approach. He also cited aggregated field results involving approximately 10,000 farmers in India, where the technology was reported to achieve average yield increases of around twenty percent together with substantial improvements in farm income. Further examples from Egypt, based on more than a decade of field implementation, were presented as demonstrating reported yield improvements of fifteen to thirty percent alongside reductions in chemical fertiliser use of between twenty and fifty percent.

Beyond agronomic performance, Dr. Walia emphasised the potential economic role of carbon farming. He argued that improving soil organic carbon could create new revenue opportunities for farmers through verified carbon-credit markets while enabling industries to meet emissions-reduction commitments and supporting governments in achieving their climate objectives under the Paris Agreement. Dr. Walia noted that approaches linking soil restoration with carbon finance represent an emerging area of innovation with significant potential to support sustainable agriculture. At the same time, they emphasised that successful implementation depends upon robust measurement, reporting and verification (MRV) systems, transparent carbon-market frameworks, supportive public policies, and independent scientific validation to ensure that environmental and economic outcomes are credible, measurable and

scalable.

Successful agricultural transformations have historically depended upon strong partnerships between governments, research institutions, the private sector and farmers. The Green Revolution, led in India under the scientific leadership of M. S. Swaminathan, demonstrated how coordinated public policy, scientific innovation, farmer demonstrations and institutional support enabled the widespread adoption of improved technologies. Dr Walia suggested that a similarly collaborative approach adapted to today's challenges of soil degradation, climate change and resource scarcity will be essential for accelerating the transition towards resilient and carbon-positive agricultural systems.



"If we increased soil organic matter on just ten percent of the world's farmland, we could reach net zero. The European Union has certified carbon farming as the number-one approach for tackling climate change."

Dr Daman Walia, Arctech Inc.

3.3 Biostimulants and Integrated Crop Nutrition

Antonis Angeletakis, Director of Biostimulants at Yara International, addressed the contribution of biological inputs. Biostimulants, he stressed, are defined by their function, not their composition: enhancing tolerance to abiotic stress (drought, temperature, salinity); improving nutrient-use efficiency through nitrogen fixation, nutrient solubilisation, uptake and availability or by improving soil health directly; and improving qualitative and quantitative yield parameters. Biostimulants can improve nutrient availability and cation-exchange capacity (chemical pillar); create an environment more conducive to microbial activity and inoculate beneficial populations (biological pillar); and promote root growth, improving soil structure and water-holding capacity (physical pillar). Yara's field trials in potato systems show improved nutrient-use efficiency for potassium and phosphorus and corresponding yield improvements; higher yields under the same input regime translate into a lower carbon footprint per tonne of production.

Mr Angeletakis identified three structural shifts. First, incentive models must reward farmers who use biostimulants to improve input efficiency, with carbon credits and government subsidies reflecting that. Second, regulatory frameworks must be harmonised globally and grounded in product function rather than composition, to build farmer confidence and enable mainstream adoption. Third, mindsets must shift: biostimulants do not compete with conventional inputs, they complement them and should be considered a structural component of an integrated crop-nutrition programme.



"Biostimulants do not compete with conventional inputs, they complement them. The future of agriculture is not about replacing one system with another, but about integrating science, biology and innovation to produce more with less."

Antonis Angeletakis, Yara International

3.4 Improved Rice Systems: Alternate Wetting and Drying

Anthony Fulford, soil scientist at the International Rice Research Institute (IRRI), addressed rice systems specifically. Producing one kilogram of rice typically requires around four thousand litres of water; where rice is exported, water is also exported. IRRI's programme combines stress-tolerant and low-emission breeding, geospatial targeting and a portfolio of management practices. The most consequential of these for the carbon and water balance is alternate wetting and drying (AWD), used in combination with direct-seeded rice. Under AWD, fields are not held under continuous flood; periodic dry-down phases reduce both water use and the methane emissions associated with anaerobic flooded conditions. IRRI's field results show greenhouse-gas emission reductions of thirty to seventy percent depending on context, alongside substantial water savings. The technical efficacy of these practices is established; the challenge, in Mr Fulford's account, is bridging the last mile, and the convergence of national soil-health policy, the Save Soil public movement and the broader Viksit Bharat 2047 development push provides a uniquely supportive moment in India for embedding rice-system reform within a wider environmental-sustainability agenda.



"The technologies and practices needed for more sustainable rice systems already exist. The challenge now is bridging the last mile, ensuring that transformative solutions reach farmers and become part of mainstream agricultural systems."

Anthony Fulford, International Rice Research Institute (IRRI)

3.5 Drylands and Climate-Stressed Realities

Dr Padmaja Karanam, environmental scientist at ICRISAT, focused on the integration of soil health with water systems, climate resilience and land-use policy in dryland contexts. Soil, she argued, is too often managed as a nutrient-delivery system. Siloed thinking (water departments focused only on irrigation, agriculture departments focused only on chemical inputs) treats soil as a separate entity, and that is the central gap. In drylands, the implementation gap is widened by a further mismatch: heavy-input technologies developed in temperate, humid zones do not transfer cleanly. Soil physics (the infiltration, structure and "sponge" function on which water retention depends) is consistently neglected in policy frameworks that focus on nutrients alone. Resource-poor dryland farmers need short-term incentives, for example through carbon farming, that reward them for building carbon, retaining water and providing ecosystem services, rather than purely for yield.



"Soil is too often managed strictly as a nutrient-delivery system. Siloed thinking treats soil as a separate entity. That is the central gap." —

Dr Padmaja Karanam, ICRISAT

3.6 The African Smallholder Lens

Maggie Munthali-Nkosi of the Mwapata Institute, a contributor to Malawi's ten-year action plan on fertiliser and soil health, addressed the disconnect between global soil-health narratives and African ground realities. More than seventy percent of food production in sub-Saharan Africa comes from smallholders cultivating less than two hectares of rainfed, resource-constrained land. Yield gains are needed immediately to survive, so carbon sequestration is at best an externality. Soil organic matter is below one percent in many regions, climate shocks undermine restoration efforts, and poor roads and storage limit access to inputs and markets. Fertiliser subsidies dominate national budgets (up to sixty percent of the agricultural budget in some countries) while regenerative practices remain underfunded; despite a decade of the Farm Input Subsidy Programme in Malawi, soil organic matter continues to decline, demonstrating that chemical inputs alone cannot restore soil health.

Equity is not an addendum to the soil-health agenda; it is a precondition for its delivery. Women produce sixty to eighty percent of food in many African countries, yet they are largely excluded from soil-health decision-making, training and inputs. Land tenure for women remains insecure, and farmers without secure tenure will not invest in five-year soil-carbon plans. Extension services are weak and are typically structured to deliver chemical fertiliser rather than lime, organic matter or biological inputs.



"In sub-Saharan Africa, soil health is the difference between subsistence and starvation. Without healthy soils there is no food security, no climate resilience and no sustainable future for African smallholder farmers."

Maggie Munthali-Nkosi, Mwapata Institute, Malawi

4. Measurement, Markets and Money

4.1 Why Direct Carbon Measurement at Farm Scale Cannot Scale

Reliable measurement, reporting and verification (MRV) systems are fundamental to the credibility of carbon farming and the development of functioning carbon markets. While internationally recognised methodologies developed by the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) provide guidance for estimating soil organic carbon and conducting soil sampling, translating these methodologies into practical, cost-effective systems for millions of farms remains a significant challenge.

As Professor Weil explained, soil-organic-carbon analysis itself is not the principal bottleneck. High-temperature combustion in accredited laboratories provides highly accurate measurements at relatively modest cost, while field-based techniques such as near-infrared reflectance spectroscopy can generate useful estimates more rapidly, albeit with lower precision. The greater challenge lies in obtaining representative soil samples.

Within a single smallholder field, soil organic matter can vary substantially between sampling locations owing to differences in topography, soil texture, management history, root distribution and biological activity. Variability also increases with sampling depth. Although the IPCC commonly recommends sampling to approximately thirty centimetres for many soil carbon assessments, significant quantities of carbon are stored below this depth, where natural variability becomes even greater. Consequently, accurately measuring changes in soil carbon across diverse agricultural landscapes requires robust sampling protocols, appropriate statistical methods and long-term monitoring.

Remote sensing can assist in certain situations, particularly where bare soils are exposed, but healthy agricultural soils are typically covered by crops or crop residues, limiting the applicability of satellite-based measurements alone. Participants therefore agreed that no single measurement technology currently provides a complete solution for farm-scale carbon accounting.

The practical implication is clear: requiring direct carbon measurements from every individual farmer would be prohibitively expensive and operationally difficult, particularly for smallholder production systems. Instead, scalable verification systems are likely to combine established scientific methodologies with practice-based verification, whereby farmers are rewarded for adopting evidence-based soil management practices whose carbon benefits have been demonstrated through research, supported by periodic field sampling, independent audits and risk-based verification.

During the discussion, Dr. Daman Walia observed that innovations capable of accelerating improvements in soil organic matter may enhance the detectability of changes in soil carbon and contribute to more efficient measurement and verification. He suggested that affordable soil-testing methods, combined with management practices that produce measurable improvements in soil health, could strengthen farmer participation in carbon markets and reduce monitoring costs over time. Participants noted, however, that regardless of the technology or management approach adopted, credible carbon markets require transparent,

scientifically robust and independently verifiable MRV systems that are widely accepted by regulators, investors and market participants.

The importance of expanding access to affordable soil-testing infrastructure, harmonising sampling pro-

ocols and strengthening laboratory capacity, particularly in developing countries. Improving the accessibility and affordability of scientifically credible soil analysis will be essential for enabling broader farmer participation in carbon markets while maintaining confidence in environmental outcomes.

4.2 Pricing Carbon, Pricing Externalities

On pricing, Professor Lal proposed a benchmark of fifty United States dollars per credit, where one credit is one tonne of carbon-dioxide equivalent. Across all 700 million farmers globally (550 million smallholders cultivating less than four hectares each, and 150 million medium and large landholders), full participation at that price would imply an annual flow of approximately one hundred billion United States dollars, comprising roughly seventy billion to smallholders and thirty billion to larger farmers. The Maryland experience, as Professor Weil noted, suggests these are realistic levels: payments of approximately that magnitude have already produced widespread adoption of cover crops in no-till systems in that state.

Beyond explicit carbon pricing, Professor Weil proposed a complementary mechanism: market-based solutions in which both the negative and positive externalities of agricultural production are reflected in the prices of agricultural products. Where the costs of fertiliser overuse, soil degradation and downstream water-quality damage are built into the supply chain, the policy objective can be advanced without the entirety of the cost falling on a public budget.

4.3 Funding Architecture and the Role of Emitters

Where would the funds come from? Professor Lal identified four primary contributors: fossil-fuel-exporting countries; the agro-industries themselves; the wider private sector; and consumers. The principle is that those who emit and those who benefit should both contribute. Building on this, Dr Walia presented a self-sustaining business model already operational in pilot form.

In that model, the government sets a policy under which emitters pay farmers to adopt verified carbon-farming practices. A typical farmer participating in the Actosol programme produces approximately ten carbon credits per acre per year. Of these, half are paid to the farmer at a market rate of around seventy United States dollars per tonne, with additional payment for the cost of the input. Farmers also benefit from yield uplift of approximately twenty percent. The result is a roughly two-to-threefold income increase for participating farmers. The emitter retains title to all ten credits, retiring half against its own emissions and trading half on the global market, netting around seventy-five dollars per tonne traded.

4.4 The Affordability Question, Reframed

Total compliance with the United Nations Paris Agreement, on the basis of current commitments aggregated across countries, has been estimated at around two hundred trillion United States dollars, an amount greater than the world's entire monetary base. Dr Walia argued that a soil-centred carbon-farming approach could deliver an equivalent climate outcome for under half a trillion dollars, an order-of-magnitude reduction in cost. Whether or not the precise numbers are accepted, the broader point stands: scaling soil organic carbon on even ten percent of the world's farmland could, on the figures presented, deliver net-zero

outcomes at a fraction of the cost of alternative pathways. [8] The European Union's certification of carbon farming as a primary climate-action approach is consistent with that conclusion.

"If we increased soil organic matter on just ten percent of the world's farmland, we could get to net zero." Dr Daman Walia

5. Policy Architecture for a Carbon-Positive Future

5.1 The “Trinity of Acts”

Professor Lal’s organising legal proposition is a “trinity of acts”: a Clean Air Act, a Clean Water Act and a Soil Health Act, instantiated in every jurisdiction. The United States has had a Clean Air Act since 1967 and a Clean Water Act since 1972, but no equivalent Soil Health Act at federal level. India’s emerging Bharat soil-protection policy is, in this account, an important first national step that could become a role model for other jurisdictions. Maryland, in the United States, has enacted a state-level Soil Health Act which, although not heavily resourced, has succeeded in elevating soil health as a policy priority.

The legal foundation matters because rights and duties shape behaviour. If soil is a living entity, then like any other living entity it requires rights: to be protected, restored, allowed to thrive and managed judiciously. Where those rights are codified, public budgets, regulatory frameworks and incentive systems align around them; where they are not, soil remains the residual category that loses to whichever sector has stronger legislation.

5.2 Aligning Subsidies with Outcomes, Not Inputs

Mr Fulford’s headline recommendation, echoed across the panel, was to align subsidies and incentives with outcomes rather than inputs. Today’s subsidy regimes in many countries actively work against soil health by paying for high or inefficient fertiliser use, locking farmers into nutrient-imbalanced systems and crowding out lime, organic matter and biological inputs. In Malawi, Ms Munthali-Nkosi reported that fertiliser subsidies dominate the national agricultural budget while regenerative practices remain underfunded; despite a decade of subsidy programmes, soil organic matter continues to decline.

A subsidy regime aligned with outcomes would reward measurable improvements in soil health and in farm-system carbon balance, while explicitly funding the diversified inputs (lime, compost, biostimulants, cover-crop seed, targeted micronutrients) that soils actually require. The European Union’s evolving Common Agricultural Policy is already moving, in places, in this direction; the African Union Fertiliser and Soil Health Action Plan offers a complementary framework adapted to African conditions. The challenge is to accelerate the transition without disrupting the food security of the populations the subsidies were designed to serve.

5.3 Harmonised, Function-Based Regulation of Biological Inputs

Mr Angeletakis identified the regulatory environment for biostimulants and biological inputs as a structural barrier to mainstreaming. Where regulation is fragmented across jurisdictions, defined inconsistently or anchored in product composition rather than function, the result is to suppress farmer confidence, restrict market entry and slow the adoption of practices that the panel agreed are essential to nutrient-use efficiency and soil regeneration. A harmonised, function-based regulatory framework, recognising biostimulants by what they do rather than by what they are made of, is therefore a public-good regulatory reform with significant carbon and food-security implications. The European Union’s Fertilising Products Regulation 2019/1009 already establishes function-based recognition of plant biostimulants and provides a precedent for other jurisdictions.

5.4 Land Tenure and the Equity Floor

Underlying both the policy and the financial architecture is a precondition that is often left implicit: secure land tenure. Farmers without secure tenure will not invest in five-year soil-carbon plans, regardless of price signals. Where tenure is structurally insecure for women, the largest cohort of food producers in many African countries, the entire soil-health agenda is built on a foundation that cannot bear its weight. Tenure reform, particularly for women, therefore belongs in the same operational sequence as subsidy reform and carbon-market design, not as a separate or downstream issue.

5.5 The African Imperative

The African continent occupies a particular place in the global soil-health agenda, both because of the scale of soil degradation and the size of the smallholder population, and because the policy moment is unusually open. Malawi has launched a ten-year action plan on fertiliser and soil health; the African Union, at the 2024 Africa Fertiliser and Soil Health Summit in Nairobi, formally adopted the Nairobi Declaration and a continental ten-year Action Plan on fertiliser and soil health. [10] The opportunity for the Global Soil Health Coalition to support these instruments through localised research, technology transfer, capacity building and dedicated finance is direct and immediate.

6. What Must Happen by 2030: Recommendations

1. Align subsidies and incentives with outcomes, not inputs : National agricultural budgets must signal that the public is paying for measurable soil-health and farm-system carbon outcomes, not for tonnes of fertiliser sold. Aligning subsidy design with the underlying objective is the single highest-leverage policy reform available in most jurisdictions, and it should be initiated in every country before 2027 with full implementation by 2030.

2. Legislate the trinity of acts : Every jurisdiction should adopt or upgrade a Clean Air Act, a Clean Water Act and a Soil Health Act, with the Soil Health Act explicitly recognising the rights of soil to be protected, restored and managed judiciously. India's Bharat soil-protection policy, the African Union Fertiliser and Soil Health Action Plan, Maryland's state-level Soil Health Act and Malawi's ten-year action plan offer working precedents.

3. Scale unified, science-based carbon-farming approaches with self-sustaining business models Carbon farming must move from pilots to the dominant operational paradigm of land management. Unified approaches that combine no-till and residue cover, complex rotations, biostimulants and (where appropriate) humic and other amendments, supported by self-sustaining business models that deliver direct income to farmers, should be the default offer to farmers by 2030.

4. Harmonise function-based regulation of biostimulants and biological inputs : Regulatory frameworks for biostimulants and biological inputs must be harmonised globally and grounded in product function. A function-based framework would unlock farmer confidence, accelerate adoption and align the regulatory landscape with the integrated crop-nutrition logic that the science now supports.

5. Price both negative and positive externalities into agricultural markets : Market-based solutions, in which the costs of fertiliser overuse, soil degradation and pollution are reflected in product prices and the benefits of soil-carbon sequestration and ecosystem services are paid for, can deliver policy outcomes without enormous public budgets. The instruments include differentiated taxation, supply-chain accountability frameworks and outcome-based payment schemes.

6. Embed soil health at the heart of every African agricultural strategy : Soil health must move from being an aftermath of agricultural strategy to being its foundation. Without healthy soils there is no food security, no climate resilience and no sustainable future for African smallholder farmers. Soil-health objectives must be hard-wired into agricultural and climate strategies, public investment portfolios and donor frameworks across the African continent.

7. Establish national soil-health task forces in every country : National soil-health task forces, co-led by government, smallholder-farmer organisations and scientists, should be operational in every country by 2027. Their mandate is to develop and implement context-specific soil-health action plans aligned with global goals, including locally calibrated payment, MRV and extension architectures.

8. Resource the Global Soil Health Coalition as the convening platform : The coordination problem is real, and at present it does not have an institutional home. Resourcing the Global Soil Health Coalition to operate as a neutral, science-led convening platform, aligning narrative, agenda, science, policy and farmer voices with global finance, is the institutional act that brings the other seven into a coherent system.

7. The Global Soil Health Coalition

The Global Soil Health Coalition (GSHC) is the World Agriculture Forum's Neutral convening platform for soil Health. Its Aim is to elevate Soil as a "Global Asset" and its purpose is to not to add another voice, but to connect the ones that already exist; to close the gap between global ambition and on-ground reality; aligning knowledge, investment, practice and farmer voices with the global finance landscape while also protecting soil systems for future generations.

7.1 Why a Coalition, and Why Now

Across the Dialogue, contributors converged on a single structural diagnosis: most existing initiatives do excellent work within their own domains, whether science, policy, implementation or advocacy, but no neutral platform exists to connect them with the global policy and finance landscape in a unified way. That coordination gap, rather than the scientific or technological gap, is now the binding constraint on progress at scale.

The GSHC is designed to close that gap. It is not an additional research initiative, an additional advocacy organisation or an additional carbon-market intermediary; it is the platform on which those constituencies can meet, align and act.

7.2 The GSHC's Three Functions

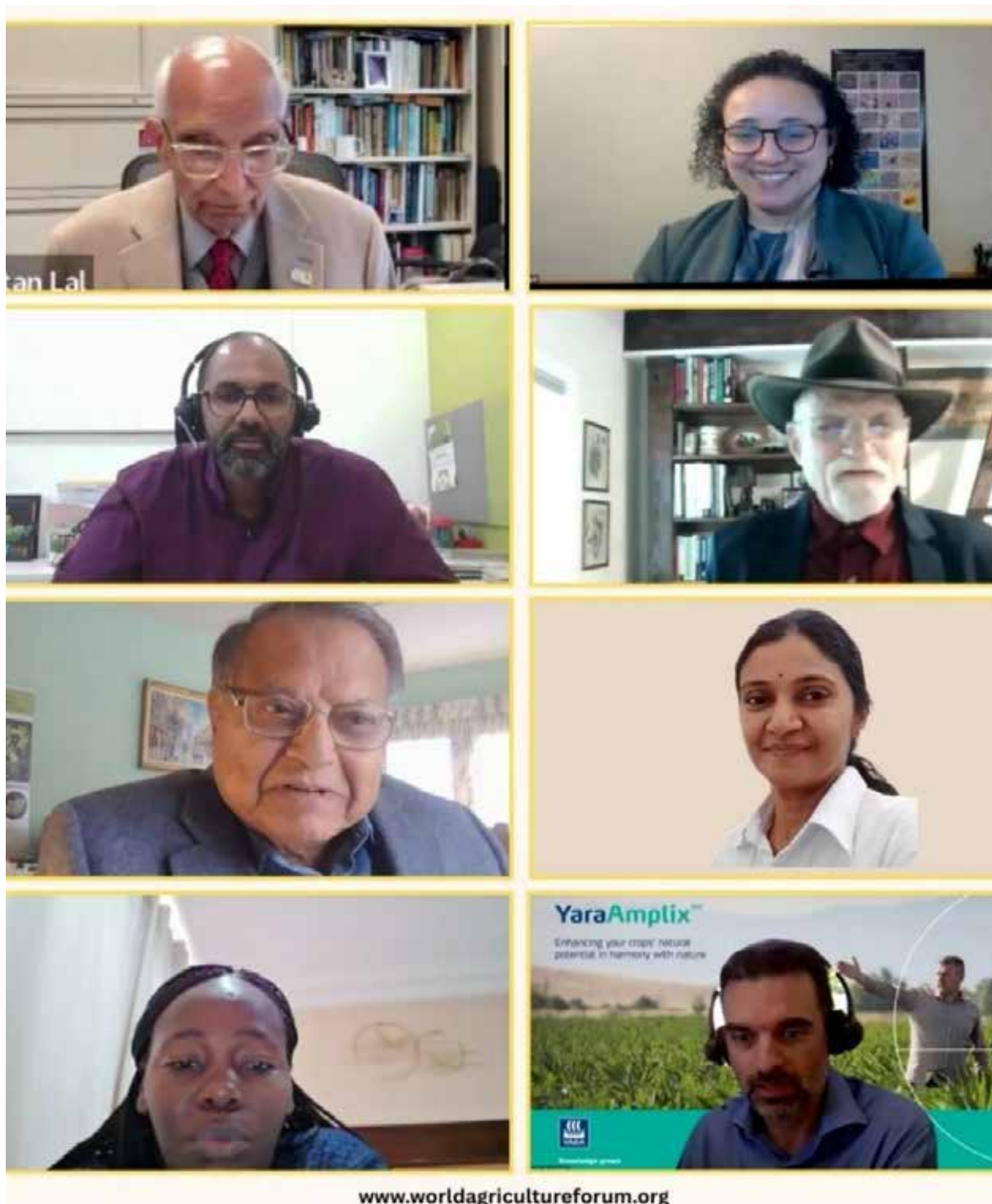
First, the GSHC is a neutral global platform that positions soil health as a global asset, with the convening role to bring science, finance and policy stakeholders into the same room and around a shared agenda. Second, it is a high-level coalition of champions focused on narrative and agenda setting, working to ensure that soil health appears, accurately and prominently, in the highest-level deliberations on food, climate and finance. Third, it is an elevation platform that lifts existing initiatives, ensuring that science, policy and farmer voices are aligned and that effort is not duplicated.

7.3 How to Engage

The Coalition welcomes engagement from governments, multilateral institutions, agro-industry, financial institutions, donor agencies, scientific bodies, farmer organisations and civil-society partners. Specific entry points include: contributions to thematic working groups; co-authorship of country and regional soil-health strategies; co-investment in priority interventions; participation in the Coalition's annual convening cycle; and bilateral engagement with the Coalition Secretariat for tailored partnerships.

Inquiries and expressions of interest may be directed to the World Agriculture Forum Secretariat. Contact details are provided in Annex E.

Annex A. Speaker Profiles



1. **Dr Carla Portugal (Moderator)** : Director of Science at the Soil Food Web Foundation. Dr Portugal continues the legacy of Dr Elaine Ingham in extending soil-food-web science as the basis for regenerative agriculture, soil-health monitoring and food sovereignty.
2. **Professor Rattan Lal** Distinguished University Professor of Soil Science at Ohio State University. A globally recognised authority on soil carbon and food security, Professor Lal delivered the keynote address by recorded contribution. He is a long-standing advocate for soil-centric approaches to climate, food and water security.
3. **Anthony Fulford** : Soil scientist with the International Rice Research Institute (IRRI), based in Varanasi, India. Mr Fulford works on improved rice systems, including alternate wetting and drying and direct-seeded rice, and contributes to early-stage policy formulation on the Bharat Healthy Soils initiative with the Government of India.
4. **Professor Ray Weil** : Professor of Soil Science in the Department of Environmental Science and Technology at the University of Maryland. A leading scholar of conservation agriculture, soil-organic-carbon dynamics and enhanced rock weathering, Professor Weil has been a central figure in Maryland's state-level work on cover crops, no-till and the Chesapeake Bay water-quality programme.
5. **Dr Daman Walia** : President and Chief Executive of Arctech Inc., based in Virginia, United States. Dr Walia developed Actosol, a humic-acid based soil-restoration product, and has spent more than five decades working on agricultural scaling across the United States, India, Africa, China, Egypt, Saudi Arabia and other regions.
6. **Antonis Angeletakis** : Director of Biostimulants at Yara International. Mr Angeletakis leads Yara's biostimulants strategy and contributes to industry-wide work on harmonised, function-based regulatory frameworks and on the integration of biological inputs into integrated crop-nutrition programmes.
7. **Dr Padmaja Karanam** : Environmental scientist at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Dr Karanam works at the intersection of soil health, water systems, climate resilience and dryland land-use policy.
8. **Maggie Munthali-Nkosi** : Research Fellow at the Mwapata Institute, an independent Malawian agricultural-policy think tank. Ms Munthali-Nkosi was part of the task force that developed Malawi's ten-year action plan on fertiliser and soil health, launched in Nairobi.

Annex B. Key Figures from the Dialogue

Indicator	Value
Global population, 1961 → 2025	3.1 billion → 8.3 billion (× 2.7)
Global cereal production, 1961 → 2025	0.88 billion t → 3.0 billion t (× 3.3)
Per-capita cereal output, 2025	≈ 354 kg
Nitrogen fertiliser use, 1961 → 2019	× 9.2
Irrigated land, 1961 → 2019	144 Mha → 350 Mha
Land degraded globally	≈ 40 percent today; up to 50 percent by 2050
Food-system share of global GHG emissions	30 – 35 percent
Optimum soil organic matter (root zone)	2.5 – 3 percent
Soil organic matter, depleted soils	Often < 0.5 percent; as low as 0.1 percent
Conservation agriculture sequestration potential	≈ 2.5 Pg organic C per year on global cropland
Total soil + biomass potential to 2100	≈ 333 Pg; equivalent to ≈ 157 ppm CO ₂ drawdown
Proposed payment per credit	US\$ 50 per tonne CO ₂ equivalent
Implied annual financing requirement	≈ US\$ 100 billion per year
Actosol carbon farming sequestration (typical)	5 – 10 t CO ₂ per acre per year
AWD rice GHG emissions reduction	≈ 30 – 70 percent
Water for one kilogram of rice	≈ 4 000 litres
Smallholder share of food production, sub-Saharan Africa	> 70 percent
Women's share of food production, many African countries	60 – 80 percent
Extension officer-to-farmer ratio, Malawi	≈ 1 : 2 000

Table 3. Key figures cited during the WAF Earth Day Dialogue 2026.

Annex C. Glossary

1. Agricultural Revolution 4.0. Professor Rattan Lal's framing of the present moment in agriculture as a fourth revolution defined by digital, AI-enabled and cyber-physical technologies, with an operating principle of producing more from less.
2. Alternate Wetting and Drying (AWD). An irrigation-management practice in rice systems in which fields are not held under continuous flood; periodic dry-down phases reduce both water consumption and methane emissions.
3. Bharat Healthy Soils Initiative. A national soil-protection policy under development in India, intended to position soil health as a national priority and to legislate its protection.
4. Biostimulant. A product defined by its function (enhancing tolerance to abiotic stress, improving nutrient-use efficiency, improving yield parameters) rather than by its chemical composition.
5. Carbon-Positive Agriculture. Agricultural systems whose net carbon balance across the production cycle is negative: more carbon is removed from the atmosphere than the system emits.
6. Conservation Agriculture. A systems-based approach combining minimum soil disturbance (no-till), permanent soil cover (residues and cover crops) and species diversification through complex rotations.
7. Drip Fertigation. Application of water and nutrients through drip irrigation systems, designed to maximise plant uptake and minimise environmental loss.
8. Enhanced Rock Weathering. Accelerated weathering of finely ground silicate rocks (such as basalt and olivine) applied to soils, where they react with carbonic acid to form bicarbonates that are eventually stored permanently in the ocean.
9. Global Soil Health Coalition (GSHC). The World Agriculture Forum's neutral platform for aligning science, policy and farmer voices with the global finance landscape on soil health.
10. MRV (Measurement, Reporting and Verification). The standard set of practices by which carbon-market and similar payment systems verify the outcomes for which payments are made.
11. NPK. Nitrogen-phosphorus-potassium fertiliser; the conventional macro-nutrient combination used in industrial agriculture.
12. One Health. The concept that the health of soil, plants, animals, people, ecosystems and the planet is one and indivisible.
13. Soil Organic Matter (SOM) / Soil Organic Carbon (SOC). The carbon-rich organic component of soil derived from plant and microbial residues; the substrate of soil biological function and the principal pool of soil-based carbon storage.
14. Trinity of Acts. Professor Rattan Lal's organising legislative proposition: a Clean Air Act, a Clean Water Act and a Soil Health Act, instantiated in every jurisdiction.
15. Viksit Bharat 2047. The Government of India's framework for the country's development trajectory toward becoming a developed nation by 2047, into which environmental sustainability and soil health feed directly.

Annex D. References

Citations in the body of this report link to the entries below. Each entry includes a hyperlink to the original source. The references reflect the principal authoritative sources for the data, frameworks and policy instruments cited; they do not constitute a complete bibliography of the field.

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Annex E. Acknowledgements and Contact

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Contact

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