

EWAP Uganda Stakeholder Workshop

Presentation Compendium

EW

NARO-NaCRRRI x Enhanced Weathering Africa Partnership (EWAP)

Namulonge, Uganda | 5 August 2026

Compiled workshop presentations and supporting slides

Prepared for circulation as a single workshop compendium.

www.ewap-project.org

- Hyperlinked table of contents
- All presentation decks presented during the EWAP Uganda workshop

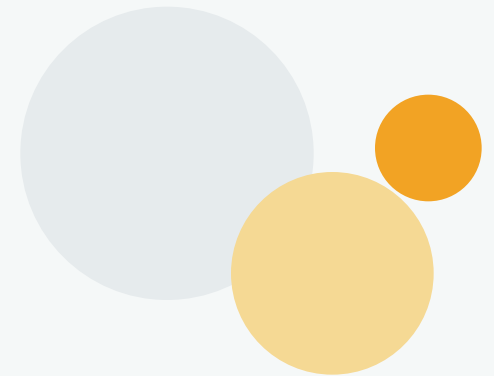


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Scientific foundations of enhanced rock weathering in agriculture

Binoy Sarkar & Birhanu Ayanssa

Future Industries Institute, Adelaide University

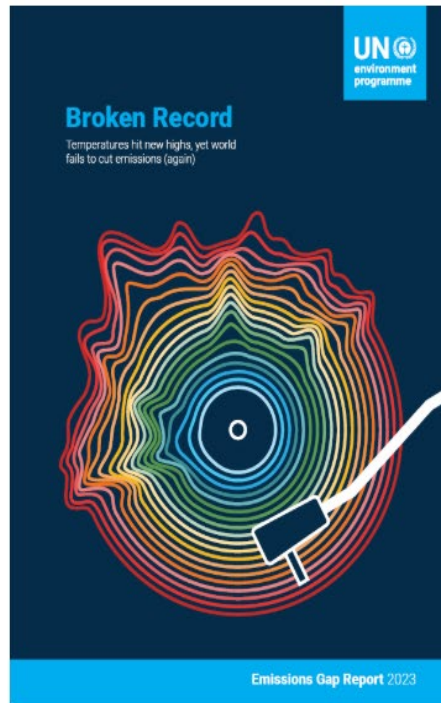
05 August 2026

E-mail: binoy.sarkar@adelaide.edu.au

20 NOVEMBER 2023 | REPORT

Emissions Gap Report 2023

Authors: UNEP



As greenhouse gas emissions hit new highs, temperature records tumble and climate impacts intensify, the *Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again)* finds that the world is heading for a temperature rise far above the Paris Agreement goals unless countries deliver more than they have promised. The report is the 14th edition in a series that brings together many of the world's top climate scientists to look at future trends in greenhouse gas emissions and provide potential solutions to the challenge of global warming.

FULL REPORT

- Agriculture accounts for nearly one-third of CO₂ and half of N₂O and CH₄ emissions globally.
- Vast majority of global agricultural soils are affected by degradations such as acidification, desilication, etc.
- Increasing productivity and transition to net zero – a dual challenge.

Ways to mitigate greenhouse gases

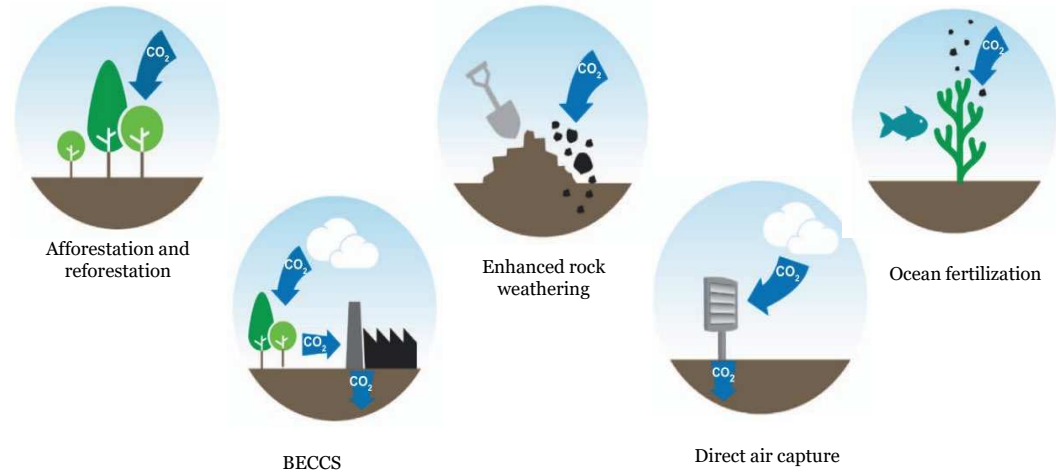
Reduce greenhouse gas emissions

- Shift to clean and renewable energy sources.
- Promote electric vehicles, public transport, biking, walking, etc.



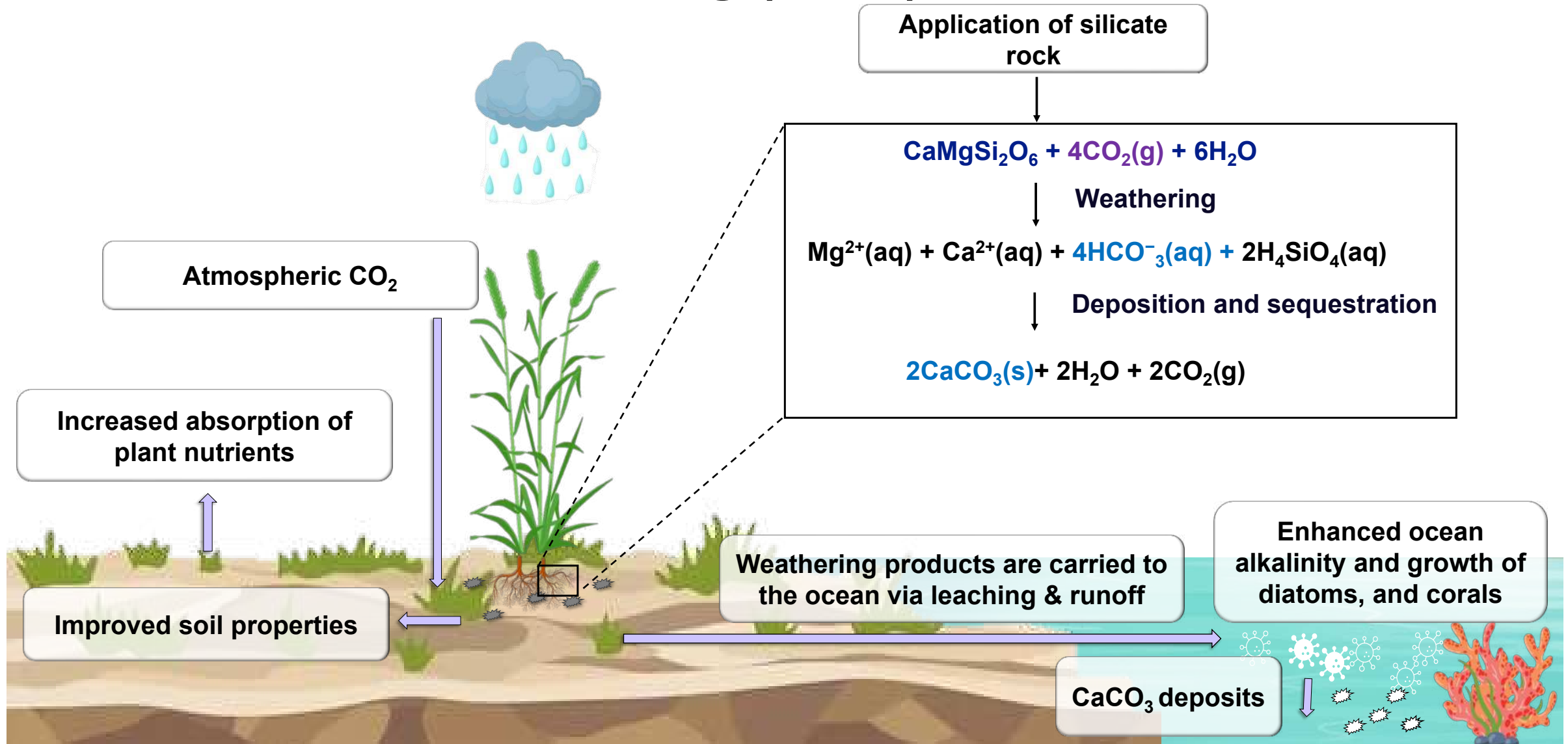
Negative emission technologies

- Negative emission technologies **remove CO₂** from the atmosphere.



IPCC, 2018

Enhanced rock weathering (ERW)



Carbon mitigation pathways via ERW

Inorganic carbon capture occurs when CO_2 reacts with rock, forming stable carbonate compounds that lock carbon away for long-term storage.



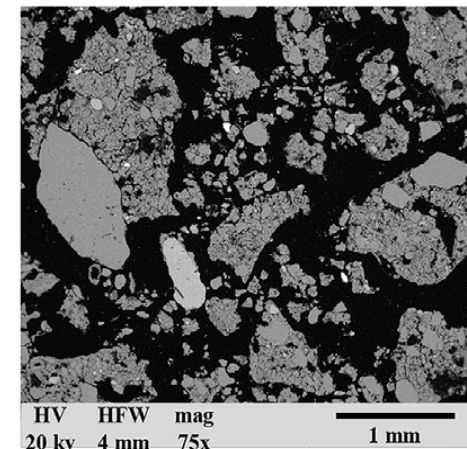
↓ Weathering



↓ Deposition and sequestration

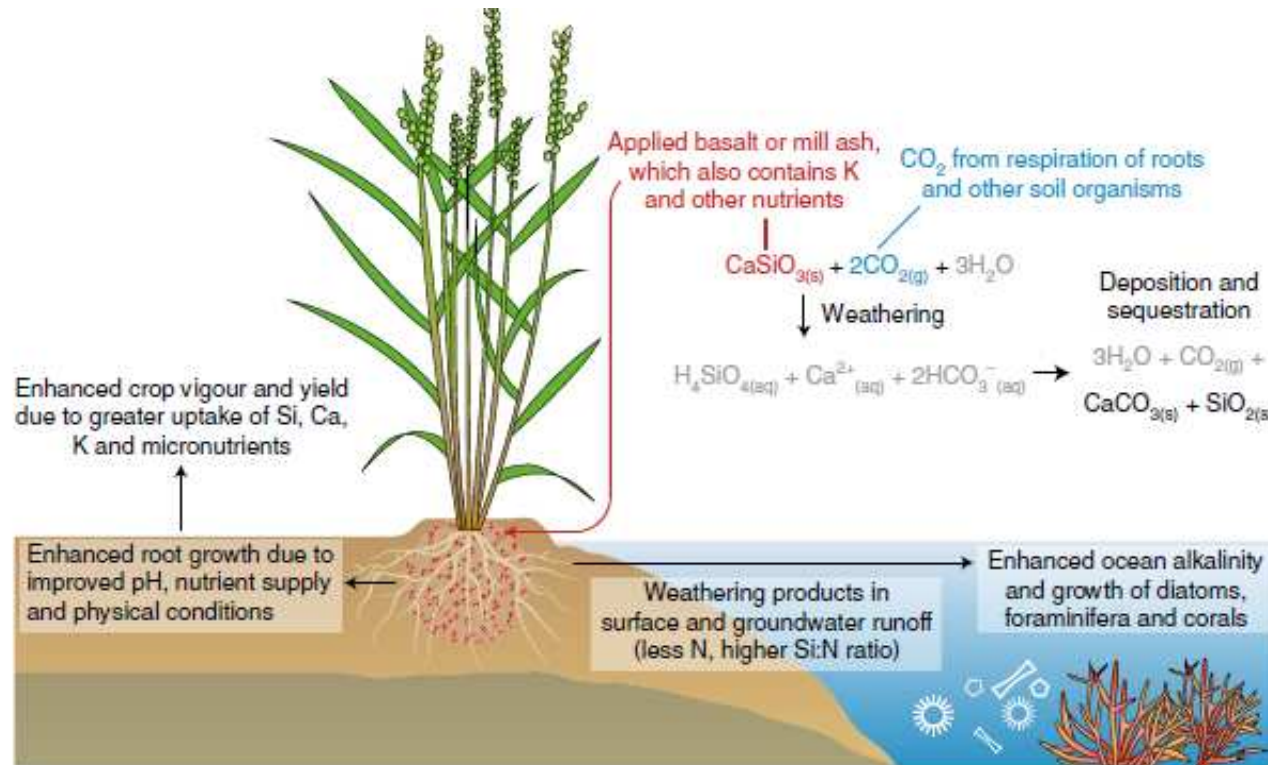


Organic carbon capture involves stabilisation of soil organic carbon, where secondary minerals formed by rock weathering protect and retain organic carbon in soil, reducing its release into the atmosphere.



Beerling....Sarkar et al. (2020) *Nature*. 583: 242–248.
Singh, Sarkar, et al., 2018; *Adv. Agron.* 148: 33-84.

Benefits of enhanced rock weathering

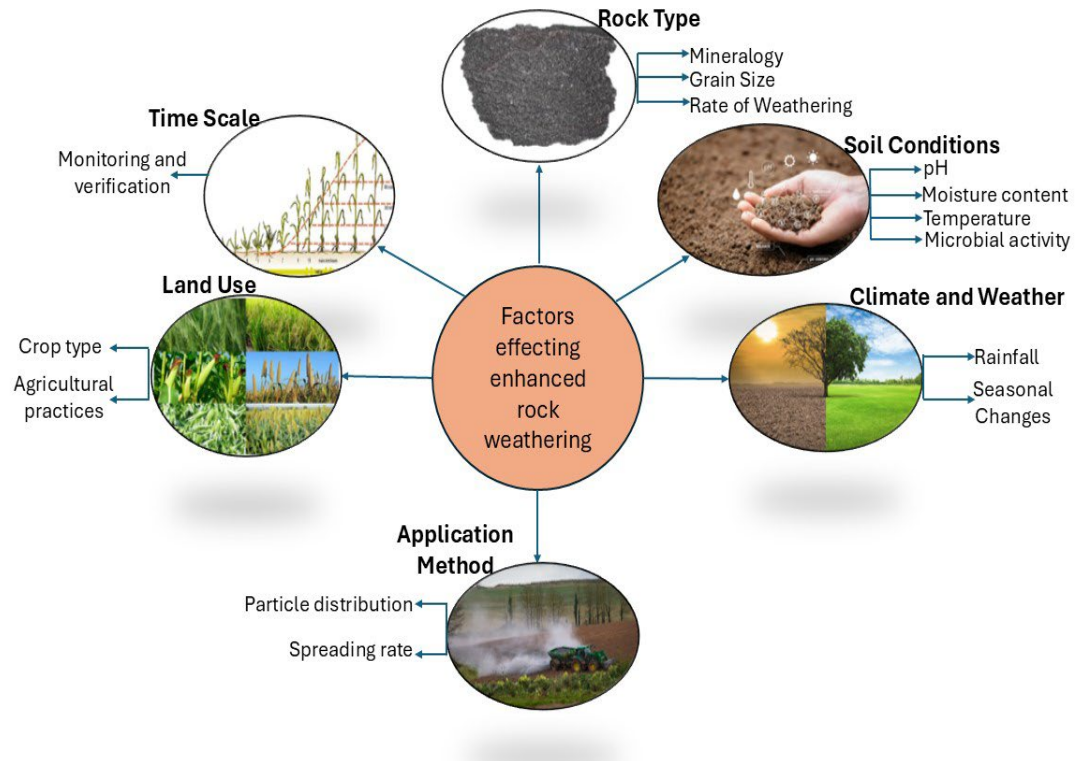


- Carbon dioxide removal
- Soil carbon sequestration
- Nitrous oxide mitigation
- Soil acidity amelioration
- Increased water retention
- Soil remineralization
- Improved soil health
- Reduced insect-pest attack
- Increased crop yield

Beerling, ...Sarkar et al. (2018) *Nature Plants*. 4, 138-147.

Factors affecting enhanced rock weathering

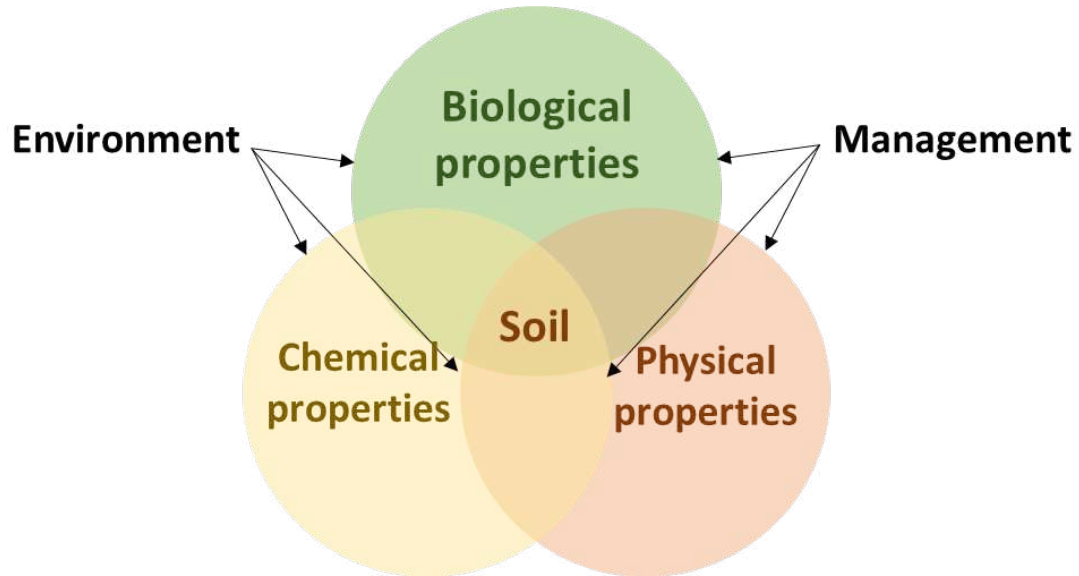
Annual CO₂ capture potential ≈0.5 – 2 Gt



- Suitable rock material
- Reasonable application rate
- Favourable particle sizes of rock
- Mildly acidic soils
- Adequate water flushing
- Measured near soil surface

Beerling, ...Sarkar et al. (2018) *Nature Plants*. 4, 138-147.

Soil conditions and Carbon Dioxide Removal (CDR)



Soil pH:

Low pH: rock weathers but limited CDR
High pH: precipitation of bicarbonates

$p\text{CO}_2$: Concentration and supply

- Organic amendments: compost and biochar
- Root abundance and activity

Dietzen & Rosing, 2023; Holden et al., 2024

Future outlook

- Monitoring, Reporting and Verification
- Mechanisms to claim national carbon credits
- Testing under different soils, crops, land uses, climates
- Rock preparation and application methods – machineries
- Food safety considerations
- Improved product development



Acknowledgements



Australian Government
**Department of Agriculture,
Fisheries and Forestry**



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Enhanced weathering research in Australia and the potential for ERW in Ethiopia

Birhanu Iticha Ayanssa (PhD), Adelaide University

Sofonyas Dargie Tefera (PhD Candidate), James Cook University

Binoy Sarkar (PhD), Adelaide University

August 2026

Brief Bio

- Mr. Sofonyas Tefera is a PhD student in Soil Science at James Cook University.
- His research examines how soil conditions and management influence Carbon Dioxide Removal (CDR) through Enhanced Rock Weathering (ERW), with a particular focus on soil pH, $p\text{CO}_2$, and the effects of different nitrogen fertiliser forms.

- Dr. Birhanu Ayanssa works as a Research Associate in Binoy Sarkar's research group at Adelaide University.
- His research focuses on enhanced rock weathering (ERW) as a novel strategy for removing carbon dioxide, increasing carbon sequestration, improving soil health, and advancing climate-smart agriculture.
- He also explored the interaction effects of inorganic and organic carbon using state-of-the-art stable carbon isotope tracing

- Dr. Binoy Sarkar is a Senior Research Fellow and project lead at Adelaide University.
- He currently oversees three significant ERW projects funded by the Department of Agriculture, Fisheries and Forestry, Cascade Climate, and Local Government in South Australia.
- Dr Sarkar collaborates with national and international institutions, including James Cook University, Carbonaught, and the Leverhulme Centre for Climate Change Mitigation -which pioneer in ERW research.

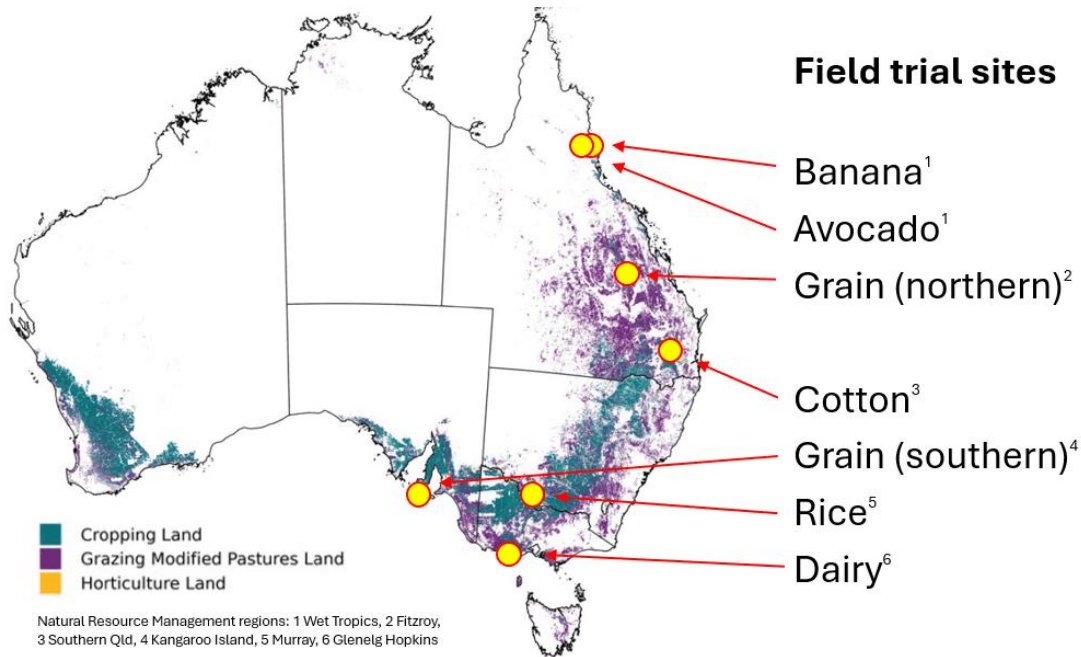
Why does ERW emerge as an alternative CDR?

It has great potential in terms of:

- ★ **Scalability:** uses existing agricultural land — no new land conversion needed
- ★ **Durability:** carbon stored as stable bicarbonate/carbonate —long-duration removal pathway
- ★ **Feedstock availability:** basalt is abundant and often a low-cost by-product of quarrying operations
- ★ **Dual pathway:** captures carbon both as exported alkalinity and as secondary carbonate minerals in soil
- ★ **Co-benefits:** improves soil pH, supplies plant-available nutrients (Ca, Mg, K, Si), and stabilises SOC

Enhanced rock weathering research in Australia

- Australia hosts one of the largest ERW projects globally



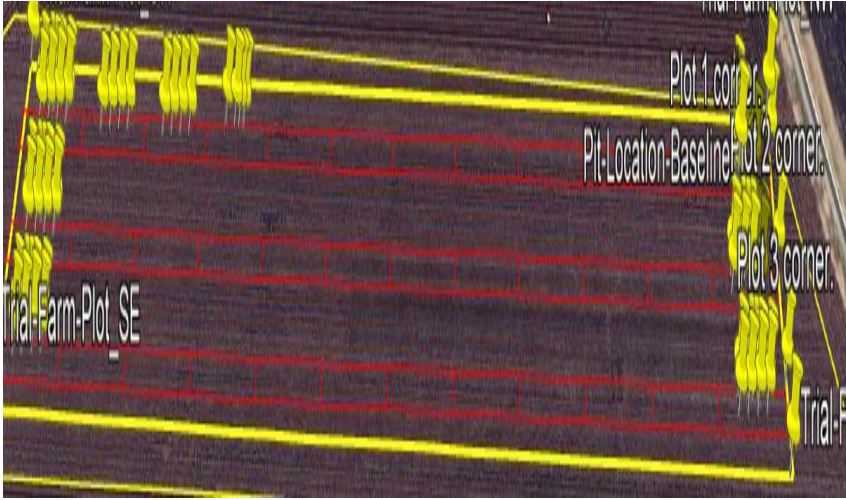
DAFF project

Rejuvenating agricultural soils to enhance productivity, resilience and carbon sequestration using enhanced rock weathering

- This project supports seven large field trials across Australia, covering various soil types, climates, and farming systems.
- The trials aim to evaluate the potential of crushed basalt applications to enhance atmospheric carbon dioxide removal, improve soil health, and increase crop productivity.

Cotton trial in Queensland

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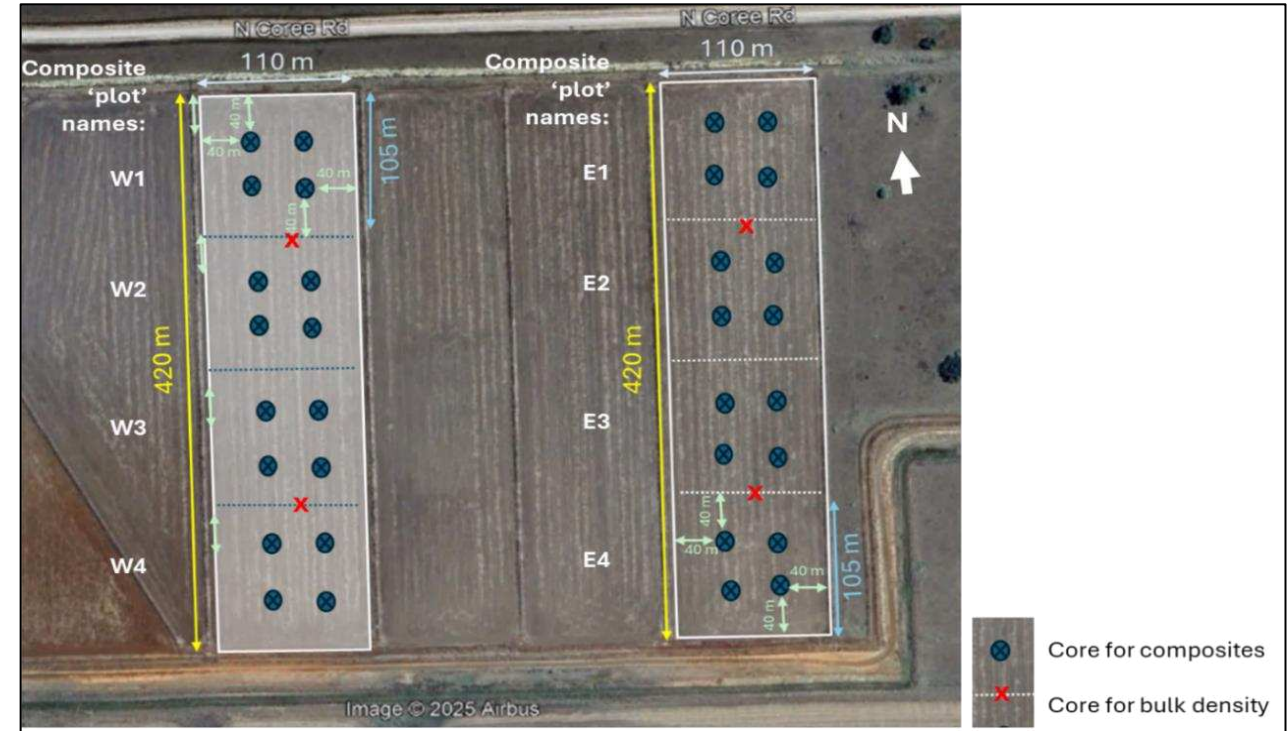
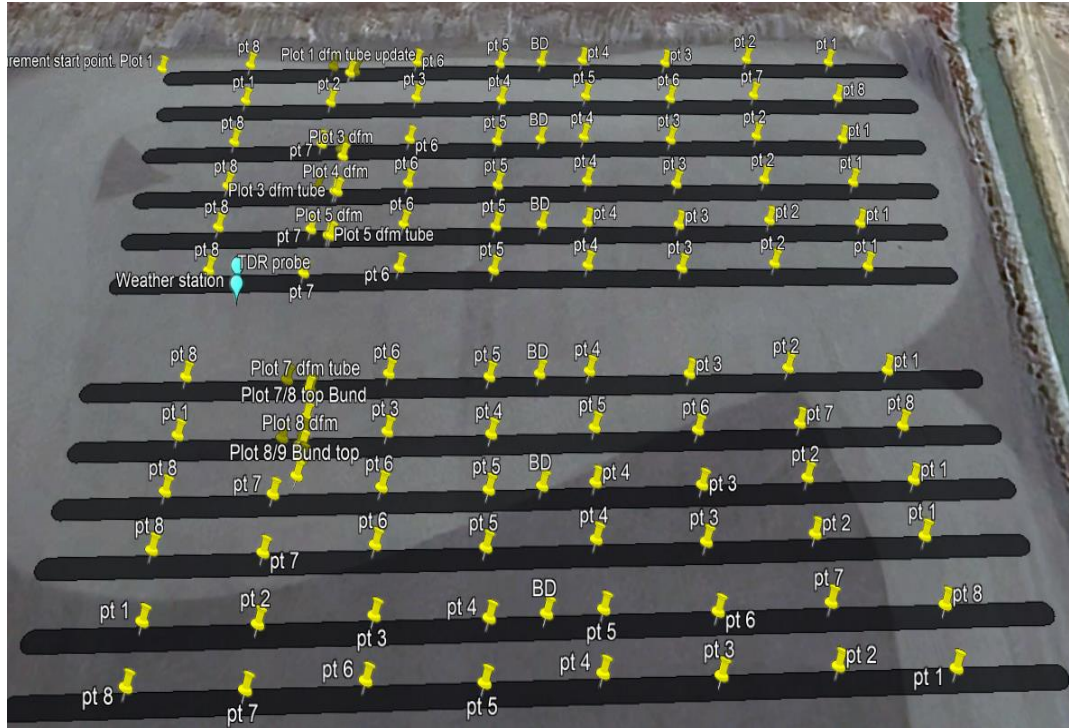
Queensland: Cotton



- The experiment comprises different application rates of crushed basalt combined with either organic fertilisers (cow manure or biosolid biochar) or chemical fertilisers.
- The experiment consisted of 36 plots, each 3 m x 70 m
- Covers a total experimental area of 840 m x 108 m (9.072 ha).

Irrigated rice trial in NSW

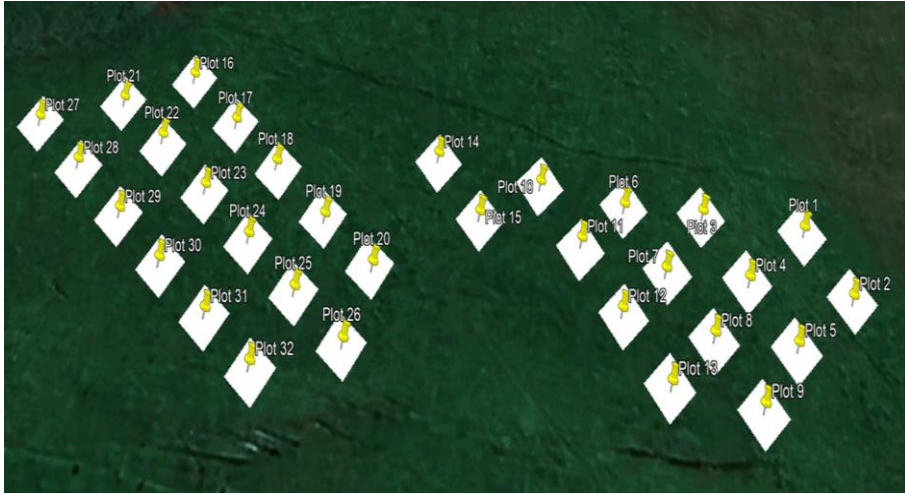
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- Two types of trials were established: a replicated plot trial and a large demonstration plot.
- The replicated trial consists of different rates of basalt application (0, 20, and 40 t/ha) arranged in a randomised complete block design (RCBD) with four replications.

Dairy Farm Trial in Victoria

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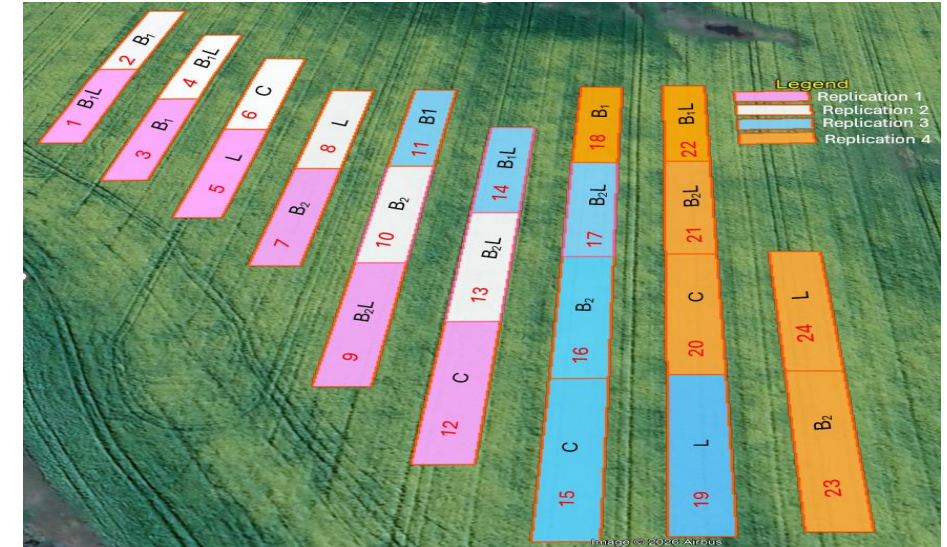
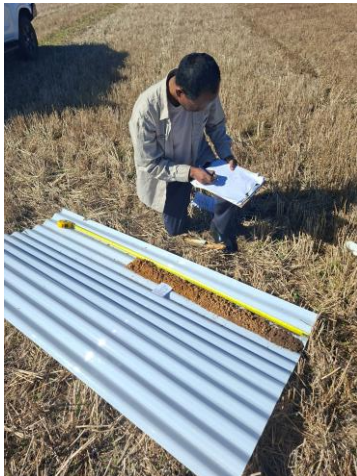
Victoria: Pastureland



- The experiment explores the combined effects of basalt and potassium (K) fertiliser on pasture biomass, soil quality, and CO₂ capture in an irrigated temperate dairy system.
- The trial was established using a randomised complete block design (RCBD) with five replications.

Grain trial on Kangaroo Island in SA

- The trial consisted of three basalt rates (0, 20, 40 t/ha) and two lime rates (0, 2.5 t/ha) across 24 plots (12 m × 62 m) with four replications.

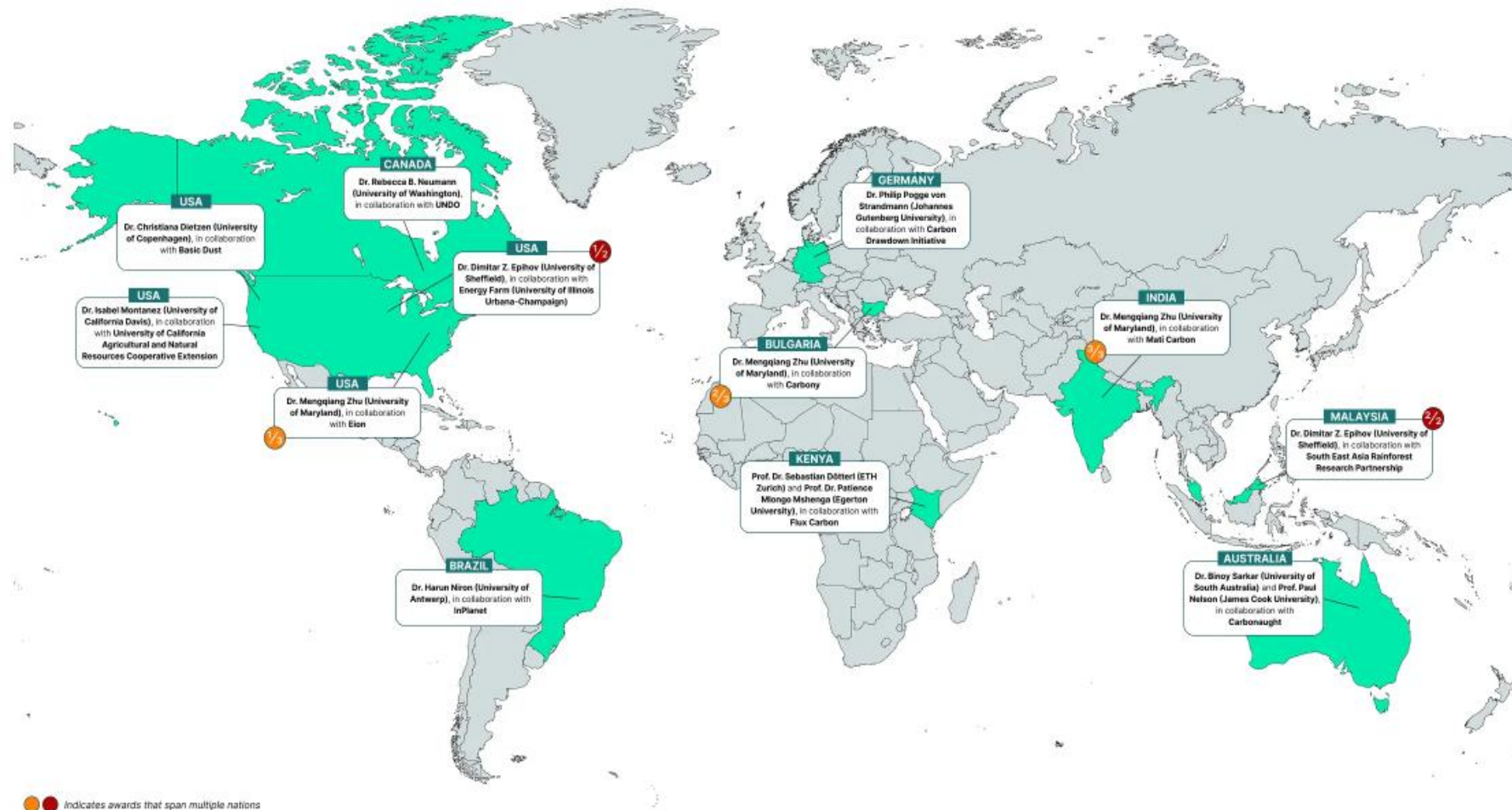


South Australia: Broad bean



Cascade Climate project

Resolving organic carbon storage pathways of enhanced rock weathering in high value orchards



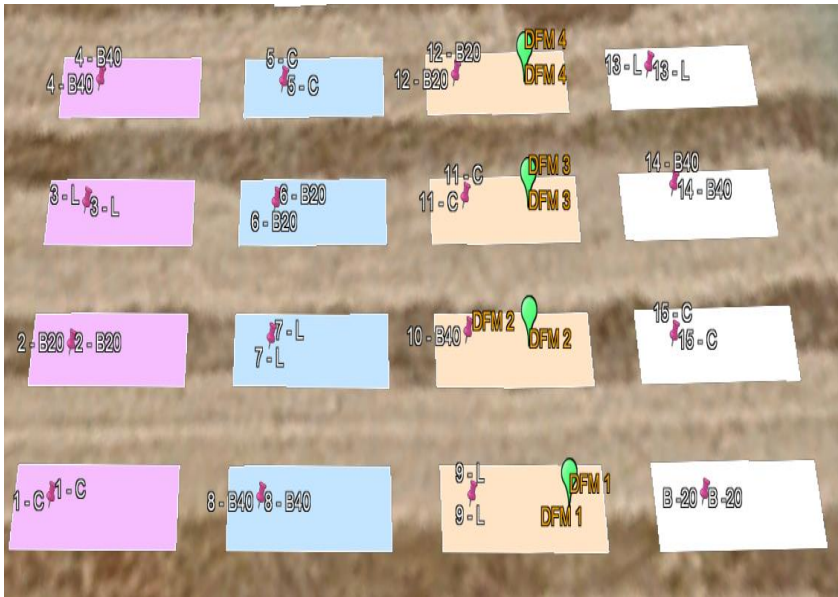
Cascade Climate project details



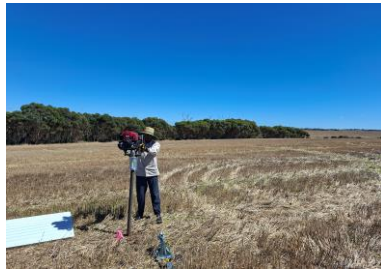
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Landscape SA project

Harnessing benefits of crushed basalt application in climate-smart management of acidic sandy soils in the Limestone Coast



Limestone Coast trial



Sofonyas PhD research project:

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The project examines how soil conditions and management influence Carbon Dioxide Removal (CDR) through Enhanced Rock Weathering



Photo credit: Mike Gailer



Photo credit: Mike Gailer

Sugarcane trial in Queensland

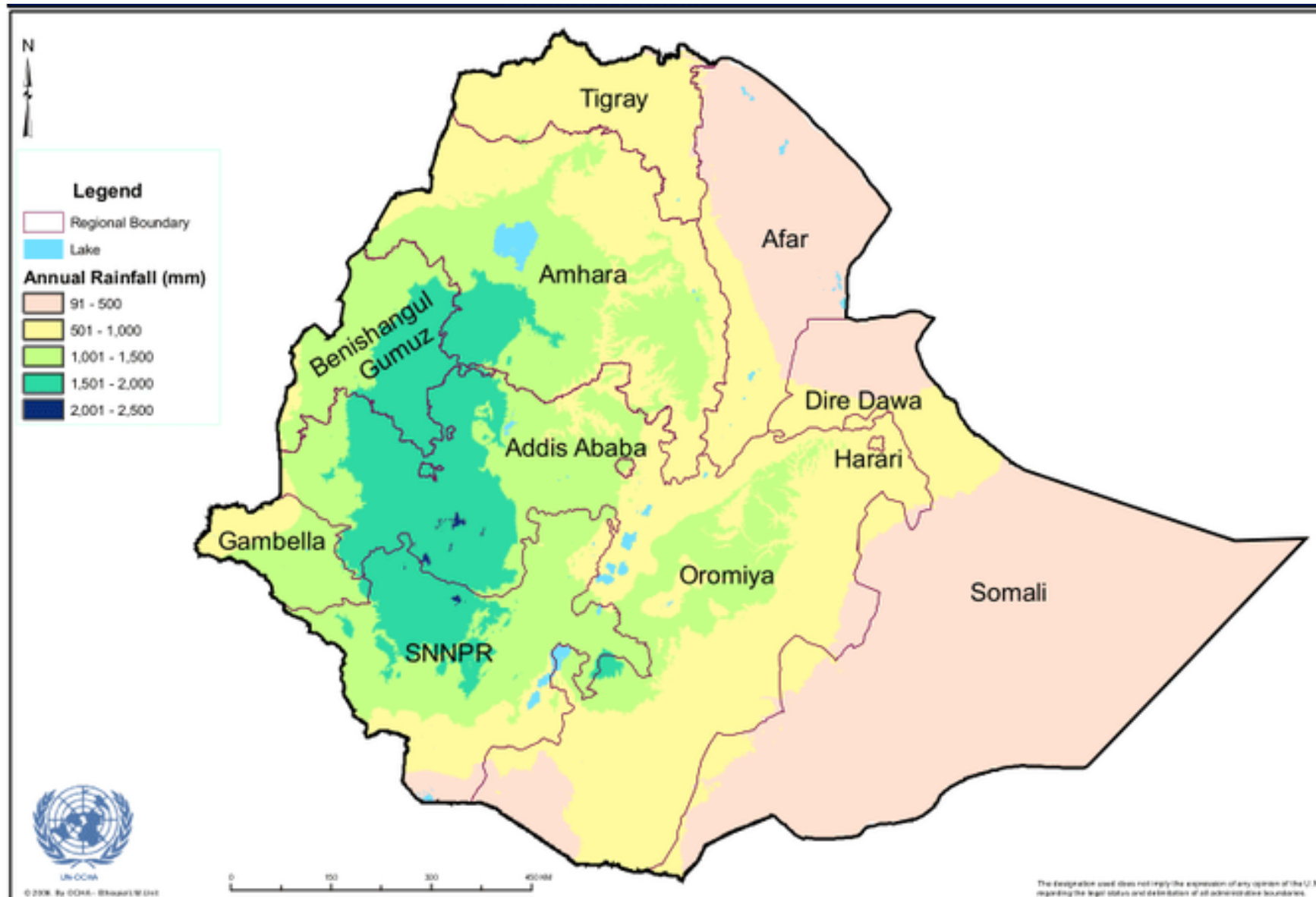
Trial monitoring

- We annually collect soil samples (time 0, 1, 2, 3 years) for analysis
- Regularly collect drainage water samples using drainage flux meters and analyse for alkalinity export, DIC/DOC, cations, anions, etc.
- At some of the sites (especially where runoff is high), we also collect surface runoff for analysis
- Installed soil moisture probes at different depths to record soil moisture
- Installed a meteorological station for each site

Part 2

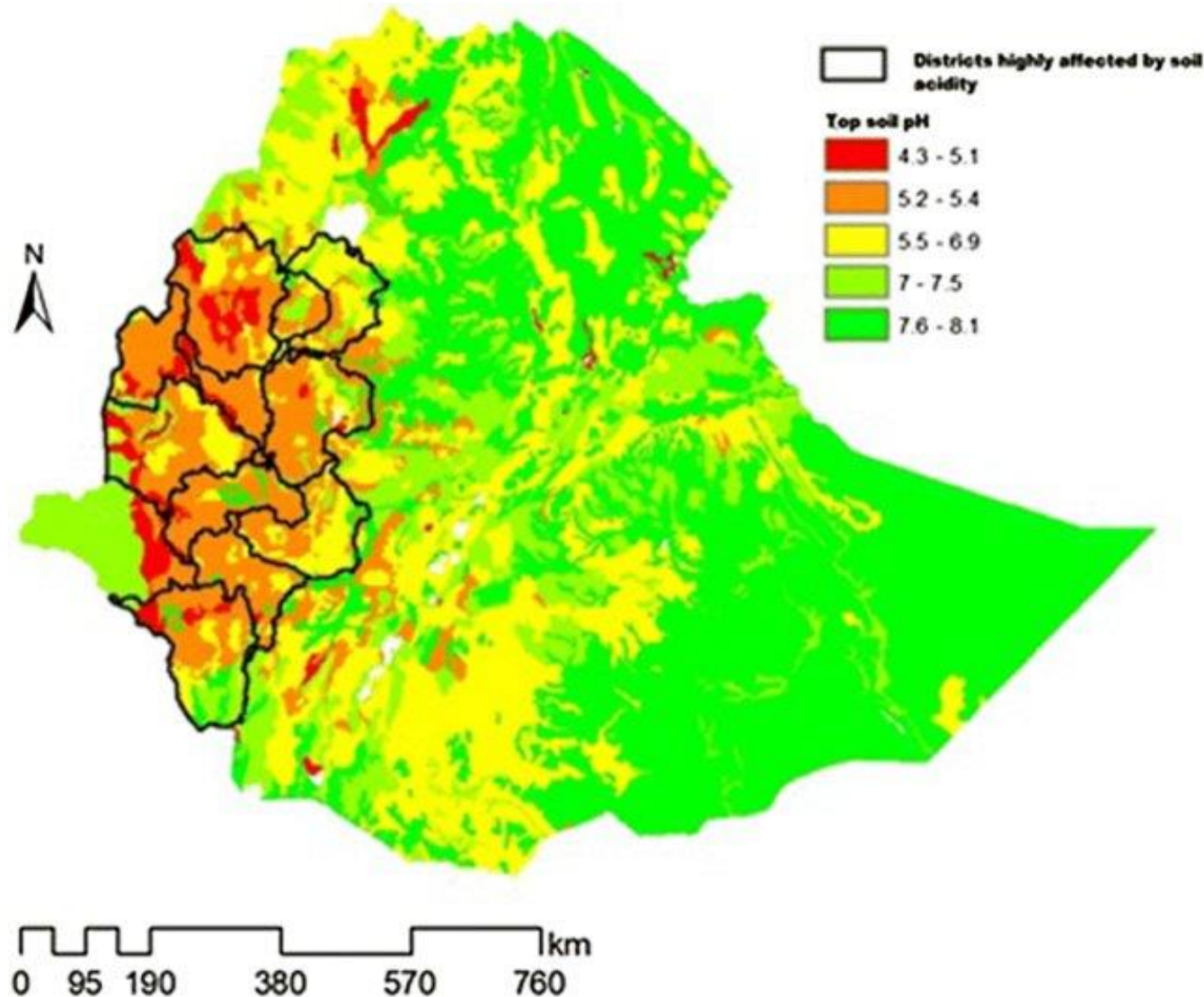
Potential for ERW in Ethiopia

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Rainfall

Soil pH map



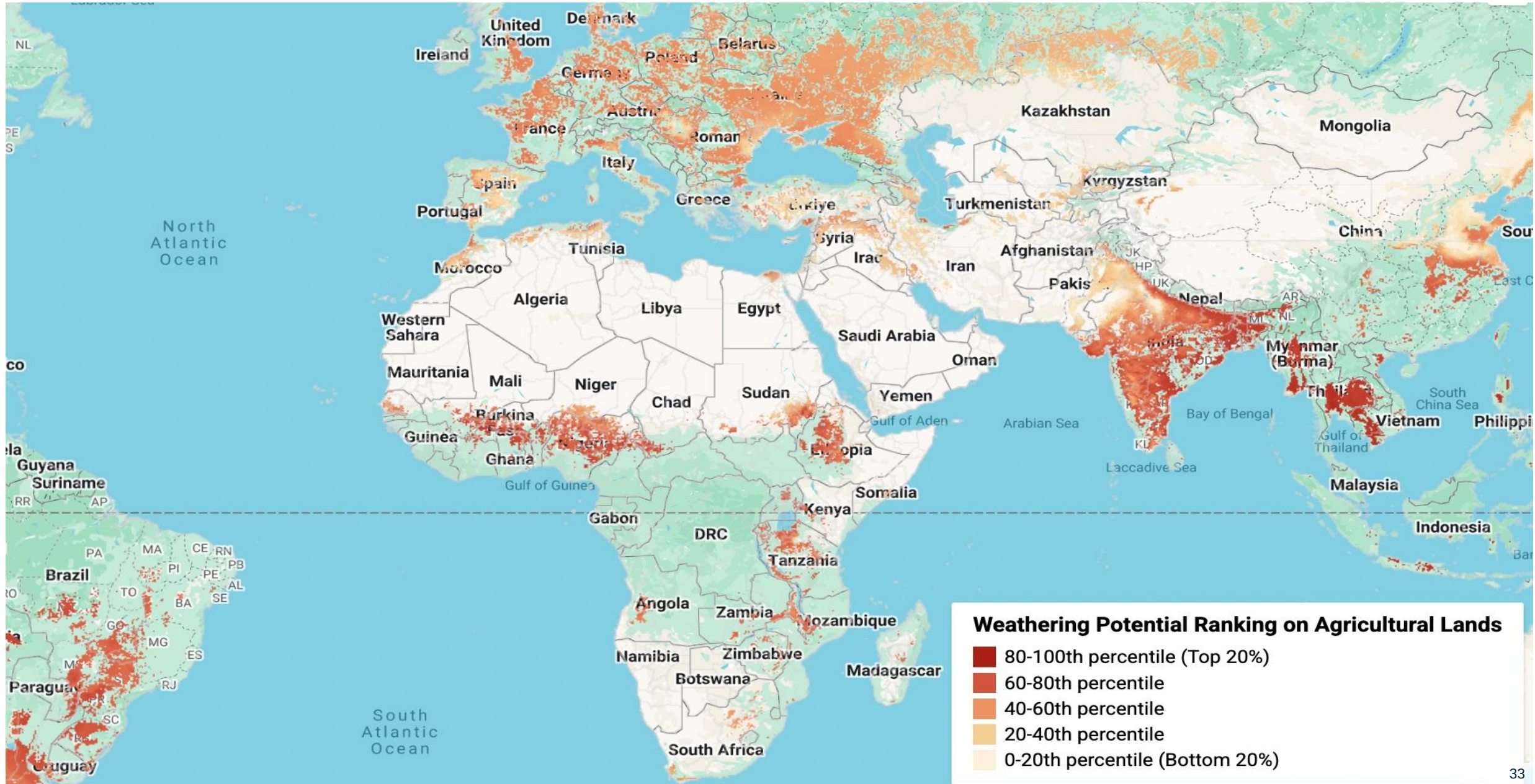
- Nearly 16 million hectares of agricultural land are affected by soil acidity, mainly due to natural processes (e.g., intensive leaching)

Agenyehu, 2020

Basalt availability

Region	Basalt availability	Main agricultural relevance
Northwestern Ethiopian Plateau	Very high (Ethiopian Flood Basalts)	Major cereal-growing regions of Amhara, Tigray, and Oromia
Central Ethiopian Highlands	High	Wheat, barley, teff production
Main Ethiopian Great Rift Valley	Very High	Mixed crop-livestock systems
Southern Ethiopian Rift	High	Coffee, maize, enset, horticulture
Southwestern volcanic highlands	Moderate to high	Coffee-growing regions

A Global Weathering Potential Explorer: developed by Cascade Climate

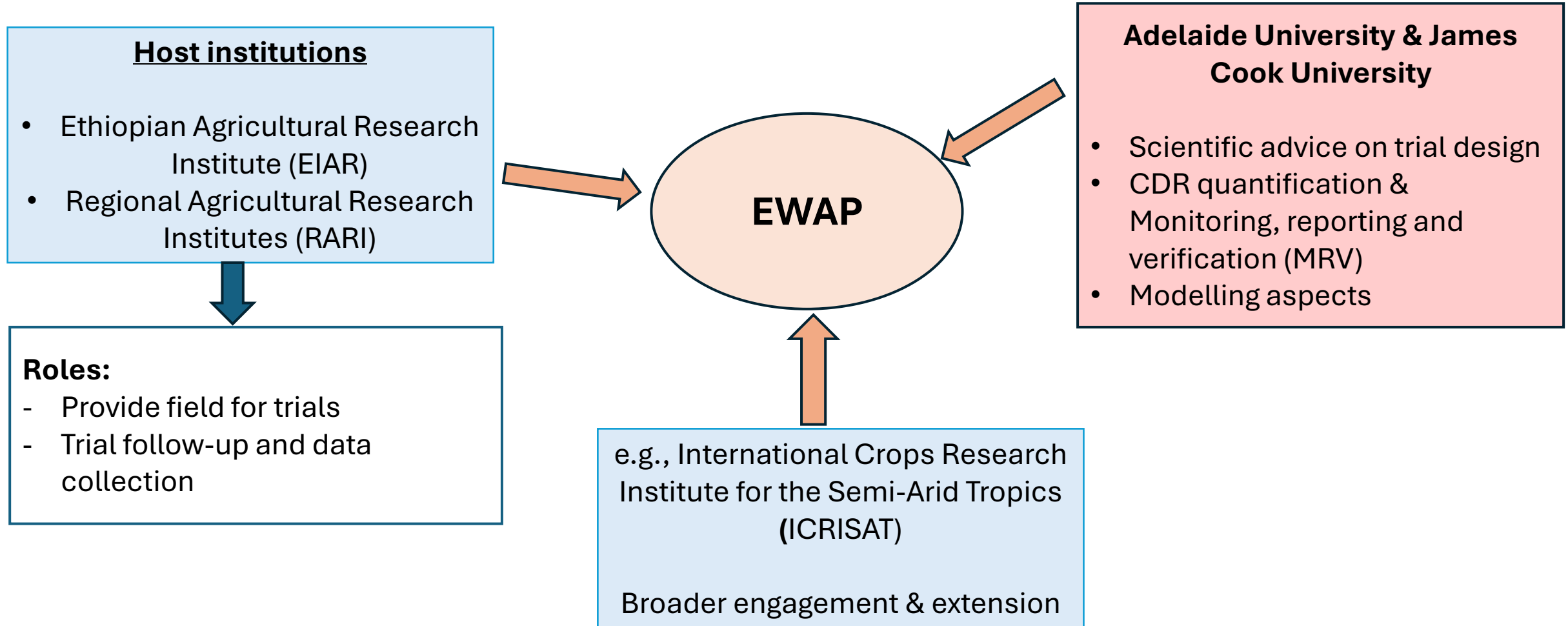


Policy frameworks

(a) As of **30 June 2026**, Ethiopia's **House of People's Representatives** approved and ratified the **Carbon Market Proclamation**, creating the country's first comprehensive legal framework for carbon markets and carbon credit trading.

- This proclamation builds on Ethiopia's **National Carbon Market Strategy (2025–2035)**, which aims to position the country as a major supplier of high-quality carbon credits from sectors such as:
 - Forestry and reforestation
 - Sustainable agriculture
 - Land restoration
 - Renewable energy
 - **Other greenhouse gas reduction and carbon removal projects.**
- (b) Carbon Crediting for Adaptation: the Gates Foundation Big Bet
 - Ethiopia is one of the target countries

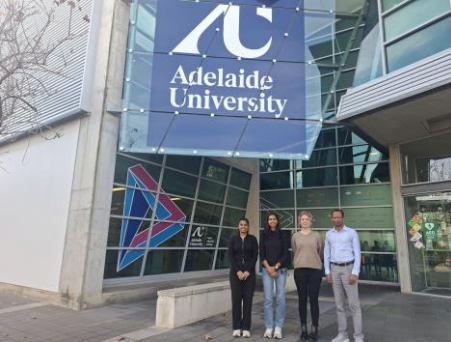
Potential collaborators and hosting institutions



Summary

- High potential for ERW in Ethiopia
- Strong host institutions
- Suitable policy for carbon credits
- Strong ties with researchers from the host institutions

Acknowledgements



Australian Government
**Department of Agriculture,
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Soil Health and Sustainable Land Management Priorities in Uganda

EWAP Uganda Stakeholder Workshop on Enhanced Weathering in Agriculture

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NARO-NACCRI, Namulonge, Uganda

5 August 2026



PRESENTATION CONTENT



1

State of soil health and land use

Where we stand today: evidence, linkages and the cost of degradation

2

Drivers of the threats

What is pushing soil health down, and what it means for crop production

3

Efforts, stakeholders and best bets

Who is already acting, from the plot up to national policy

4

Priorities and enhanced rock weathering

Strategies to revamp soil health, and the ERW option for pH, nutrients and carbon

From evidence to action - and to ERW



KEY TERMS DEFINED



Soil health

The continued capacity of soil to function as a vital living system within land-use boundaries (Doran & Zeiss, 2000; Karlen et al., 2001)

Soil fertility

The capacity of soil to supply plant nutrients in available forms, in proper balance and free of toxicity

Land degradation

Reduction or loss of the biological and economic productivity of land (UNCCD, 1994)

Sustainable land management

Use of land resources to meet changing human needs while sustaining ecosystem functions for the long term (TerrAfrica, 2009). It is how SDG 15.3 - a land degradation-neutral world by 2030 - and SDG 2 on food security are delivered on the ground (UN, 2015)

Land degradation neutrality

A state where the land resources needed to support ecosystem functions and food security remain stable or increase (UNCCD, 2017). Uganda set its national LDN targets in 2018 (UNCCD, 2018)

Enhanced rock weathering (ERW)

Spreading finely crushed silicate rock such as basalt on farmland to accelerate natural weathering. Soil CO₂ dissolves the rock, releasing Ca, Mg and K for crops while the carbon is stored as bicarbonate for more than 10,000 years (Washbourne et al., 2015; Beerling, 2017)



SOIL HEALTH IN UGANDA



Share of land that is degraded

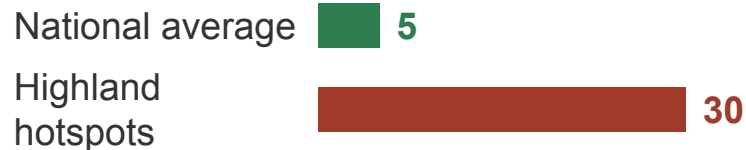


41% of the land is degraded (Vagen et al., 2016)

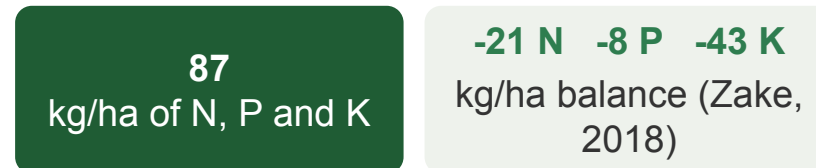
Fertiliser use, kg of nutrients per ha



Soil loss, tonnes per ha per year



Nutrients mined from farmland each year



Low fertility, acidity and erosion compound each other: soils have acidified below the ideal pH 5.5-6.8, are dominated by Ferralsols low in organic matter, and lose nutrients faster than they are replaced

Sources: Vagen et al. (2016); World Bank (2025); MAAIF (2023); IAEA (2021); Wortmann & Kaizzi (1998); Zake (2018); Kaizzi et al. (2006); FAO/World Bank (2023)



Land Use change in Uganda



LAND COVER CHANGE, MILLION HECTARES



ARABLE LAND PER PERSON, HECTARES



Expansion is onto the steep, erosion-prone land, not better soils - hotspots in the Kigezi and Elgon highlands and the cattle corridor

Sources: FAOSTAT (2023); World Bank (2019, 2021, 2023); MAAIF (2023); NEMA (2024)



Top: cultivation pushed onto steep highland slopes. Below: fragmented smallholder plots on fragile terrain (field photos, Kigezi highlands)

Drivers of Land Degradation

Driven by pressure on land, loss of vegetation cover and a changing climate



**Population growth
and land
fragmentation**



**Cultivation of steep,
marginal land**



**Continuous cropping
without nutrient
replenishment**



**Deforestation for
wood fuel and
charcoal**



**Wetland reclamation
and encroachment**



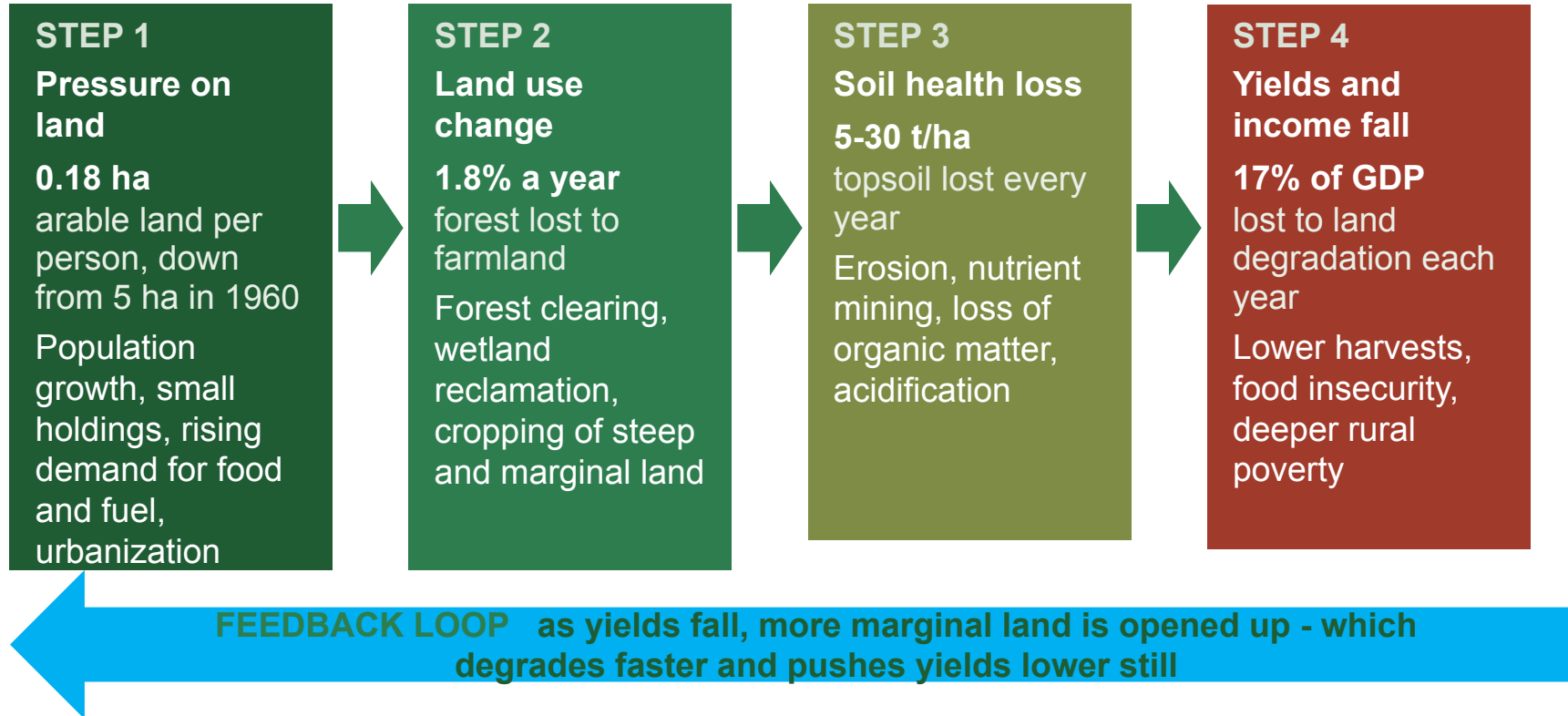
**Overgrazing and
bush burning in the
cattle corridor**



**Climate change:
floods, drought,
erratic rain**



**Insecure tenure and
weak policy
enforcement**



Sources: NEMA (2024); MAAIF (2023); World Bank (2019, 2021, 2025); UBOS (2020); Mwanjalolo et al. (2018)



What This Means for Crop Production

3.3

kg/ha of fertiliser used, against 8 in sub-Saharan Africa and 135 worldwide (FAO/World Bank, 2023)

87

kg/ha of N, P and K mined from farmland every year (Wortmann & Kaizzi, 1998)

1.5-2.5

t/ha typical cereal and rice yields, well below attainable potential (ISRIC, 2018)

Soils that are acid, low in organic matter and short of N and P give a poor response to any input.

Correcting acidity and rebuilding base cations comes first - which is exactly what enhanced rock weathering with crushed basalt is designed to do, while also removing CO₂.

NOTE: In the Nairobi Soil Health and Fertilizer Summit, the heads of state were deeply concerned with low fertilizer consumption in Africa (only increased from an average of 8kg/ha to about 18kg/ha, which is less than half of the target of 50kg/ha set in the declaration; global fertilizer consumption rate is about 135kg/ha)



Cost of Soil health/Land Degradation

Land degradation costs Uganda about 17% of GDP every year

What it costs

Land area already degraded



Annual GDP lost to degradation



Agricultural GDP lost



- 87 kg/ha of N, P and K lost from farmland each year
- 5 t/ha of soil lost annually, up to 30 t/ha in the highlands
- Up to 27% of agricultural GDP forgone
- 5-7 million ha lost to degradation globally each year

Farm households using no fertiliser



Sources: World Bank, 17th Uganda Economic Update (2025)Vagen et al. (2016); IAEA (2021)



Nutrient mining & limited re-cycling- a challenge



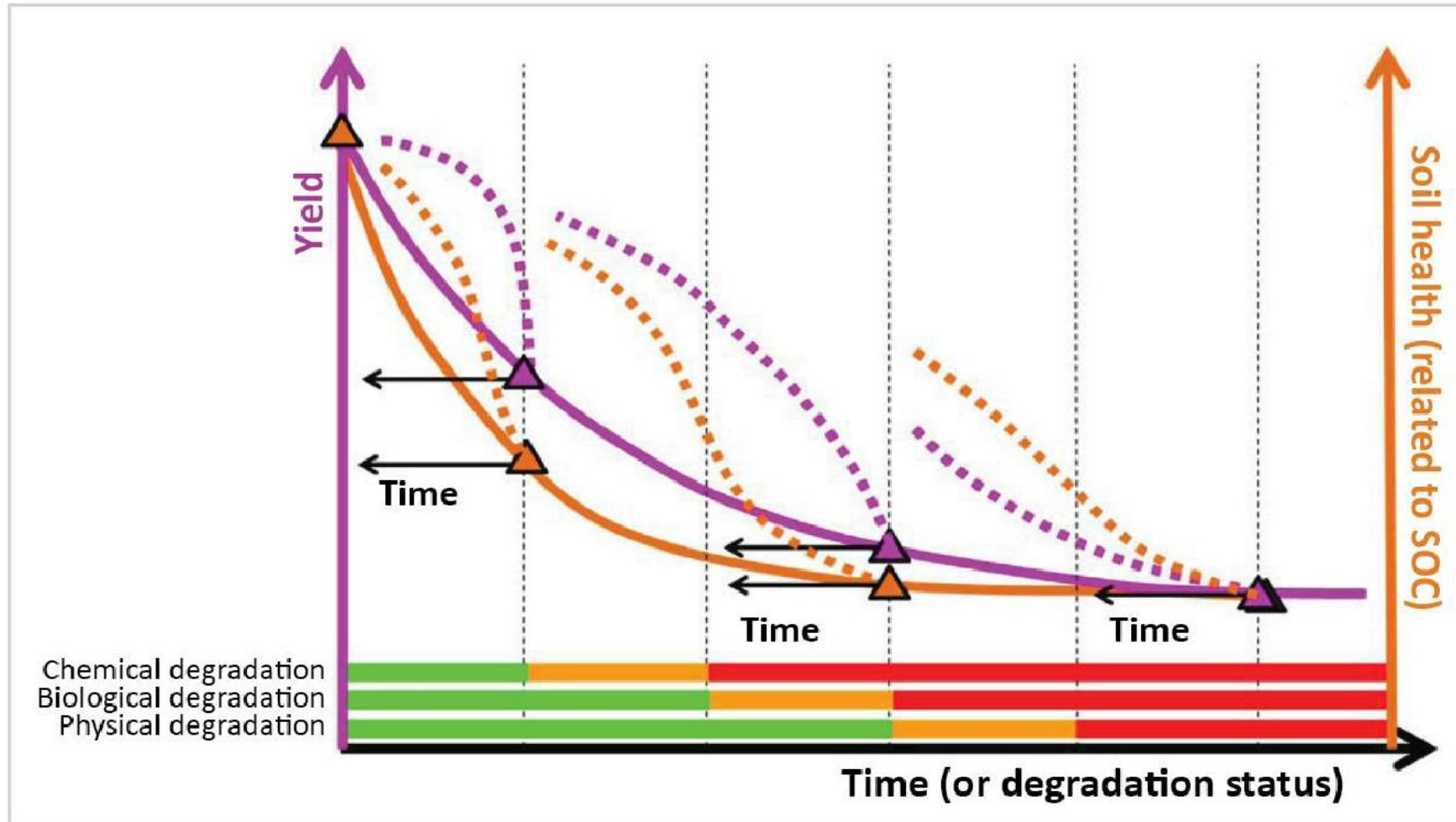


Wide Yield Gap in Crop Production

Crop	Farmer yield kg per hectare per year	Attainable kg per hectare per year	Potential kg per hectare per year
Robusta coffee	647	1,464-1,737	2,196-2,606
Arabica coffee	923	1,550-2,440	2,333-3,660
Common beans	500-800	875-1,772	over 2,000
Upland rice	under 900	1,200-1,500	over 3,000

Farmers harvest a third to a half of what the same land could give. The gap is mostly soil: depleted nutrients, acidity and poor water retention. Closing it is how land productivity breaks the poverty trap (Sanginga et al., 2009; Tittonell et al., 2012)

Sources: Wang et al. (2015); Wairegi et al. (2010); Bulyaba et al. (2020); Musinguzi (2022)



Rate of degradation may not allow rapid restoration thus protecting soil health to boost yield key: Source: Chivenge et al. (2022a).



Current efforts towards restoration



Policy and planning	National Fertiliser Policy (2016) targets 50 kg/ha of nutrients; NDP IV (2025/26-2029/30) agro-industrialisation; national LDN targets (UNCCD, 2018); Soil Health and Fertilizer Action Plan for African (2022-2023); Nairobi Soil Health and Fertilizer declaration
National programmes	Sustainable Land Management project, Climate smart Project - MAAIF; 1:50,000 national soil mapping program; MWE catchment restoration programs
Research and evidence	NARO, Makerere university, Busitema Uni, MoM etc on soils, ISFM proven concept; emerging enhanced rock weathering trials
Partners and restoration	FAO Global Soil Partnership; AGRA soil health and fertiliser agenda; IFDC; AFR100 pledge to restore 2.5 million ha by 2030; ERW developers and carbon buyers entering East Africa. More needed
On the farm	Agroforestry, conservation agriculture, regenerative agriculture, manure and compost, contour bunds and terracing; agroecology, key practices documented through UGACAT/WOCAT; Soil test kit support;

Sources: MAAIF (2016, 2023); NPA (2025); UNCCD (2018); slm.go.ug; FAO GSP; AFR100 (2023)

Best Bet Practices in Soil Health and SLM



Bench terraces



Contour cropping



Fanya juu and fanya chini



Mulching



Cover cropping



Alley cropping and fodder banks



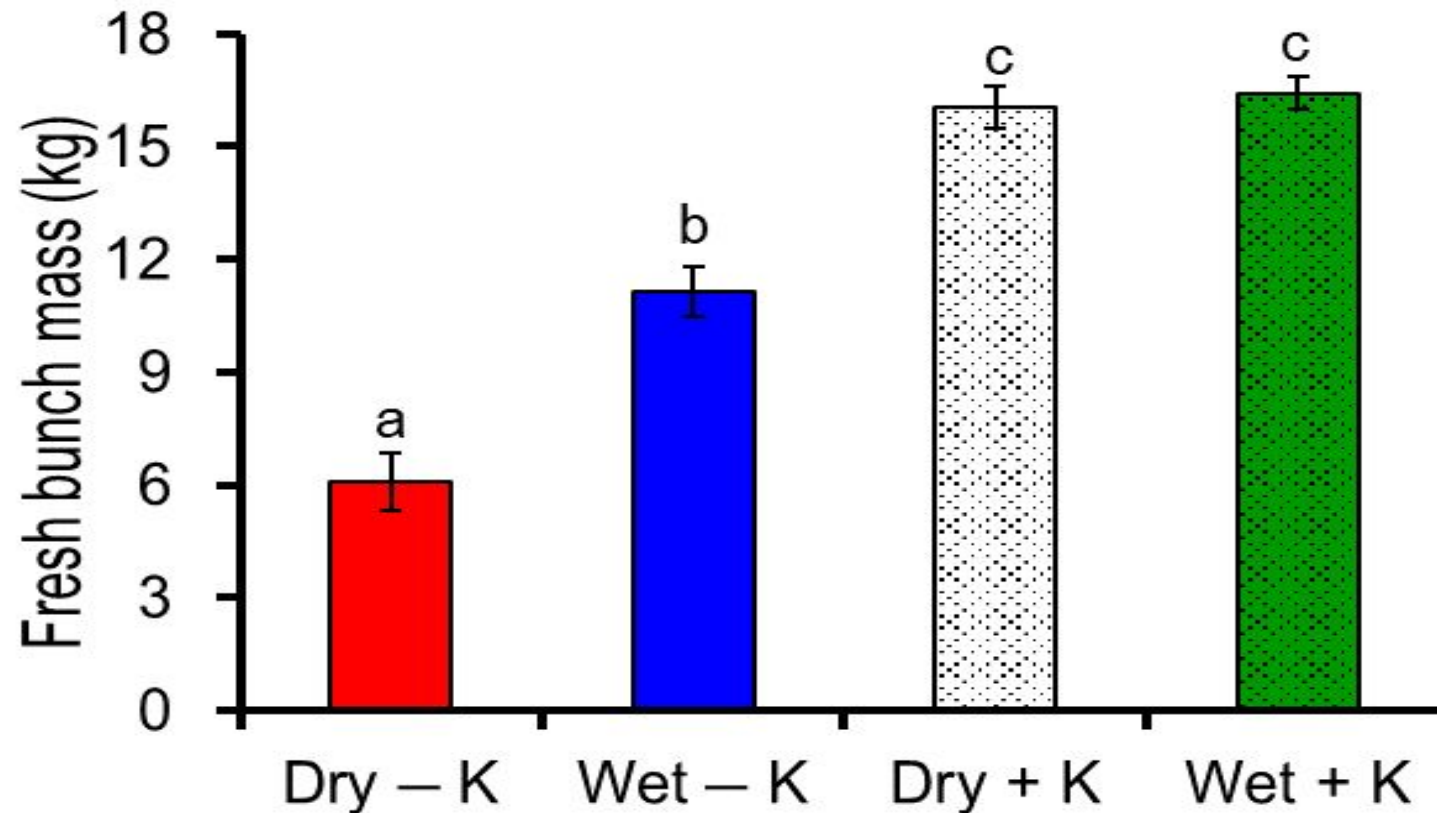
Contour trenches, Sheema

Practice at plot scale is where soil health is won: erosion control structures, organic inputs and 4R nutrient use - and now crushed basalt, the amendment that these practices hold in place and that pays back through carbon sequestration

Also: strip cropping, retention ditches, stone lines and bunds. Field photos: soil and water conservation training, Uganda highlands; training approach after Musinguzi, Twinamasiko & Ahaabwe (2021)

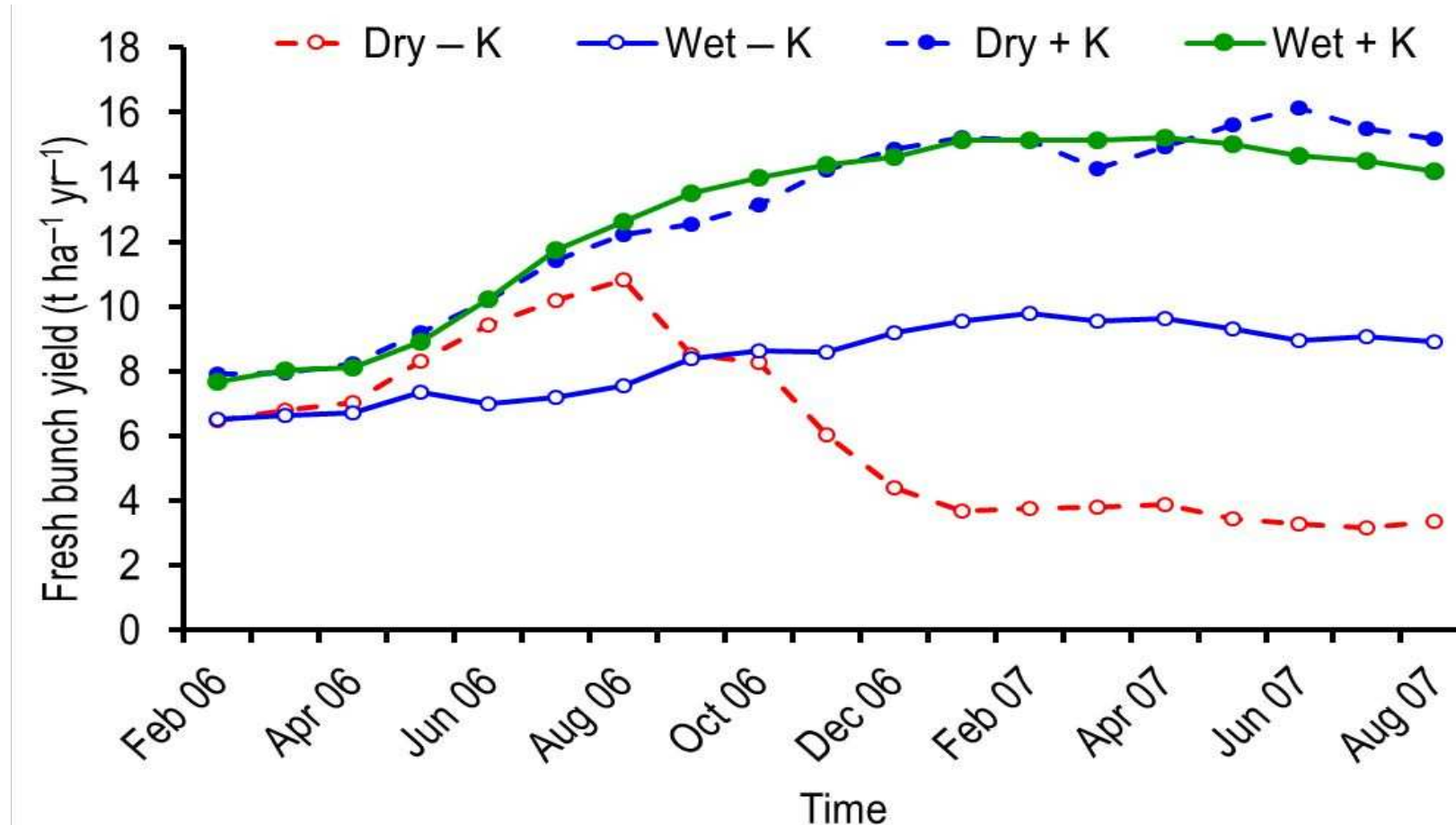
Results evident with proper SLM /nutrient management

- Strong yield increase with nutrient application and drought management (Banana)



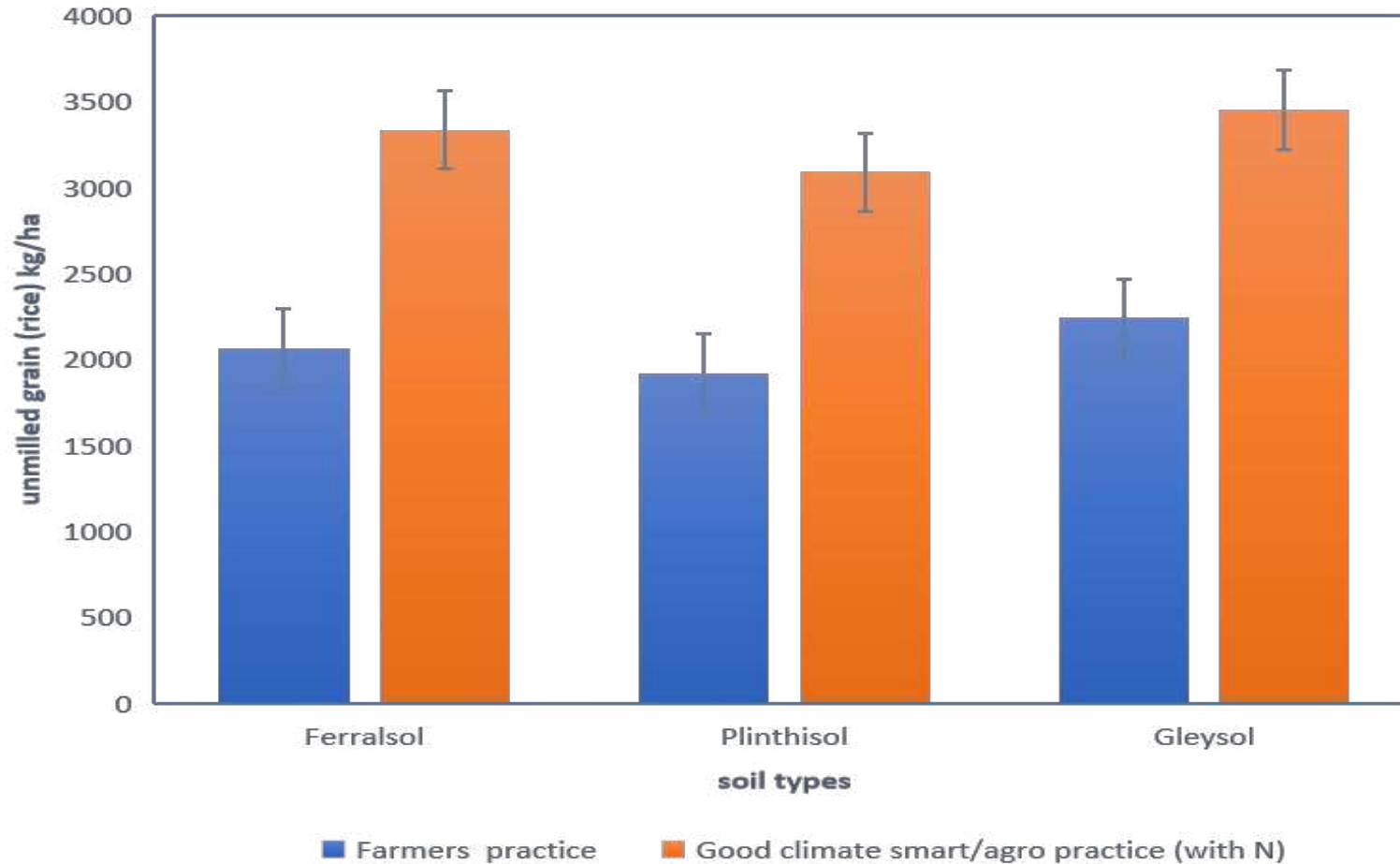
Proper nutrient management

- Strong yield increase with nutrient application (K key)



Source: Taulya et al. 2013

- Strong yield increase with good climate smart package in rice



Source: Musinguzi et al.



Priorities to Revamp Soil Health



1. Scale integrated soil fertility management/agroecology

Combine organic inputs with balanced mineral fertiliser, matched to site and crop; support agroecology approaches

2. Tackle soil acidity

Targeted liming of acid soils and use of ERW, guided by soil testing and response trials, key

3. Close the input gap

Move fertiliser use toward the 50 kg/ha policy target with quality assurance and affordable access

4. Invest in soil information

Complete and open up the soil information system; strengthen testing laboratories and advisory tools

5. Mainstream SLM in local plans

Embed erosion control, agroforestry and wetland protection in district and Parish Development Model plans, with land use planning at parish level

6. Test and scale enhanced rock weathering

Crushed feedstock is a joint gain for soil pH, base cations, crop quality and permanent CO₂ removal - build Uganda's evidence base now, with trials, MRV and carbon finance

Sources: MAAIF (2016); Kollie et al. (2023); FAO GSP; UNCCD (2018); ETH Zurich ERW in Tropical Africa (2025)



Enhanced Rock Weathering: Potential and Research in Soil Health Enhancement





Soil Health and ERW: Potentials



ERW offers multiple co-benefits for agricultural systems, including improved soil chemical properties, enhanced nutrient availability, increased soil resilience, and potentially higher crop productivity

ERW improves soil condition (Steeley et al., 2026)

Evidence from rock-dust trials - basalt cut nitrogen leaching by up to 45% and released Mo that drives N fixation and use efficiency

+71%

Yields respond (Haque et al., 2024)

Kisumu ERW pilot: 56 women farmers, 20 t/ha rock powder

Ca Mg K Si

Fertility rebuilt

Base cations and silicon that lime alone does not supply

10,000 yrs (Boudinot et al., 2023)

CO₂ locked away

Carbon credits can pay for the amendment, which lime never could provide

Gebrekidan, B., Silva, J.V., Sida, T., Baudron, F., Chamberlin, J. et al. (2024). Targeting Agricultural Lime for Acid Croplands in Uganda. CIMMYT / GAIA technical brief, www.acidsoils.africa | ERW evidence: Flux & UNCCD, Kisumu County ERW pilot (2024); Steeley, I.L. et al. (2025),



Soil Health and ERW: Research Areas



01

Matching feedstock to soil

Which feedstocks weather fastest on soil types, at what size and rate

02

Measuring the carbon sequestration

MRV application under tropical rains on ERW in smallholder fields

03

Agronomic trials

Multi-season yield and pH response in crops eg. coffee, beans, maize, rice, banana key

04

Modelling, Soil biology

Impacts of ERW; influence on Microbes and soil health

05

Safety limits

Trace metals, dust exposure, water quality, long-term soil effects

06

Economics and delivery

Crushing, transport, carbon finance, adoption and extension

Research priorities drawn from ETH Zurich, ERW in Tropical Africa (2025); Nature Reviews Earth & Environment (2025); IGSD (2024); Beerling et al. (2020), Nature



SLM and ERW: The Linkages in Uganda



Acid, depleted soils	41% of land degraded, soils acidified below pH 5.5, and 87 kg/ha of N, P and K mined from farmland every year	ERW targets exactly this: acidity, lost base cations and low fertility
Rock and climate	East African Rift basalts and quarry fines close to farmland, in a warm humid climate that keeps weathering going year round	Uganda has both the feedstock and the conditions ERW needs
SLM practices	Terraces, contour bunds, mulching, agroforestry, conservation agriculture and 4R nutrient management	Rock dust rides on existing SLM operations, and erosion control keeps it in the field
Policy and targets	National Fertiliser Policy 50 kg/ha target, national LDN targets (UNCCD, 2018), NDP IV agro-industrialisation and the NDC	One practice contributing to soil, land-neutrality and climate targets at once
Finance and partners	Carbon buyers and ERW developers, NARO, Makerere, ETH Zurich, districts, agro-dealers and farmer groups	Carbon revenue can pay for soil restoration that farmers cannot finance alone

ERW does not replace SLM - it is the amendment that makes SLM work, and that can pay SLM back through carbon finance



Conclusion



Soil health is an economic issue, not only an agronomic one

41% of the land is degraded and the country loses about 17% of GDP each year

Farmer centric, Integrated soil health/fertility management is key; targeted soil fertility management and optimizing returns vital for sustainability

The drivers are known and largely manageable

Land pressure, nutrient mining, acidity and vegetation loss all have tested remedies

Delivery depends on stakeholders acting together

Policy, research, districts, farmers, carbon buyers and the private sector each hold one part of the solution

Enhanced rock weathering is the option to test now

One amendment that raises soil pH, resupplies base cations, lifts crop quality and permanently removes CO₂ is worth consideration amidst climate change

Acknowledgement

Soil Science Society of East Africa (Ug)



Makerere University



Bukusu carbon solutions Ltd





A PHASED PATHWAY FOR ERW PROJECT DEVELOPMENT AND FIELD IMPLEMENTATION IN UGANDA

EWAP Uganda Stakeholder Workshop

Presented

by

Makune Aggrey

Bukusu Carbon Solutions Limited

5th August 2026

Bukusu Carbon Solutions Ltd

UGANDAN –BASED CLIMATE SOLUTIONS COMPANY

- Subsidiary of Namekara Mining Company Ltd that mines and processes Vermiculite for local and international markets.
- Bukusu Carbon Solutions Ltd derives its name from Bukusu Hill, reflecting the company's geographical and geological provenance within the Bukusu Alkaline Carbonatite Complex in Manafwa District
- BCSL is developing an Enhanced Rock Weathering project using locally sourced Vermiculite tailings from Namekara's mining operations and Silicate rich materials from the Bukusu Alkaline Complex

OUR PURPOSE

- Remove atmospheric CO₂ while improving soil health/fertility and crop productivity.



Why Bukusu, and why Uganda?

The opportunity

- Highly weathered, nutrient-depleted agricultural soils across several farming regions
- Soil acidity, declining fertility and the high cost of agricultural inputs constrain farm productivity
- Warm temperatures and seasonal rainfall that supports mineral weathering
- The Bukusu Alkali Complex offers access to potentially suitable calcium oxide and magnesium oxide bearing silicates
- Existing vermiculite mining and processing that will provide usable mineral tailings and powders

Indicative feedstock available

~554,083 tons

Stockpiled at the mine site in Manafwa District



These figures are indicative project-planning estimates, subject to verification and operational plans

Proposed feedstocks and suitability assessment

Candidate feedstock materials



Vermiculite Mine tailings

Mineral/Rock residues from existing processing operation



Pyroxenite and silicate powders

Other suitable silicate-rich material streams



Basalt

Potential option for blending with the available mine tailings

What must be established before any field deployment

- Mineralogy and geochemistry

- Particle-size distribution and surface area

- Dissolution and weathering rates

- Dust, handling and occupational-health risks

- Calcium oxide, magnesium oxide and silicon content

- CO₂-removal potential: theoretical and achievable

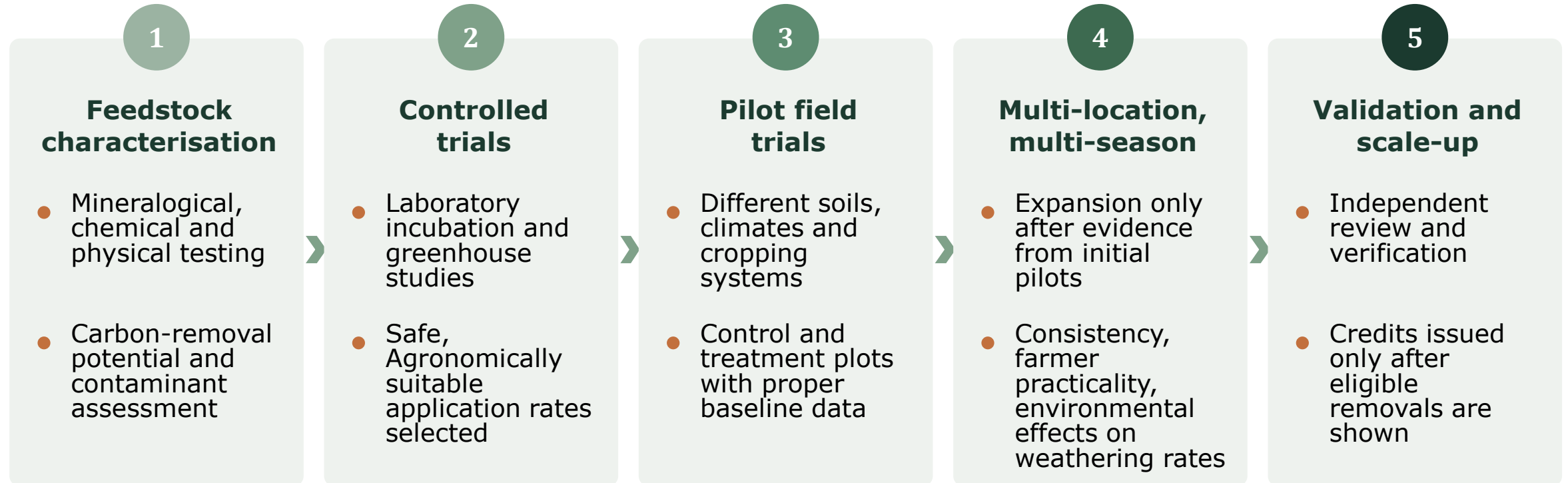
- Potentially toxic-element concentrations

- Agronomic compatibility with Uganda's soils and crops

Feedstock availability alone does not establish suitability - safety, additionality and measurable weathering must all be demonstrated.

A phased, evidence-led project development model

With each phase producing evidence before the next one begins



Bukusu is not looking at immediate large-scale spreading: It will be phased where advancing from one phase to another will be based on scientific evidence from the previous phase.

Proposed field implementation in Uganda

Organised across contrasting Agroecological conditions, starting with 2 sites & later make it 4 sites.

Targeted research locations



Buginyanya ZARDI

Mount Elgon highland farming systems



MUARIK / Mukono ZARDI

Lake Victoria Crescent



Ngetta ZARDI

Northern moist farming systems



Mbarara ZARDI

Western rangeland and associated cropping systems

At every site

- Baseline soil and water characterisation
- Untreated control plots
- Application rates set by prior safety testing
- Locally important crop systems considered
- Standardised spreading and incorporation
- Crop response and soil-health monitoring
- Farmer participation and socioeconomic assessment
- Seasonal Monitoring of water, soil and weathering indicators

Begin with a limited number of well-controlled sites, then expand to four agroecological zones only when the evidence supports expansion.

Measurement, reporting and verification

MRV is will separate expected removal from verified removal

What will be measured

- Soil chemistry and exchangeable cations
- Weathering products and elemental mass balances
- Soil-water, drainage-water and river chemistry
- Greenhouse-gas emissions, where material is processed and during haulage.
- Carbon losses, reversals and leakage
- Feedstock mass and composition
- Soil inorganic carbon, where scientifically applicable
- Crop nutrient uptake and biomass removal
- Mining, grinding, transport and spreading emissions
- Measurement uncertainty and conservative discounting

Proposed technical collaboration



Makerere University

National scientific leadership and field research partner.



Specialist modelling partners

Geochemical, reactive transport and permanence modelling



Independent technical review

External scrutiny of methods and results



Accredited verifier/registry body

Validation, verification of removals & Issuance



NARO and participating ZARDIs

Field coordination and implementation across AEZs

Carbon credits must reflect conservatively quantified net removal- not simply the quantity of rock spread.

Next steps

What Bukusu considers necessary for credible ERW development in Uganda

Safeguards and governance

- ☐ Compliance with Uganda's Climate Change Mechanisms Regulations
- ☐ Early engagement with government and carbon-market authorities
- ☐ Transparent agreements with farmers and research institutions & partners
- ☐ Feedstock safety and environmental safeguards
- ☐ Community consultation and informed participation
- ☐ Clear land-access and benefit-sharing arrangements
- ☐ Data transparency and independent scientific review

Immediate next steps

- ☐ Complete detailed characterisation of candidate feedstocks
- ☐ Obtain required regulatory permissions
- ☐ Finalize the scientific research and MRV framework
- ☐ Conduct greenhouse and incubation studies
- ☐ Select initial crops, soils and pilot sites
- ☐ Mobilize technical and financial partnerships
- ☐ Establish baseline datasets before any feedstock material application

Bukusu Carbon Solutions seeks to work with Uganda's research institutions, regulators, farming communities and international ERW experts to build a scientifically credible and scalable farmer-relevant ERW project.



CO₂
↓ ↓

THANK YOU!



KNUSTRocks

A national siting framework for enhanced rock weathering in Ghana

Prioritise. Characterise. Verify.

The Net-Zero Carbon Emission Lab at KNUST



College of Engineering, KNUST · est. 2025

MEASURE & VERIFY

Emissions quantification, monitoring, reporting and verification (MRV)

REMOVE & STORE

Enhanced rock weathering, and carbon capture and storage (CCS)

ACCOUNT

Carbon inventories and net-zero pathways for institutions and sectors

KNUST Rock Enhanced Weathering: four workstreams



SUITABILITY

complete

Suitability index and the KNUSTRocks siting platform — 216 districts scored and ranked.



FEEDSTOCKS

underway

Ghanaian silicate sources characterised for reactivity, grain size and trace elements.



MRV

in development

Locally-validated measurement, reporting and verification of removal and soil change.

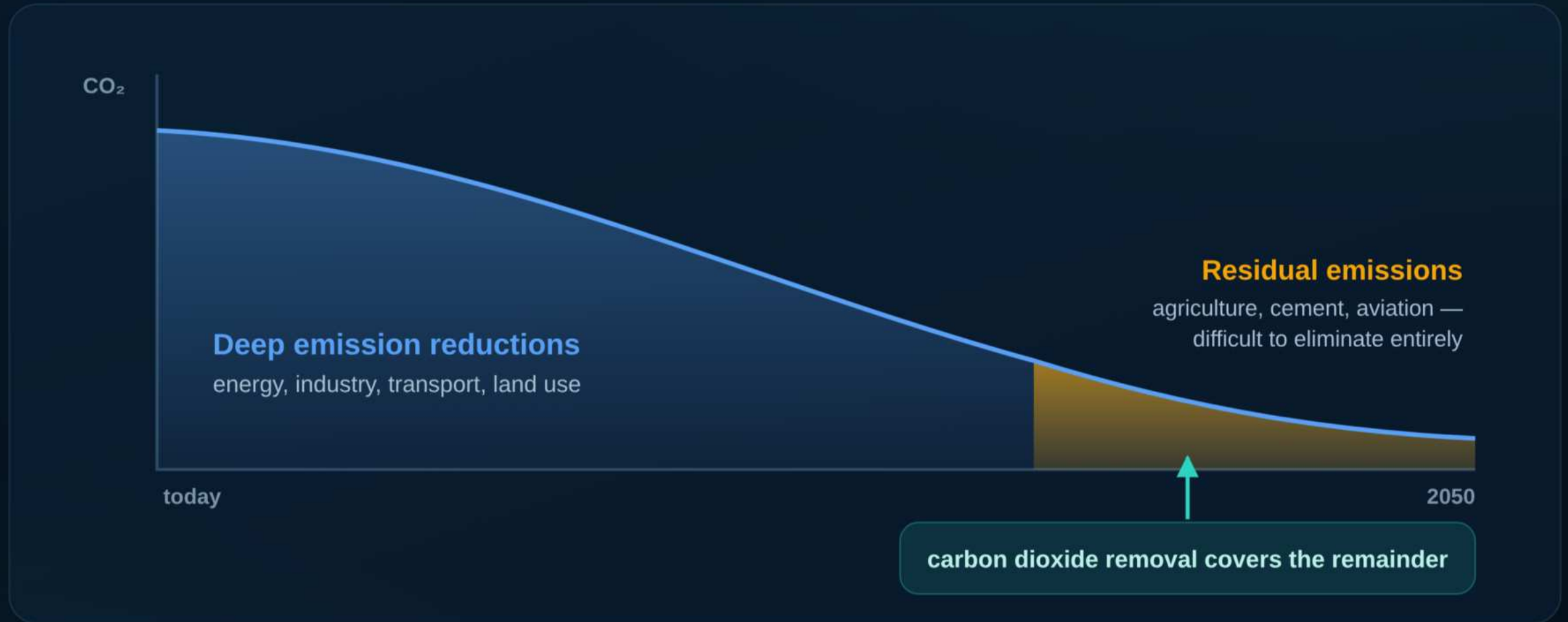


PILOTING

planned

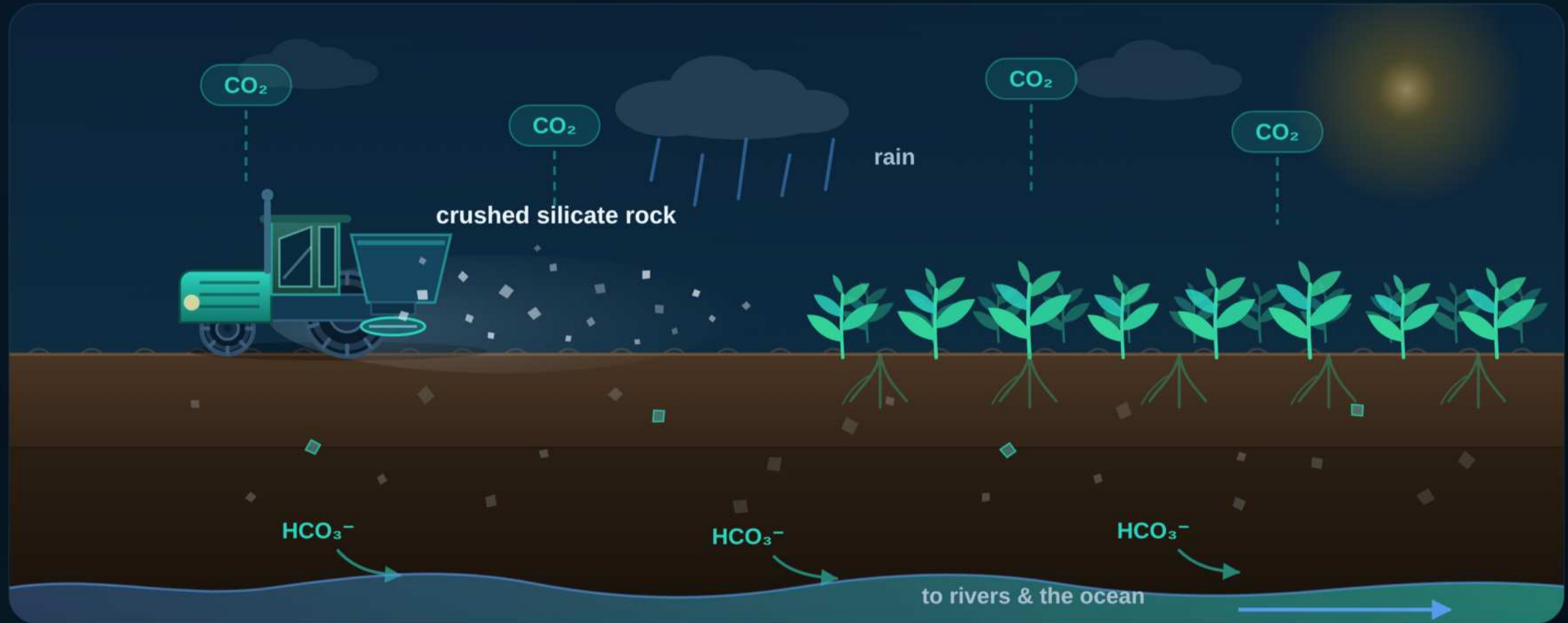
Replicated field trials in priority districts, designed with farmer and industry partners.

Residual emissions create a requirement for carbon dioxide removal

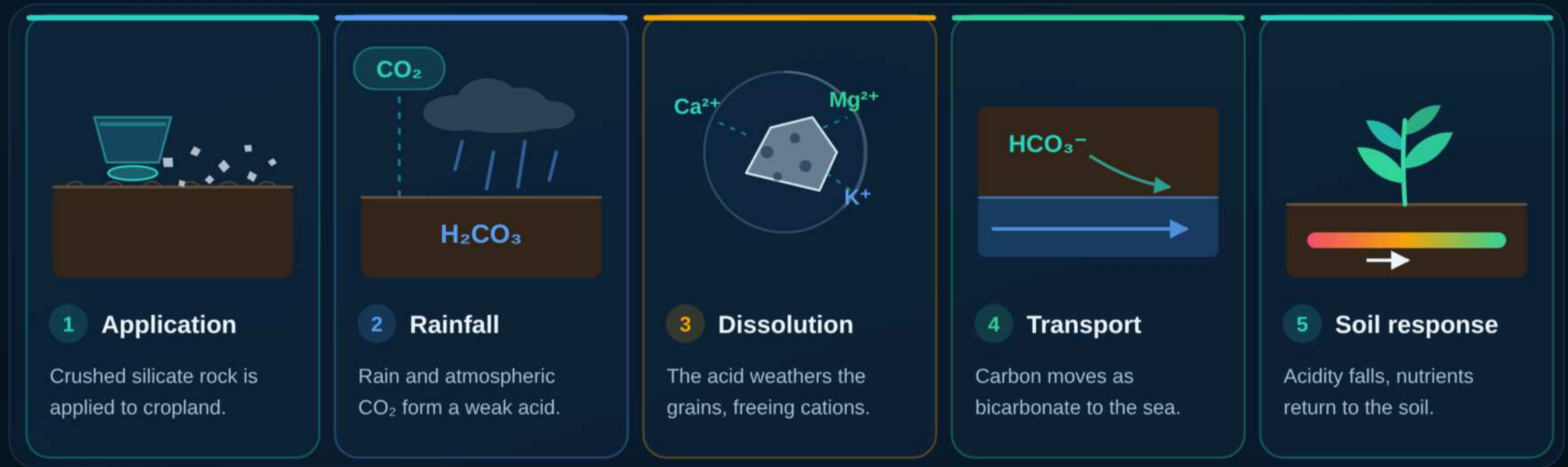


Emissions from agriculture, cement production and aviation are difficult to eliminate entirely. Meeting a net-zero target therefore requires removal as well as reduction.

Crushed silicate rock applied to cropland removes carbon dioxide and amends soil

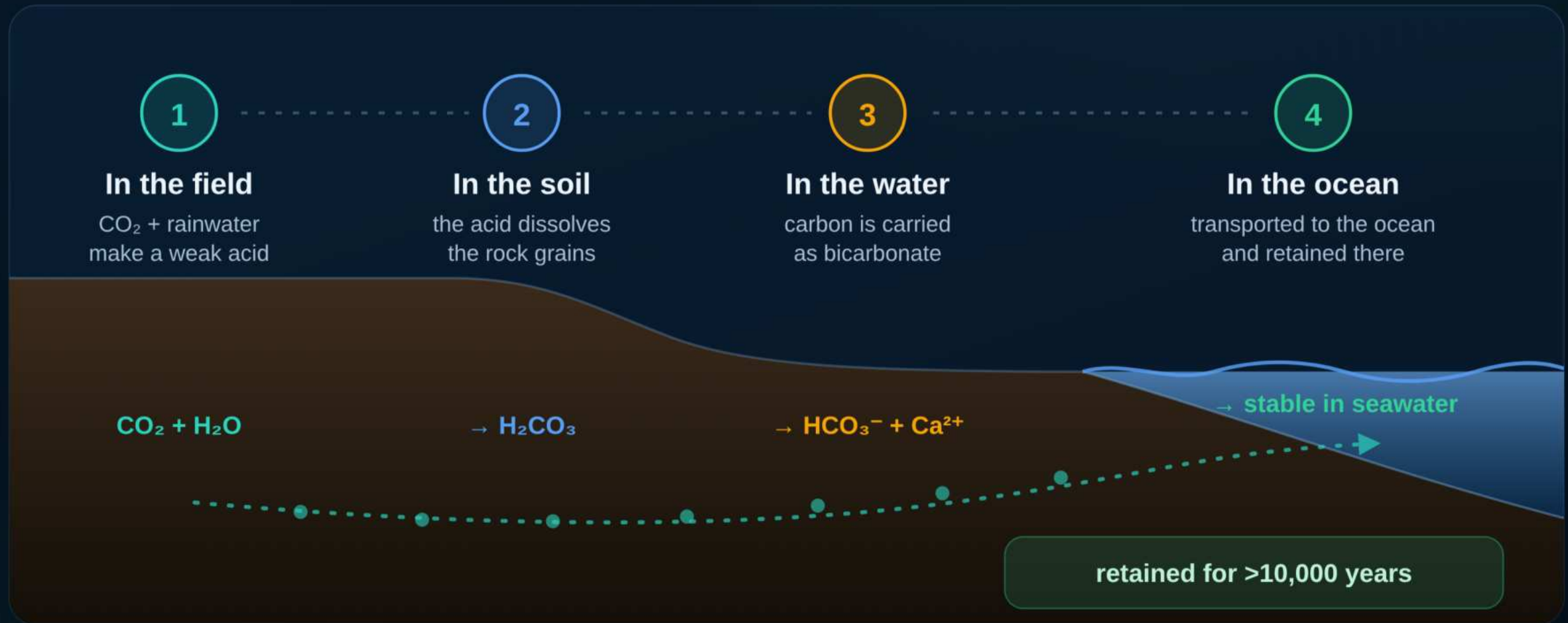


The process in five stages

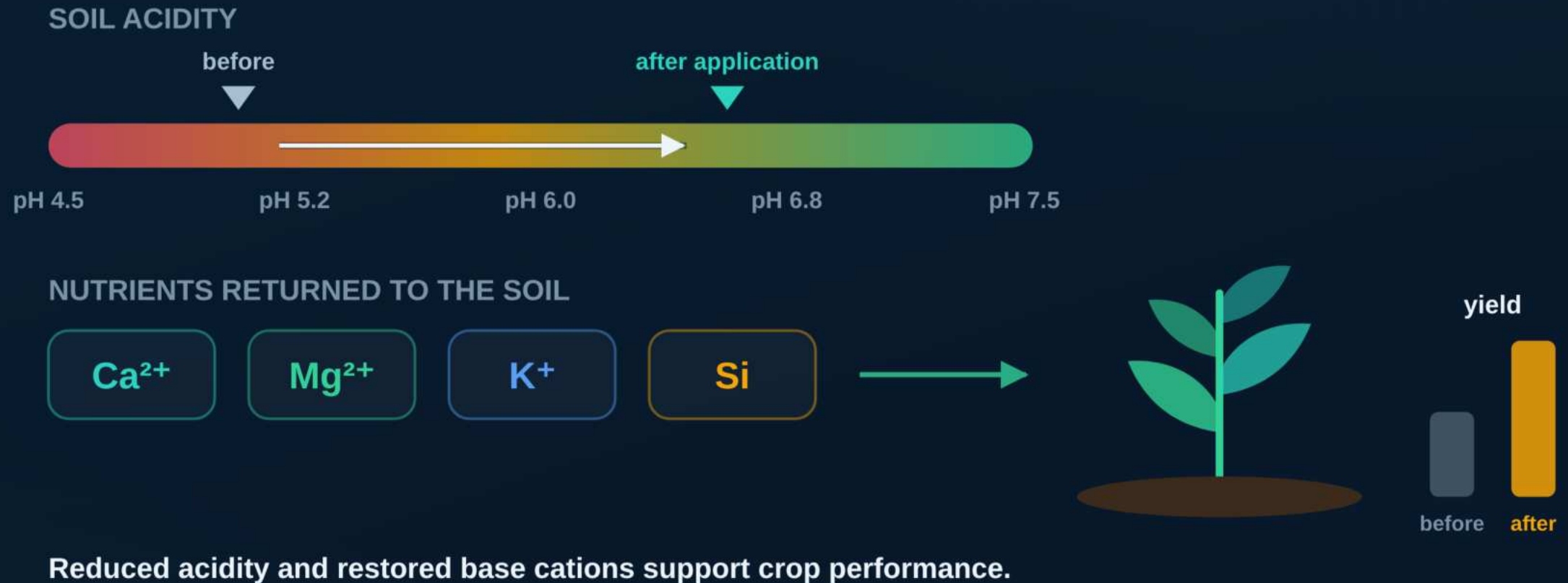


The reaction is the same silicate weathering that regulates atmospheric CO_2 over geological time. Grinding the rock increases reactive surface area and shortens the timescale from millennia to years.

Where the captured carbon is stored



Silicate application raises soil pH and returns base cations



Conditions for rapid weathering coincide with tropical cropland



Climatic controls on weathering rate

Silicate dissolution rates increase with temperature and water flux. Within the tropical belt — West Africa, the East African highlands, South and Southeast Asia — these conditions coincide with extensive existing cropland.

- land inside the tropics
- land outside it
- the tropics, 23.4° N and S

Cropland best suited to enhanced weathering is concentrated in the Global South.

National-scale siting guidance is largely unavailable



No district-level differentiation.

With a national screening index



Districts scored, ranked and documented.

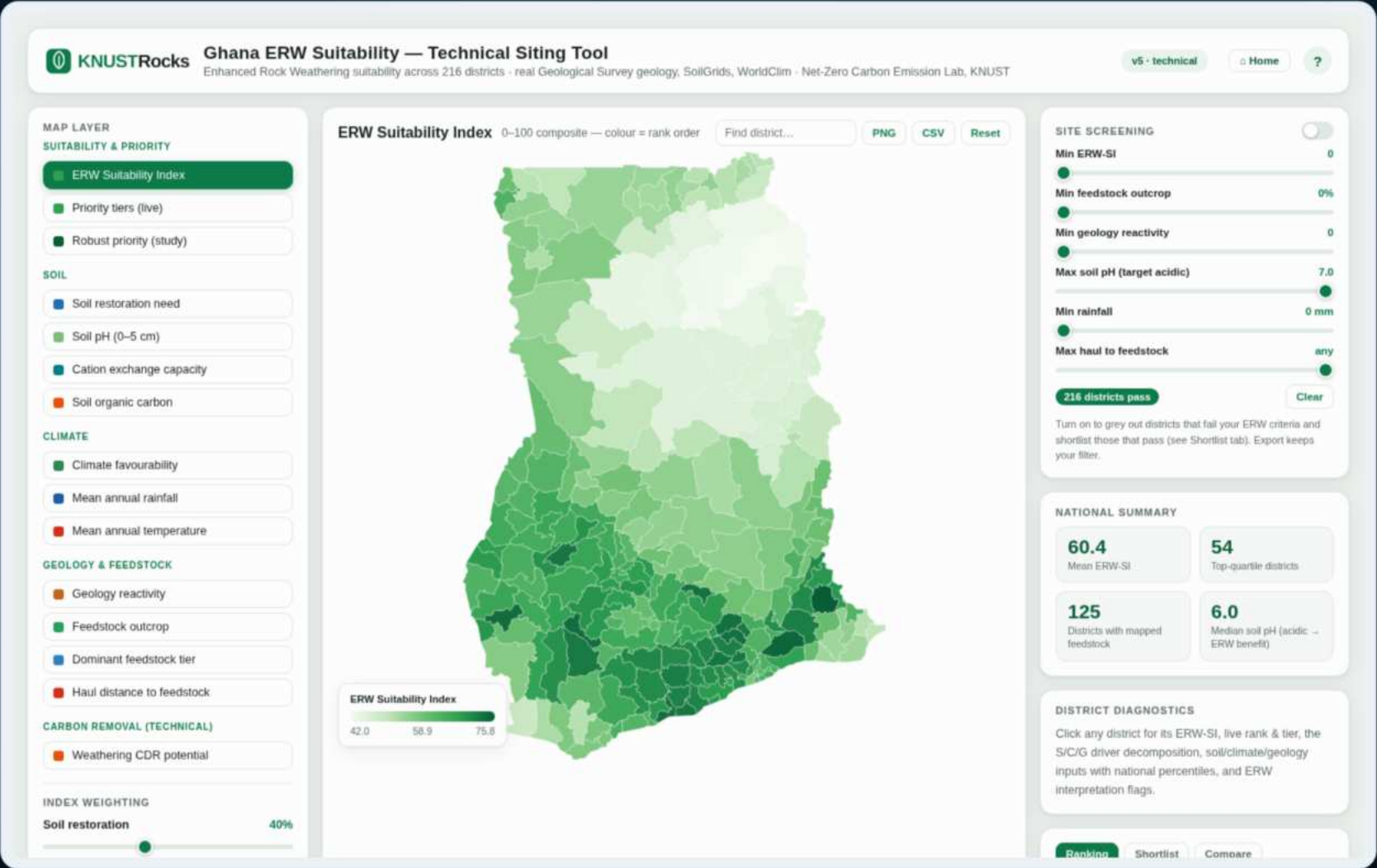
ERW-SI

Global assessments resolve to continents or agro-ecological zones. Most African countries have no district-level basis for deciding where enhanced weathering should be trialled first.

KNUSTRocks: a national siting platform for Ghana

- 216 districts scored on open data
- Soil · climate · geology · feedstock
- User-adjustable weights and criteria
- Open access, browser-based

Designed to move from a national overview to a documented shortlist of districts.



A transparent index from soil, climate and geology



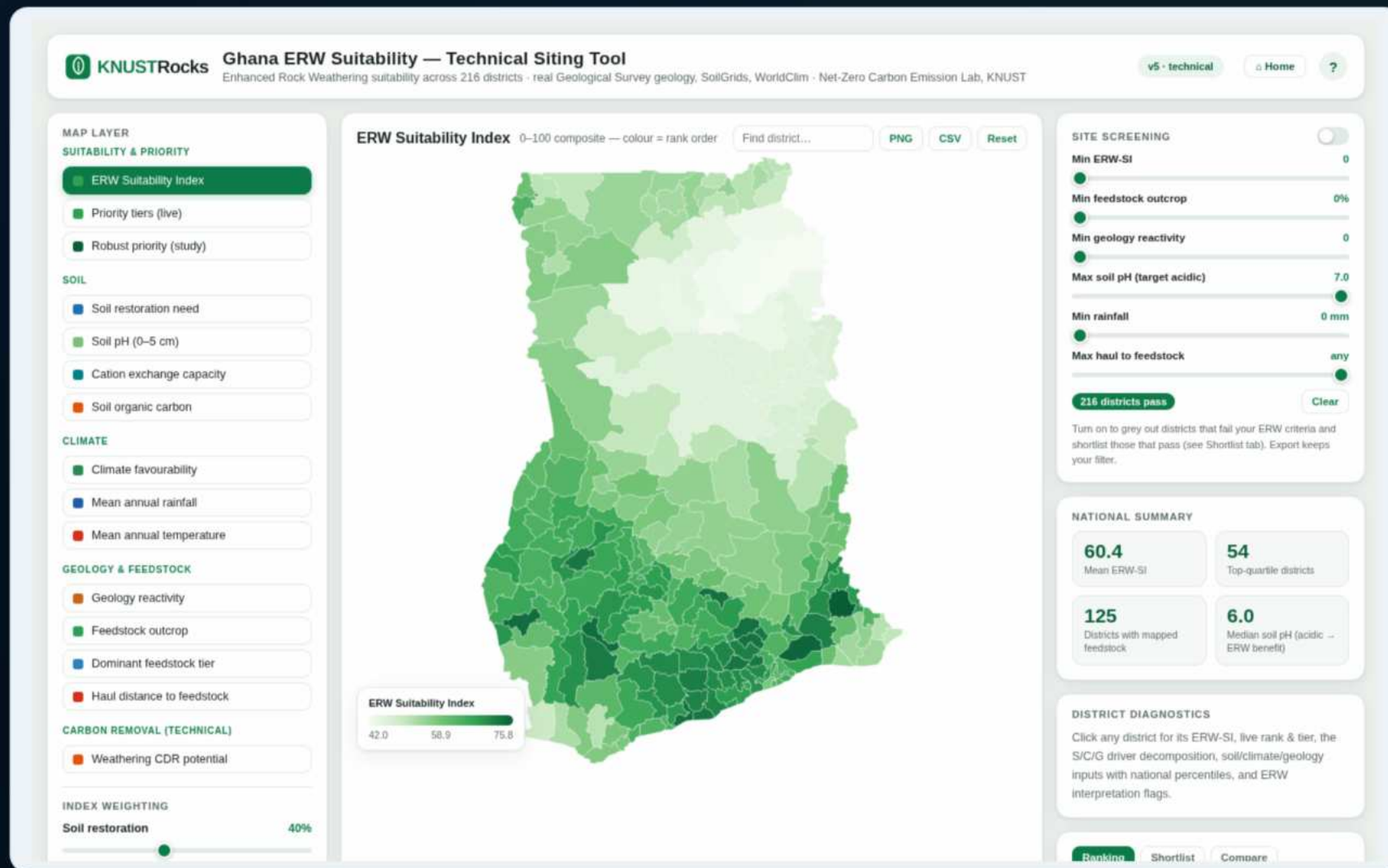
All inputs are openly available datasets — SoilGrids, WorldClim and the national geological survey. Sub-indices are normalised with documented membership functions, and the ranking is tested against alternative weightings.

ERW suitability across all 216 districts

42–76

ERW-SI, 0–100 scale

Suitability is highest in the forest-belt south, where acidic, well-buffered soils coincide with high rainfall and reactive silicate lithologies. The drier north scores lower.

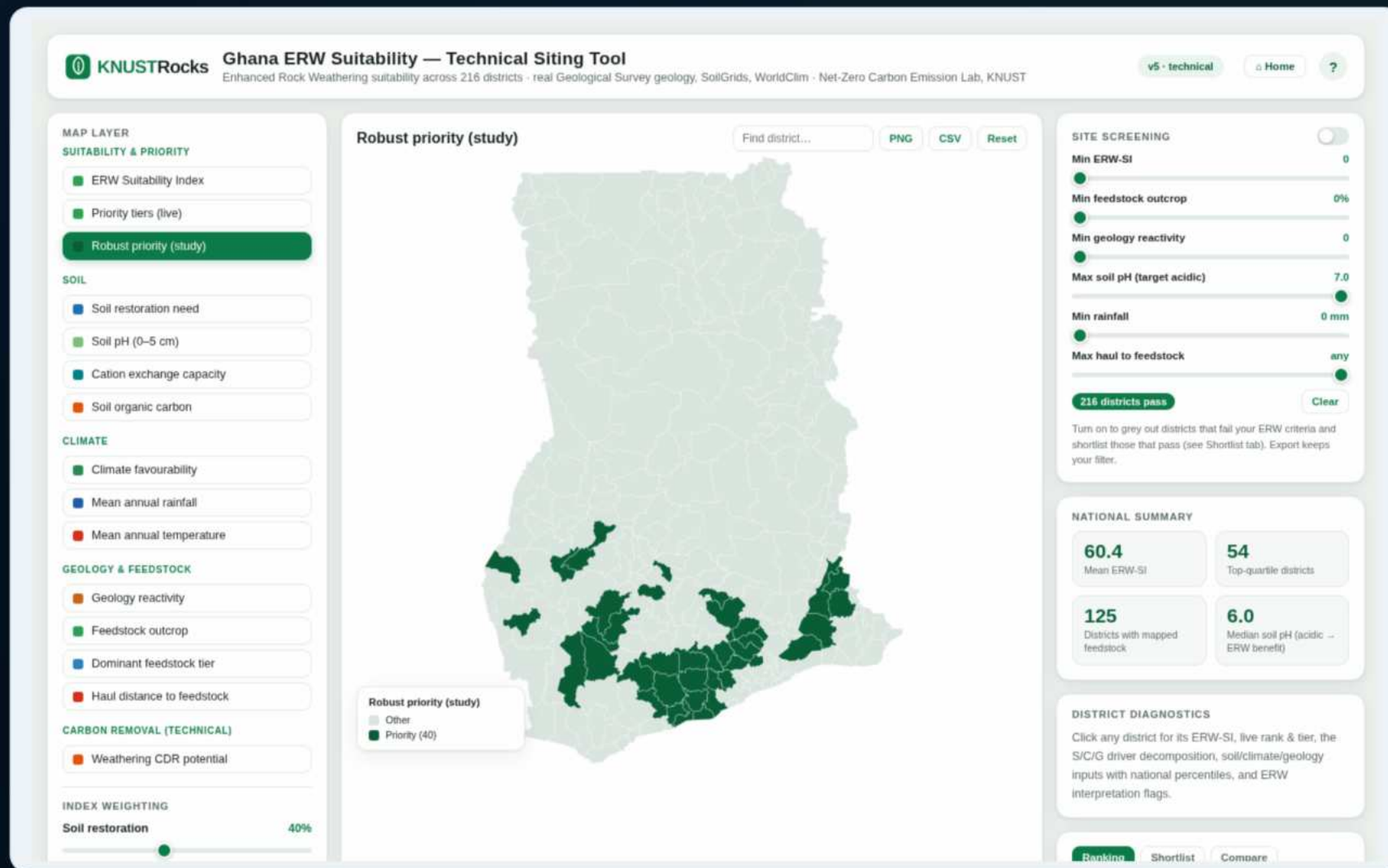


Priority districts are stable across weighting schemes

40 districts

robust top quartile

Rank agreement of $\rho = 0.88\text{--}0.99$ across alternative soil, climate and geology weightings. The same forty districts remain in the top quartile throughout.

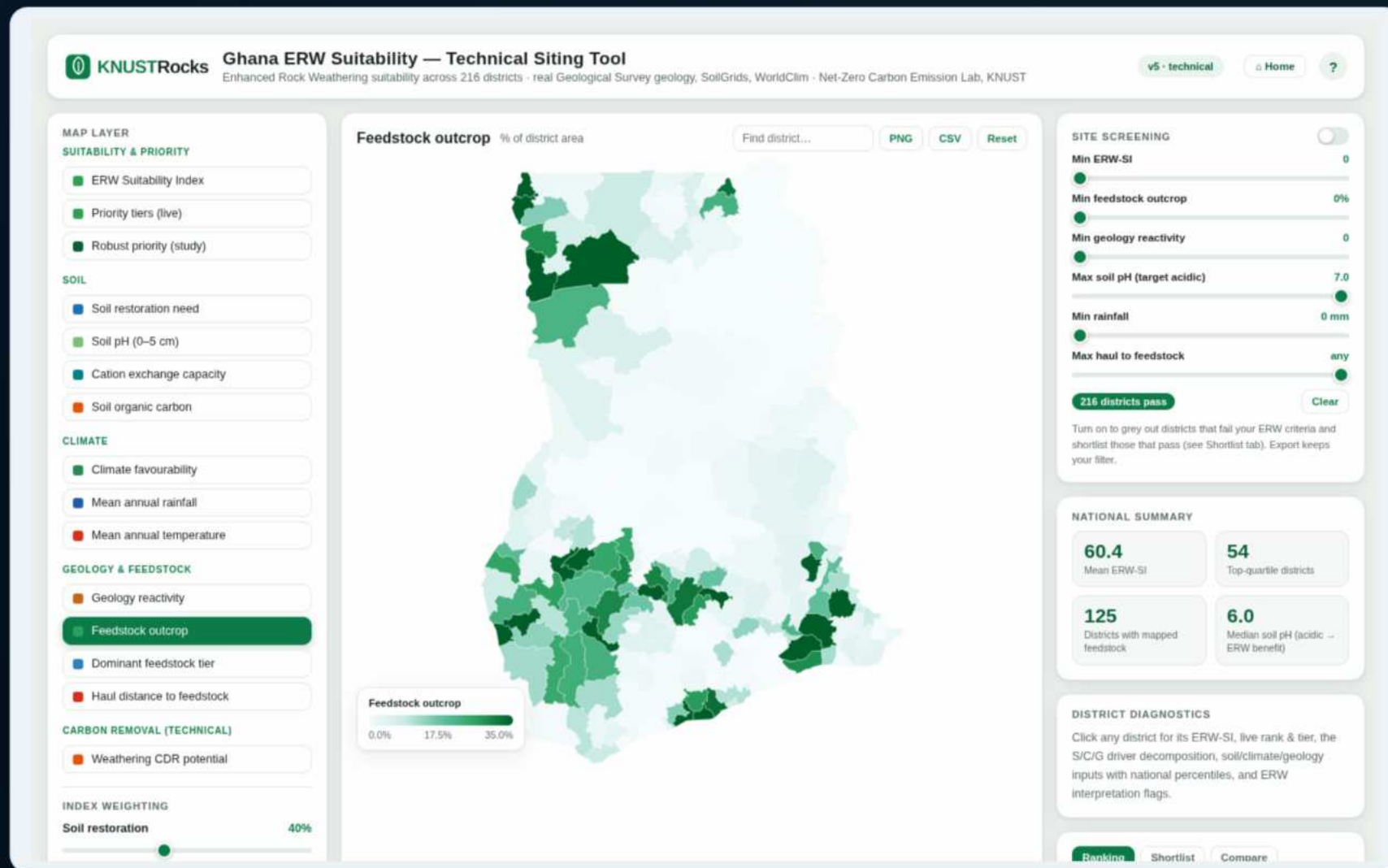


Reactive feedstock is widely distributed

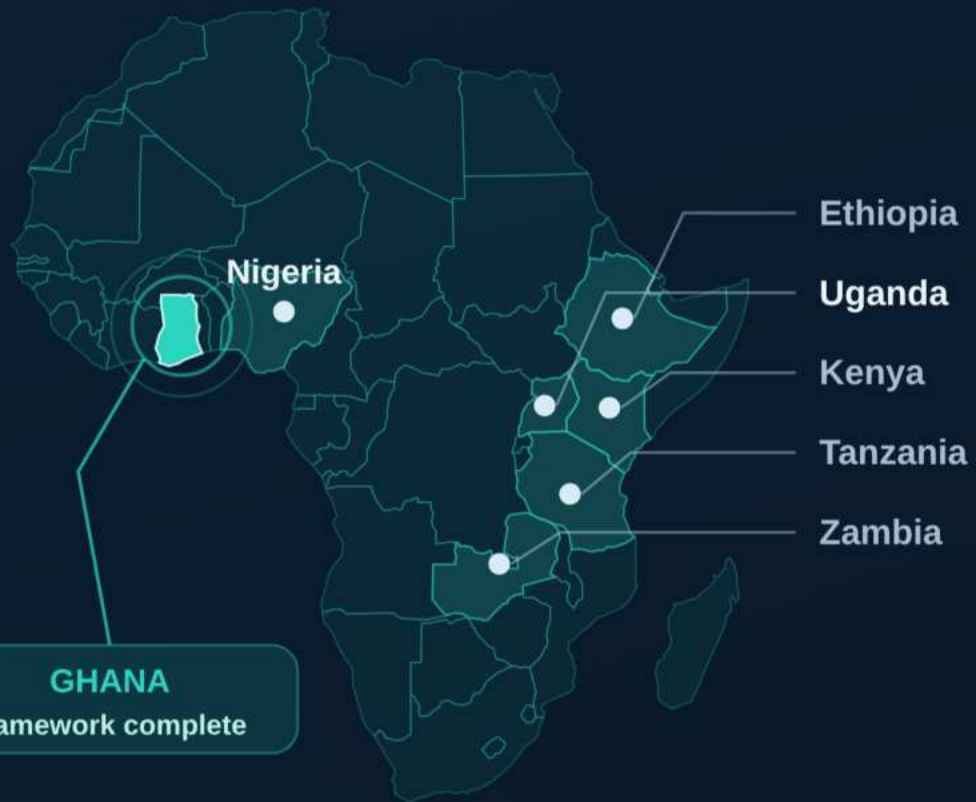
18,550 km²

of mapped reactive silicate rock

Greenstone, gabbro, dolerite and amphibolite outcrop in proximity to the priority districts, so feedstock supply is unlikely to be the binding constraint.



The framework extends to other tropical countries



Required inputs and their sources

- **Global soil data**
SoilGrids — free, worldwide
- **Global climate data**
WorldClim — free, worldwide
- **Your own geology map**
from your national survey

The same inputs are available
for every tropical country.

Roadmap and invitation to collaborate



We would welcome collaboration with EWAP partners on national siting tools for other countries, on joint field-trial and MRV design, and on an open, comparable evidence base owned by African institutions.



Cascade
Climate

Cascade Climate: Who we are

A philanthropically backed non-profit. We pick climate solutions with outsized potential, diagnose what each one still needs in order to take hold, and then assemble those missing pieces.

In enhanced rock weathering (ERW), that has meant creating:

- A comprehensive technical reference for quantifying carbon dioxide removal (CDR) in ERW
- Tools that explore ERW's metal accumulation risk and global weathering potential
- Data sharing platform to unlock deployment-led learning

ERW Coordinated Research Network

ERW field trials today measure different things in different ways, so their results cannot be intercompared. The network is built to gain understandings about ERW's CDR potential and agronomic effects across different global contexts.

What it is

- Network of heavily replicated & densely measured small-plot trials in high-priority geographies
- One standardized design and one set of standard operating procedures used at every site
- Deliberately diverse hydro climates and soil types
- A minimum five-year measurement window

Where it stands

- Expression of interest opened for host sites February 2026
- 90 applications received, from 21 countries
- Two pilot sites launching in 2026 / early 2027
- Expand to up to 12–15 sites by 2029

What the network is designed to answer

1



Agronomic
impacts and
mechanisms

How does ERW change yield, soil health and organic carbon? Through which mechanisms: pH, nutrient availability, silicon, micronutrients?

2



Constraining
the magnitude
and timing of
carbon removal

How much carbon is removed, over what timescale, and how much does that vary with climate, soil and feedstock?

3

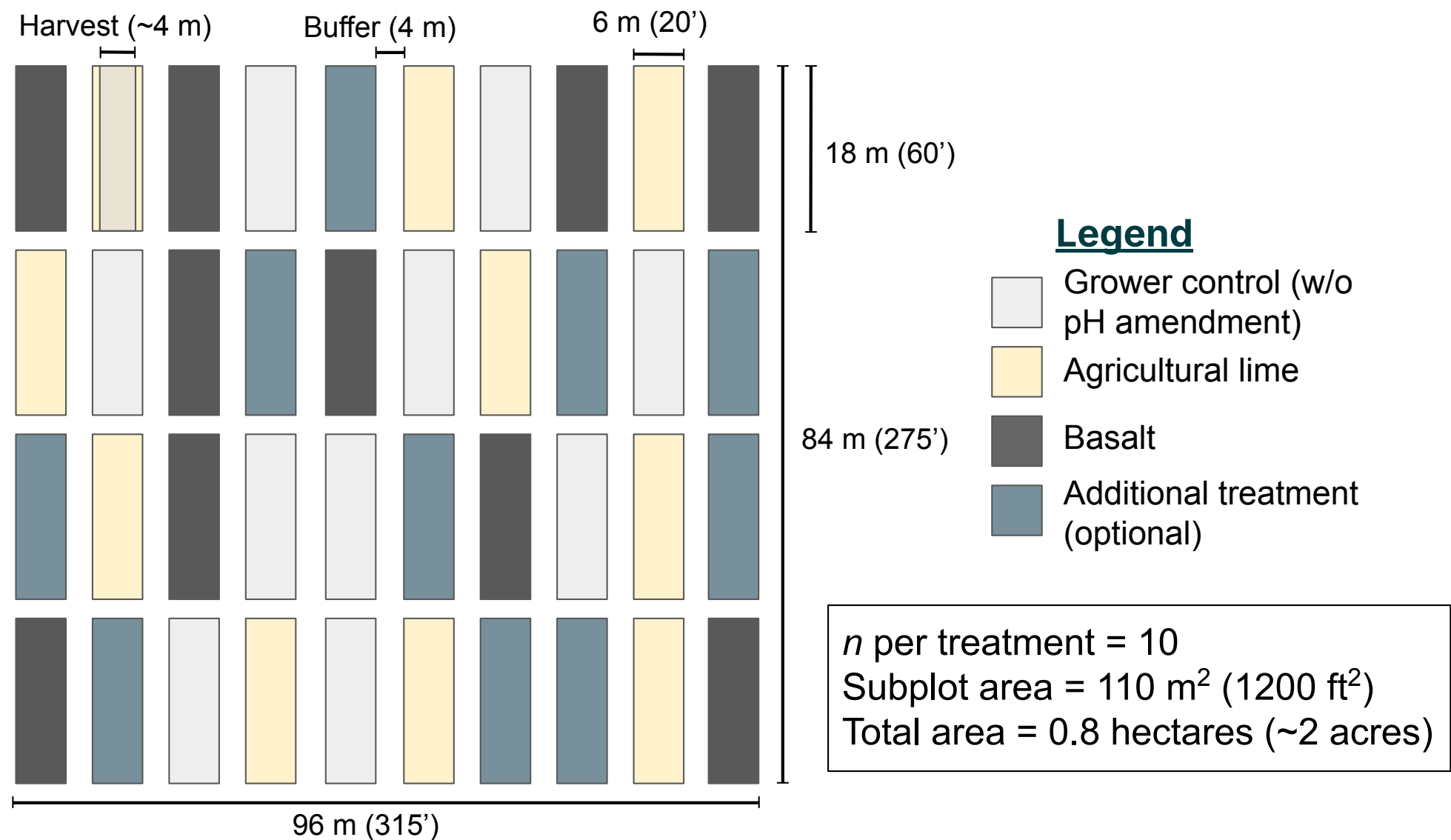


Understanding
deep soil
processes via
models

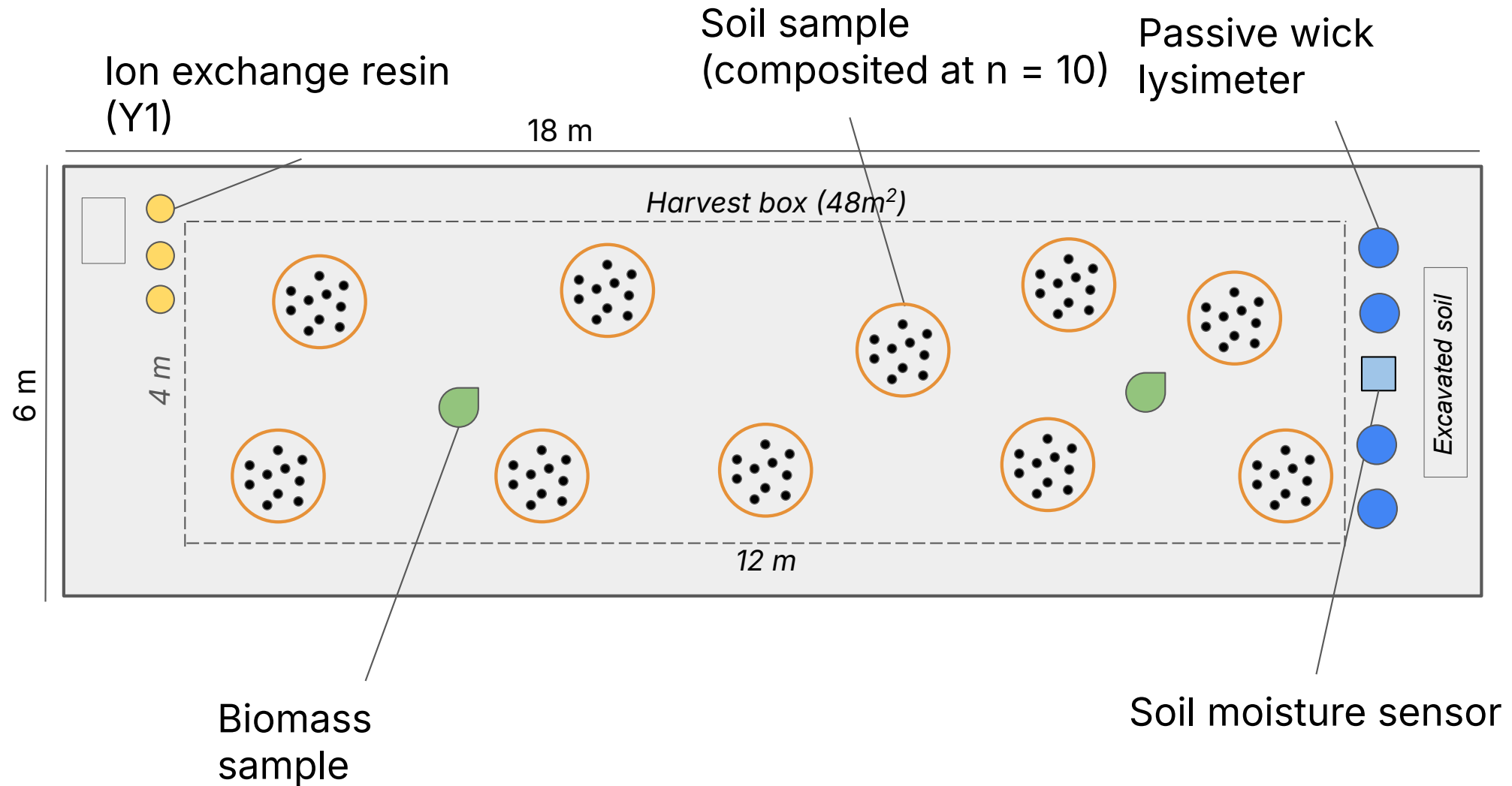
What processes control reversals of CDR in deep soils (> 1 m) and groundwater systems, and what is the potential range of magnitudes of these reversals?

One cross-cutting question, asked at every site: do the three CDR quantification methods (solid-phase mass balance, porewater, and ion-exchange resins) actually agree?

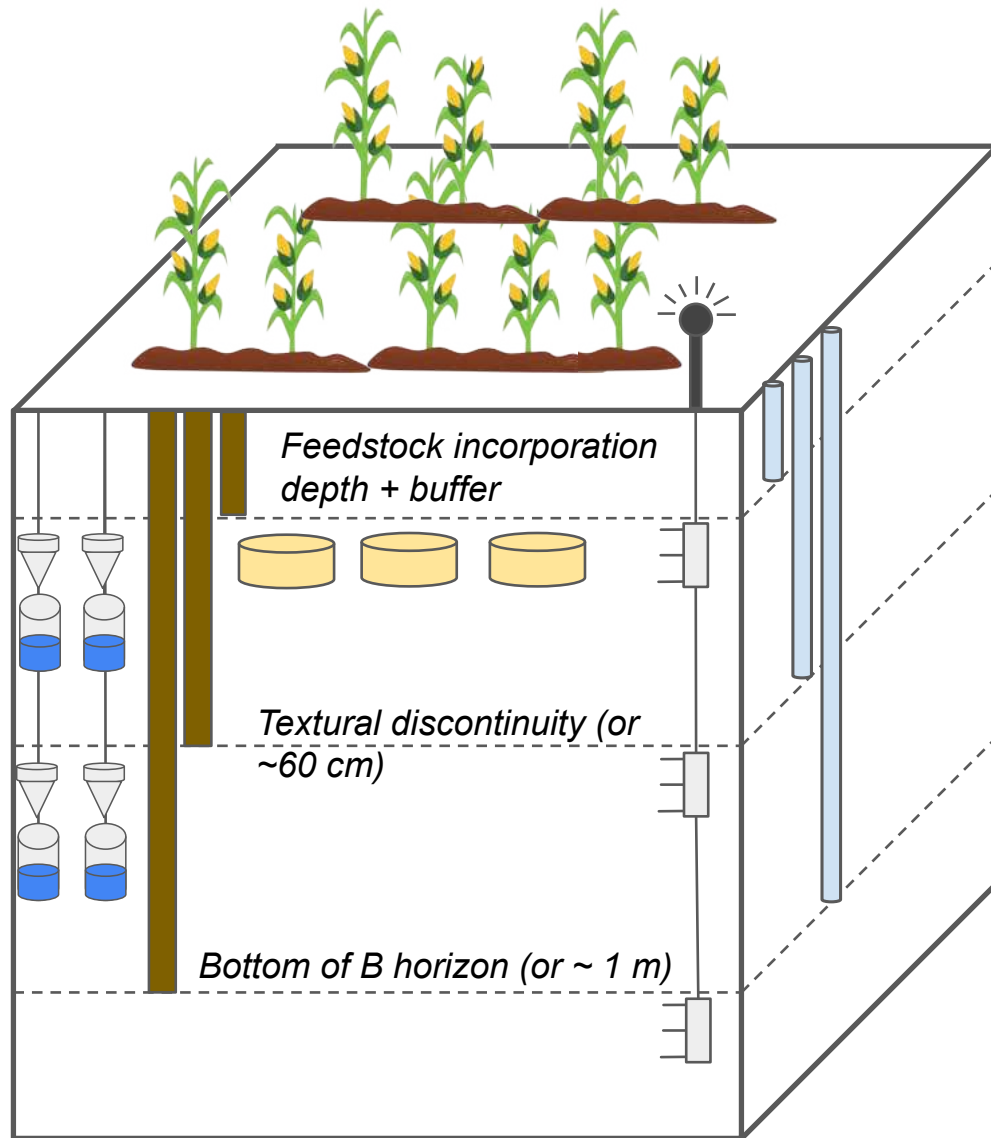
Plot layout



Approach: CDR and agronomic quantification



Approach: understanding deeper carbon fluxes



-  Soil core
-  Passive wick lysimeter
-  Ion exchange resin
-  Soil moisture sensor (subset of plots)
-  Soil gas well (subset of plots)



EWAP Uganda Stakeholder Meeting on Enhanced Weathering in Agriculture

Uganda's Agricultural Priorities, Crops and Farming Systems

Dr. Pamela Paparu

August 05, 2026

UGANDA'S AGRICULTURAL PRIORITIES

Uganda's agricultural priorities are aligned to:

- UN's SDGS
- AU Agenda 2063
- CAADP Strategy 2026-2035
(Building Resilient Agri-Food Systems in Africa)
- Vision 2040





Uganda's National Development Plan IV

- PART III of NDPIV lists 17 development programmes envisaged to ensure successful implementation of the plan
- The 1st being **Agro-industrialization**
- Agro-industrialization has a total of 6 objectives including **“Sustainably increase agricultural production and productivity”**
- This objective has 11 intervention areas including;
 - Undertake and support appropriate research and genetics improvement and uptake
 - Increase the uptake of fertilizers
 - Produce, multiply and distribute seed and inputs
 - Promote climate adaptation and mitigation practices
 - Strengthen pest, vector and disease management and control
 - Etc.



NARO's Strategic Plan 2026-2030

▪ **Strategic theme** = An Innovation led Resilient Agro-industry in Uganda

Strategic Objectives

- 1: Increase production and productivity-enhancing agricultural technologies and innovations
- 2: Increase generation of quality-enhancing and loss-reducing harvest, post-harvest and storage technologies and innovations
- 3: Increase market and industry responsive value-added agro-based products and services
- 4: Enhance access and sustainable utilisation of improved agricultural technologies and innovations
- 5: Strengthen institutional capacity to undertake and coordinate agricultural research



National Crops Resources Research Institute

EST. 1947

Goal: improve productivity, quality and access to crop technologies for enhanced food security, nutrition, incomes and inclusive growth



Key area of Research for Development

- Production and productivity increase - breeding, genetic innovations – focusing on traits such as yield, nutrition, industrial and stress tolerance(drought, soils, pests, diseases)
- Resilient production systems – plant health (pests, diseases), agronomy, soils, water, climate
- Genetic resources management
- Utilization of modern biosciences at both the discovery and application stages
- Early generation seed production and development of demand-led seed systems
- Inclusive value chains - value-addition and product development
- Technology promotion, scaling, access and application at critical value chain nodes
- Capacity building of Partners and stakeholders – Entrepreneurs, off-takers farmers, extension, etc
- Communication, knowledge and information dissemination
- Socio-economics – market and industry intelligence, adoption, impact, gender, youth
- Policy and partnerships
- Research capacity - both human and infrastructure
- Funding and funding diversity



SELECTED CROPS OF ECONOMIC IMPORTANCE IN UGANDA

LEGUME CROPS

COMMON BEAN



- Grown by >85% Households
- Ecosystem friendly (fix nitrogen, easily intercropped, ground cover, etc.)
- Food and nutrition security crop – early maturing, nutrient dense

GROUND NUTS



- Ground nuts are the 2nd most important legume after common bean
- Cash crop, earning \$ 440 million annually

Other legumes of economic importance include Soy bean, Cowpea, Field Pea, Chick pea, Pigeon pea, etc.

CEREAL CROPS

MAIZE



- Annual production = 5.0 million MT
- Annual earnings from maize is about

RICE



- Second most-produced cereal after maize
- Annual production is >160,000 MT

Other cereals of economic importance include Wheat, Finger millet, Sorghum

ROOT CROPS

CASSAVA



- *Cassava is a food crop and cash crop*
- *Grows well in diverse environments throughout the country*
- *An important industrial crop (beer, ethanol, starch, etc.)*



YAM

SWEET POTATO



- *Sweet potato is a food crop and cash crop*
- *Uganda is the 4th largest producer in the world, and 3rd in Africa*
- *Annual earnings from the crop is about 150 million USD*

BANANA

- *Banana is a staple food and cash crop to over 50 million people in East Africa*
- *Uganda accounts for 15% of global banana production*
- *Per capita consumption in Uganda is 300 kg*
- *It offers opportunities for industrial products, e.g starch, hair extension, sanitary pads, etc.*

GREEN BANANA (MATOOKE) RESISTANT STARCH



Natural,
Gluten free,
organic,
Unmodified

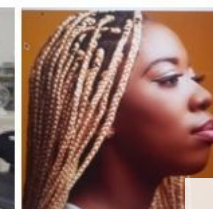


Produced by:

National Banana Research Program,
National Agricultural Research
Laboratories - (NARL) Kawanda
P.O.Box 7065, Kampala (U),
Tel: +256 414 699 242,
www.banana.go.ug



Biodegradable, natural hair extensions from banana fibre



HORTICULTURAL CROPS & OIL PALM



Mangoes-*Mangifera indica*



Passion fruit-*Passiflora edulis*



Cabbage-*Brassica oleracea*



Chilli pepper-*Capsicum annuum*



Oranges-Citrus



Nakati-*Solanum aethiopicum*



Dragon fruit-*Hylocereus undatus*



Oil palm-*Elaeis guineensis*

COFFEE

- Coffee has been a major cash crop since colonial times
- Grown by 4.2 million households
- Annual earnings from coffee is about 284 million USD
- Employs over 500,000 in its trade
- Uganda mostly exports





UGANDAN CROPPING SYSTEMS

Cropping System = Cropping Patterns and Crop Management Practices

Key Cropping Patterns in Uganda

- Uganda has > 8 agroecological zones, and crops have adapted differently to these zones (**see table below**)
- Monocropping – A single crop on a piece of land. Mostly practiced by large scale growers
- Intercrops – 2 or more crops on a piece of land, in an orderly manner. Popular among smallholders.
- Crop rotation – Sequential planting of different crops on a single piece of land – less practiced due to crop specialization
- Fallows – Leaving the land without crop. Less practiced due to land shortage
- Multiple cropping – Uganda has 2 growing seasons. However crops like beans and vegetables can be grown several times in the year



Ugandan Agroecologies and Major Crops Grown



Agroecology	Annual Temperature (°C)	Annual Rainfall (mm)	Altitude (masl)	Main Crops Cultivated
West Nile Farming System	15-25	1340-1371	918-1454	Beans, cassava, tobacco ground nuts, coffee
Northern Mixed Farming System	15-32	1197	942-1182	Sim sim, beans, cotton, cassava, sweet potato
Karamoja Pastoral Zone	>20	<1000	1164-1475	Sorghum, beans, millet
Western Mixed Farming System	≤20	1000-1200	1052-1501	Banana, maize, beans, cassava, tobacco, g.nuts
Lake Victoria Crescent and Mbale Farmlands	15-32.5	1215-1328	1040-1433	Banana, coffee, beans, sweet potato, maize, etc
Eastern Highlands	≤20	>1200	1500-2200	Maize, banana, coffee, beans, Irish potato, etc.
Southwestern Highlands	≤20	>1200	1247-2313	Banana, beans, Irish potato
Teso Farming System	>20	<1000	1072-1130	Sorghum, sweet potato cassava, beans, millet



UGANDAN CROPPING SYSTEMS

Cropping System = Cropping Patterns and Crop Management Practices

Common Crop Management Practices

- Land cultivation – using either hoe, oxen or tractor
- Variety choice – local or improved (NARO released)
- Planting – mostly by hand, planters may be used, planted in rows or scattered
- Harvesting – mostly non-mechanized
- Fertilizer use – very limited use among farming household (est. 10%)
- Weed control – mostly mechanical (hand weeding), selective and non-selective herbicides are available on the market
- Pests and Diseases management – cultural practices, pesticides and biological control are implemented variously



Key Agronomic Constraints

- Poor soils – exhausted, nutrient deficient, hard pans
- Droughts
- Heat stress
- Pests and diseases
- Non-adaptable



**THANK YOU FOR
LISTENING**

Enduring Gains in Maize Yield as Co-Benefit of enhanced Weathering of Greenlandic glacial rock flour in Ghana

**Eric Oppong Danso and Christiana
Dietzen**



UNIVERSITY OF GHANA

INTRODUCTION



- **Glacial rock flour (GRF) is an ultrafine silicate rock powder produced by the Greenland Ice Sheet.**
- **Chemical composition suggests potential to enhance crop yield.**
- **Proof of concept was demonstrated in field trials in Denmark**
- **Three experiments were subsequently conducted in Ghana.**



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GRF EXPERIMENTS IN GHANA

Field Experiment 1 (on station):

- Compare GRF at 10 and 50 t ha⁻¹ vs control over five consecutive growing seasons

Field Experiment 2 (Farmers field):

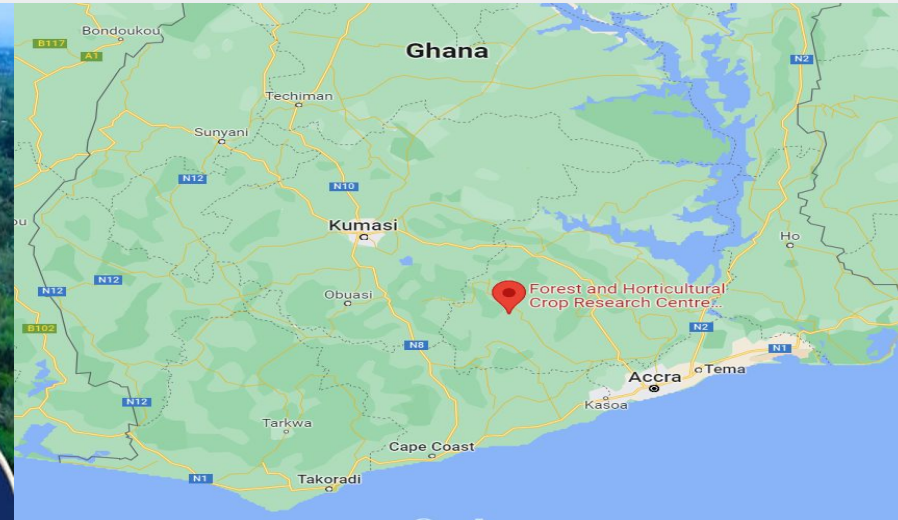
- Farmer-led field trials were conducted across seven locations in eastern Ghana
- Sites were amended with GRF at 20 t ha⁻¹ vs control over five consecutive growing seasons.

Field Experiment 3 (on station):

- Compare Optimized NPK (BAU) vs. negative control vs. GRF at 50 t/ha
- Single 20 t ha⁻¹ GRF application compared with two repeated 10 t ha⁻¹ applications.



LOCATION OF EXPERIMENTS



- ❖ University of Ghana, Accra.
- ❖ Forest and Horticultural Crops Research Centre (FOHCREC), Kade.
- ❖ Mean annual rainfall: 1,500 mm
- ❖ Mean annual temperature: 28 °C
- ❖ Acidic soils (pH of 5), texture is sandy clay loam.



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FIRST FIELD EXPERIMENT



- ❖ GRF amendment rates of 0, 10 and 50 t/ha
- ❖ Replicated 4 times
- ❖ Test crop: maize
- ❖ Soil: Sandy clay loam
- ❖ Location: FOHCREC, UG



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FIRST FIELD EXPERIMENT CONT.



Data collected:

leaf area index,

Leaf chlorophyll content index,

Plant height,

Grain yield,

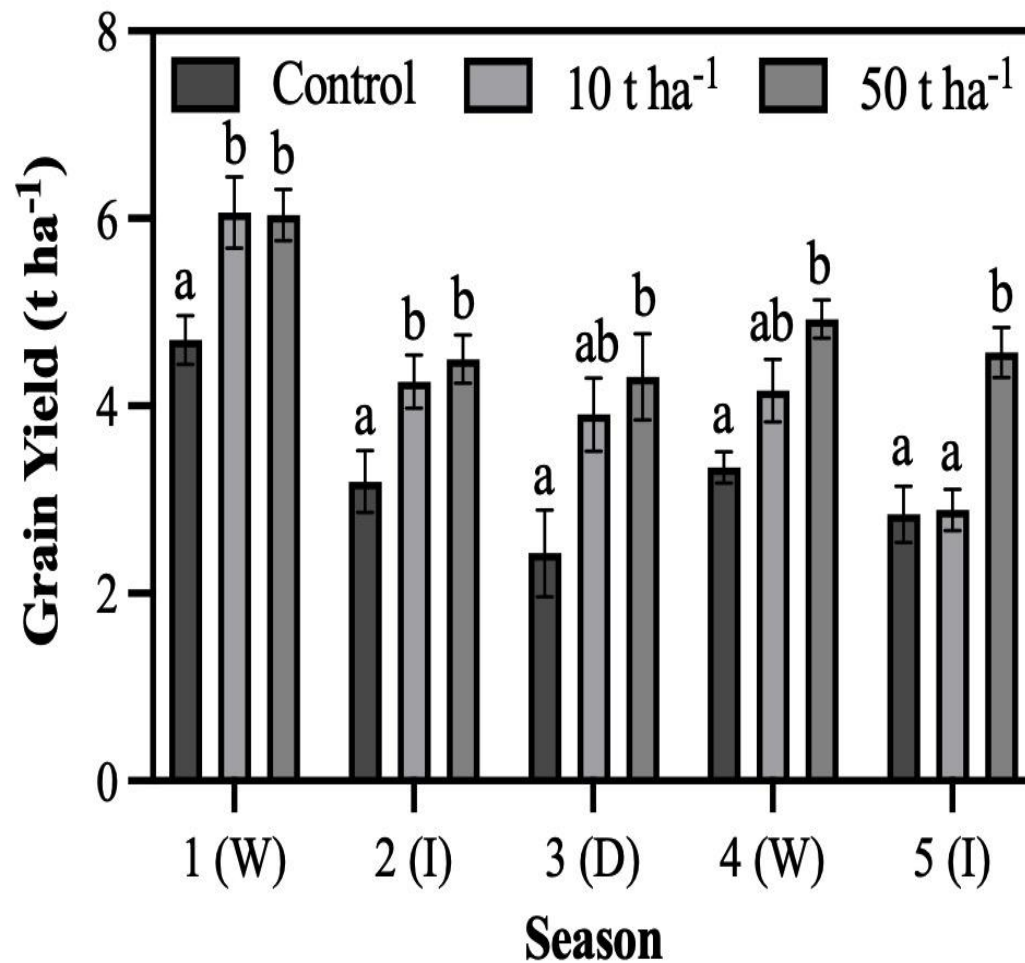
Total dry matter yield,

Soil water content



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RESULTS: YIELD OF 5 CONSECUTIVE FIELD EXPERIMENTS



Test crop: maize



Soil: Sandy clay loam



Location:
FOHCREC, UG



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FARMERS' FIELD EXPERIMENT.



- ❖ GRF application in 7 farmers' fields
- ❖ Rates of 0 and 20 t/ha
- ❖ Replicated 4 times
- ❖ Location: Seven locations in the Eastern province of Ghana

FARMERS' FIELD EXPERIMENT.



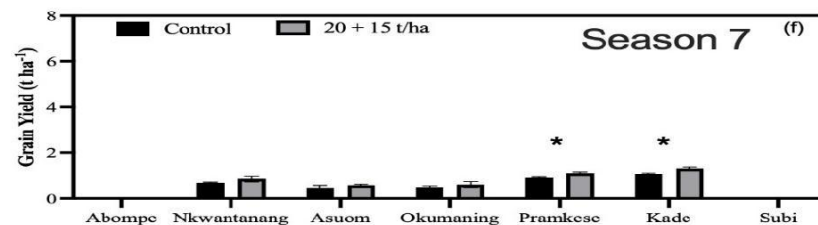
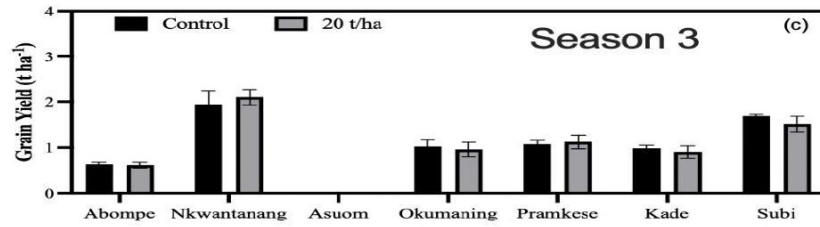
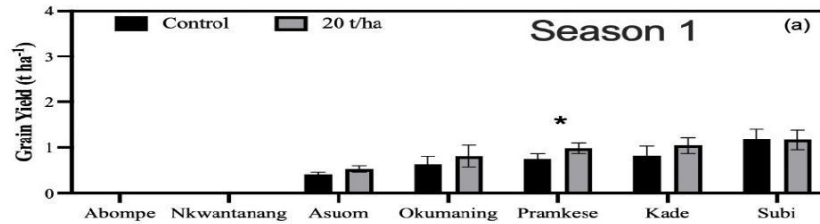
Representative photographs of maize grown under different treatments: (a) control (no GRF application) and (b) GRF-amended treatment.



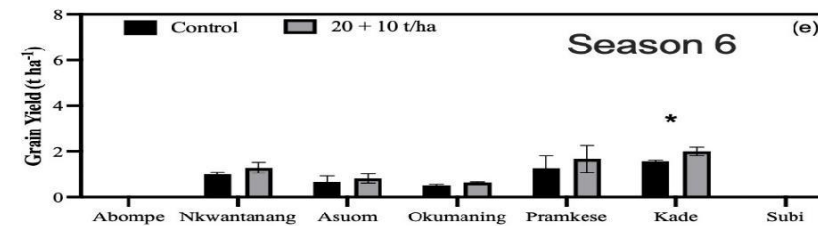
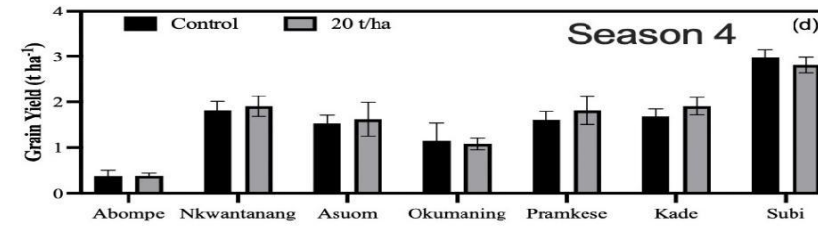
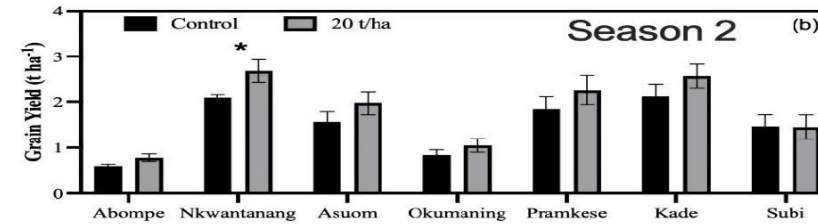
RESULTS:

YIELD OF 7 CONSECUTIVE FIELD EXPERIMENTS

Minor Seasons



Major Seasons



THIRD FIELD EXPERIMENT

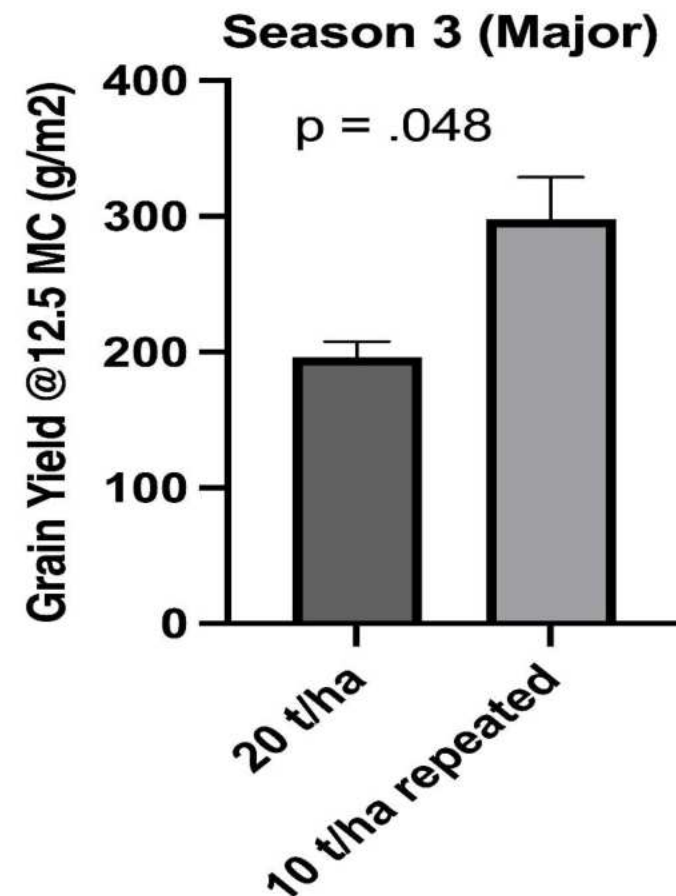
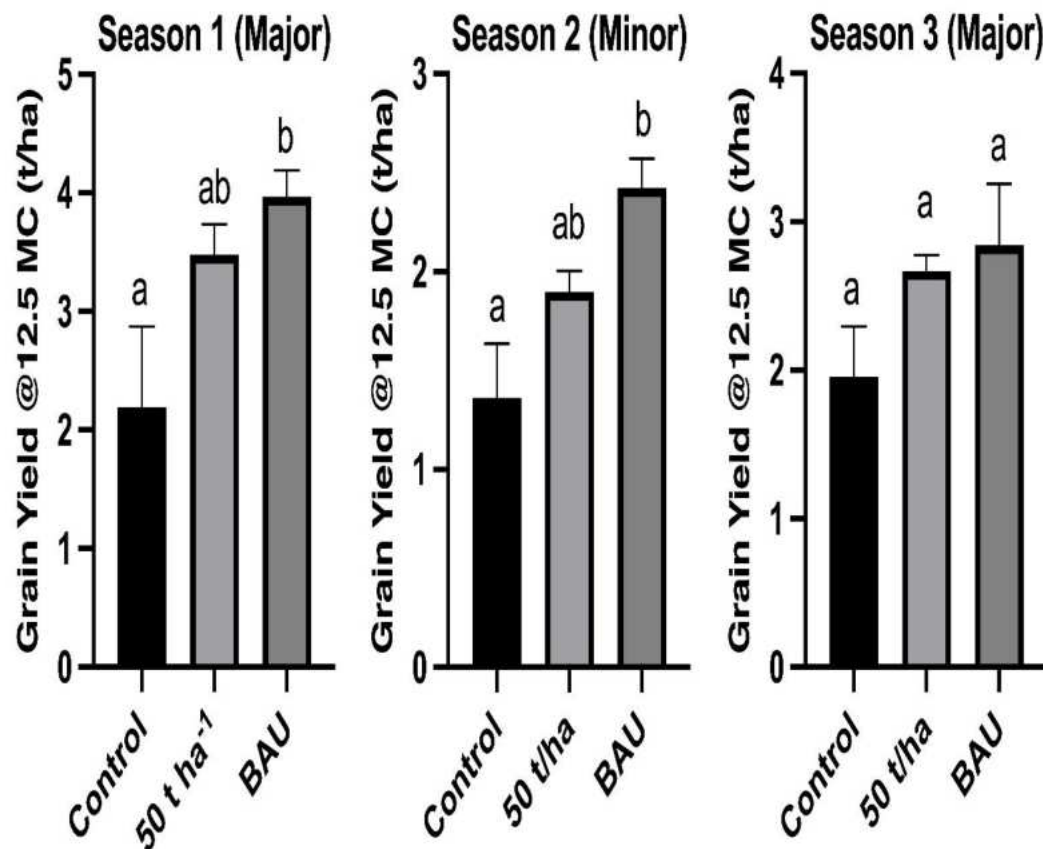


- ❖ GRF applied at 50 t/ha vs Optimized NPK (BAU) vs. negative control vs
- ❖ Single 30 t ha⁻¹ GRF application compared with three repeated 10 t ha⁻¹ applications.
- ❖ Replicated 4x
- ❖ Soil: Sandy clay loam
- ❖ Location: FOHCREC, UG



UNIVERSITY OF GHANA

RESULTS: THIRD EXPERIMENT



CONCLUSIONS

- On-station, GRF at **10 and 50 t/ha** increased maize yield by **~30%** relative to the control.
- Residual yield benefits persisted for **2 seasons** at **10 t/ha** and **5 seasons** at **50 t/ha**.
- On-farm, on average, **20 t/ha** of GRF increased maize yield for two seasons.
- In a separate on-station trial, **50 t/ha GRF** produced yields comparable to **optimized NPK fertilization**.
- **Two consecutive applications of 10 t/ha** outperformed a **single 20 t/ha application** by **~30%**.



THANK YOU



UNIVERSITY OF GHANA



EWAP Uganda Stakeholder Workshop on Enhanced Weathering in Agriculture

5th August, 2026

NARO-NaCRRI, Namulonge, Uganda

Enhanced Weathering Africa Partnership (EWAP-GHANA)

Partnership with University of Exeter Business School

CSIR Thematic Area: Food Security and Poverty Reduction & Climate Change, Environmental Management and Green Technology

**Scoping Review and Feasibility Studies of Enhanced Rock Weathering in Ghana
(Design Phase)**

The Team

NAME	RANK/ SPECIALIZATION	INSTITUTION
Dr. Eunice Oppon	Senior Lecturer/ EWAP Lead	University of Exeter Business School
Dr. Benedicta Nsiah Frimpong	Research Scientist/ Agricultural Economist	CSIR-Crops Research Institute
Dr. Joyce Afua Sarpong Haleegoah	Principal Research Scientist/ Rural Sociologist/ Gender Expert	CSIR-Crops Research Institute
Dr. Albert Kobina Mensah	Research Scientist/ Environmental Soil Scientist	CSIR-Soil Research Institute
Dr. Ephraim Sekyi-Annan-	Senior Research Scientist/ Soil and Water Engineer	CSIR-Soil Research Institute

Presentation Outline

- Background
 - Research problem
 - Benefits of Enhanced Rock Weathering (ERW)
 - Global applications of ERW
- Research Objectives
- Area of Work/ Planned Activities
- Research Approaches
- Progress and Next Steps
- Analytical Approaches

Background

- Africa's population is to reach 2.5 billion by 2050, placing additional strain on already overburdened agricultural systems
- Food production is expected to increase by 100-110% (Elferink and Schierhorn, 2016)
- Achieved through intensification resulting in negative nutrient imbalances
- Ghana has one of the lowest fertilizer application rates in the sub-region, primarily due to economic factors (Yeboah *et al.*, 2023)
- Given the inadequate soil conservation efforts and the increasing impacts of climate change, initiatives promoting sustainable agricultural practices, soil conservation, and fertility management are critical

Benefits of Enhanced (Rock) Weathering

Benefits

- Climate solution as it captures atmospheric carbon
- Carbon sequestration through chemical weathering of the rocks.
- Improves soil structure
- Improves soil fertility and crop yields
- Enhances incomes and livelihoods of stakeholders

Global Applications of Enhanced Weathering (EW)

Countries

□ United Kingdom

□ USA

□ Brazil

□ Kenya

Crops



Sorghum



Potato



Maize



Sugarcane

Other suitable
crops



Cassava



Yam



Plantain



Rice

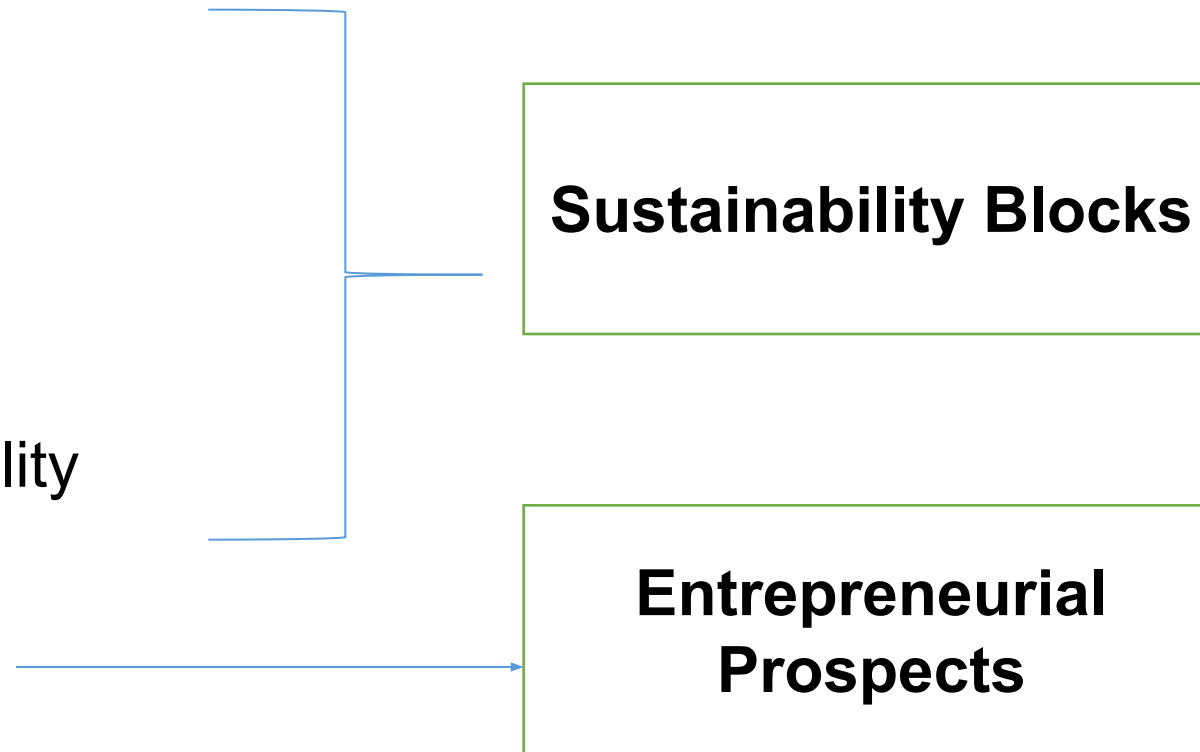
Broad Project Objectives of EWAP

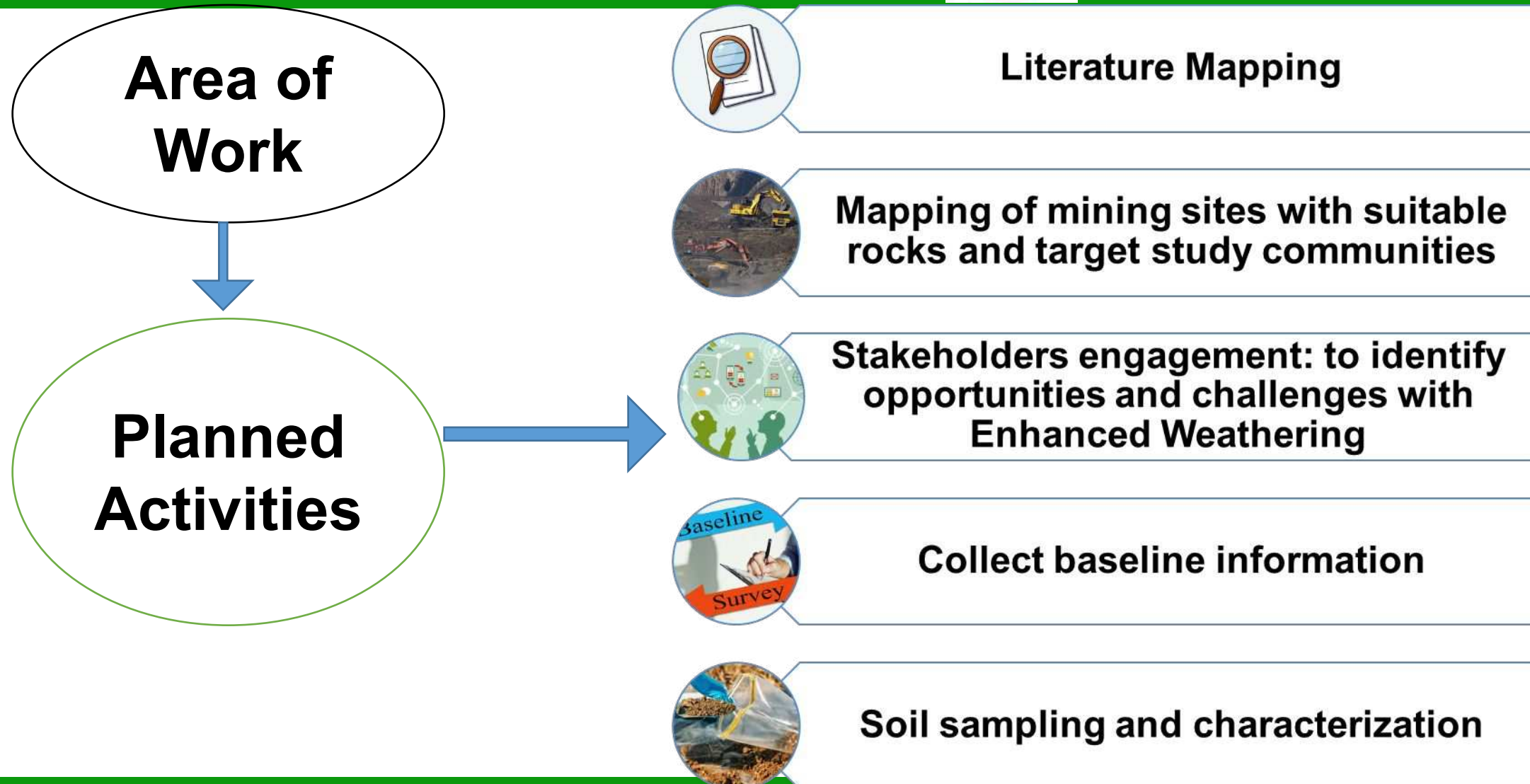
- EWAP seeks to spearhead the adoption and scaling of Enhanced Weathering (EW) as a climate solution across Africa.
- Identify and address both the opportunities and challenges associated with Enhanced Weathering
- Create a knowledge hub

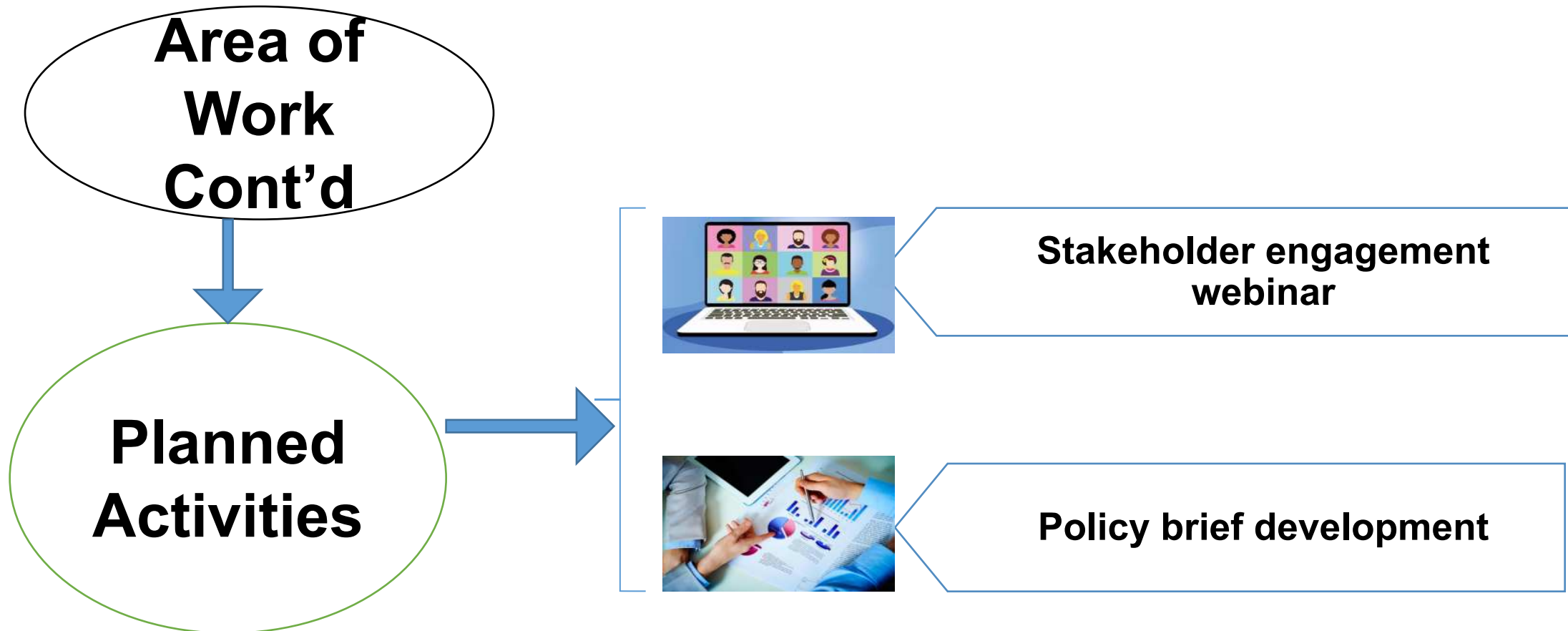
Specific objective for the design phase- Ghana

Conduct scoping and feasibility study of the Enhance Rock Weathering Innovation in Ghana

- Technical Feasibility
- Social Acceptability
- Economic Feasibility
- Environmental Feasibility
- Business Potential







Our Approaches

Mixed method approach

□ Qualitative

- Participatory decision-making methods (Stakeholders as co-researchers)
- Personal visits/ observations

□ Quantitative

- Survey in one mining district in Eastern Region

Progress and Next steps

Scoping Review Progress

- **Search conducted across four databases (2006-2026)**
 - Crossref -10000
 - Google Scholar-189
 - PubMed- 9
 - Semantic Scholar-26
- **10224 records identified**
- **Deduplication: 7192 records in Rayyan**
- **Title screening: 50% complete**

Progress and Next steps

Next steps: Scoping review

- **Title screening**
- **Abstract screening**
- **Full-text screening**
- **Data extraction**
- **Reporting using PRISMA-Scr checklist**

Progress and Next steps

Feasibility Study Progress

- **Mining sites identified and final site selection made**
- **Study communities selected**
- **Stakeholders engagement initiated**
- **Field instruments finalized and programmed**

Progress and Next steps

Next steps: Feasibility study

- **Conduct enumerator training**
- **Undertake data collection, Analysis and Reporting**
- **Host stakeholder validation webinar**
- **Develop policy brief**

Analytical Procedure

□ Qualitative

- Thematic Analysis
 - Develop themes and identify patterns
 - Categorize the themes and establish connections

□ Quantitative

- Logistic regressions
- Financial viability and stability analysis (Costs, Benefits, Return on investment)
- Network analysis

Details of Literature Search

Database	Records Identified
1. Crossref	10000
“Enhanced rock weathering” Ghana	1000
ERW Ghana	1000
“Basalt application” Ghana	1000
“enhanced rock weathering” barriers challenges Ghana	1000
“enhanced rock weathering” adoption Ghana	1000
“enhanced rock weathering” feasibility Ghana	1000
“enhanced rock weathering” opportunities Ghana	1000
“enhanced rock weathering” “soil sampling” soil characterization” Ghana	1000
“silicate weathering” Ghana	1000
“rock dust” Ghana	1000

Details of Literature Search

Database	Records Identified
2. Google scholar	189
Basalt “Soil characterization” Ghana	71
“enhanced rock weathering” barriers challenges Ghana	34
“enhanced rock weathering” adoption Ghana	37
“enhanced rock weathering” feasibility Ghana	34
“enhanced rock weathering” “soil sampling” Ghana	13
3. PubMed	9
“Rock weathering” Ghana	5
“dust rock” Ghana	2
“enhanced rock weathering” OR “rock dust” OR basalt Ghana	1
Basalt Ghana	1

Details of Literature Search

Database	Records Identified
4. Semantic scholar	24
“rock dust” Ghana	8
“enhanced rock weathering” Ghana	11
“basalt application” Ghana	3
“enhanced rock weathering” “soil sampling” Ghana	2

THANK YOU FOR YOUR ATTENTION

The background image shows a group of people, mostly men, standing in a dense field of tall green corn plants. They are dressed in casual clothing, including patterned shirts and a bright yellow shirt. The field is vibrant green, and the background features a line of trees and a cloudy sky. The overall tone is natural and agricultural.

SINC

TRANSLATING ERW SCIENCE INTO THE GHANAIAN FIELD

Youp Dumas, Founder Sinc
youp@sinc.earth

EWAP Uganda Workshop
August 5th, 2026

WHERE THIS STARTS

- Origin: decarbonisation strategies, carbon quantification research → research in The Netherlands
- Core question: does it hold up in a real farming system, under real conditions?
- Not alone → several ERW pilots running in parallel across Africa



THE PILOT, TWO TRACKS

- Prep: late 2025 → Field pilot live: May 2026, Ashanti Region
- Track 1 → CDR quantification: Isometric protocol, translated, with CSIR
- Track 2 → Agronomic: soil health & yield, smallholder systems
- Demonstration plots: trust first, bottom-up not top-down



GHANA'S FEEDSTOCK GAP

- Large mining sector ≠ easy feedstock
- Right rock likely exists geologically → location & active mining unclear
- Miners: no data on composition of extracted rock or tailings
- Feedstock ID today = site visits + sampling + lab analysis, one by one



WHY KAC?

- Partner: Kwadaso Agricultural College
- Translating Dutch research needs real local farming knowledge
- Goal: minimal distance between pilot and a real smallholder farm



AN UNCONTROLLED FIELD

- Controlled research $\neq$ uncontrolled field
- Multi-week drought mid-rainy-season $\rightarrow$ emergency interventions to save crop & porewater sampling
- Building local ERW capacity in parallel
 $\rightarrow$ very few experts yet in Ghana



EARLY SIGNALS

- Early vegetative growth data: height, stem diameter, leaf count
- Modest positive signal, treatment plot, by late season
- One season, one plot → no stats, yield, or soil chemistry yet
- Early signal, not conclusion



CLOSE

- Many small ERW pilots across Africa → limited shared learning
- Feedstock & farmland: abundant, not the real constraint
- Not competition → collaboration toward one shared goal
- Open to connect: feedstock characterisation, local-lab MRV



A photograph of a group of people, mostly men, standing in a lush green cornfield. They are dressed in casual clothing, including patterned shirts and a bright yellow t-shirt. The corn plants are tall and healthy. In the background, there is a dense line of tropical trees, including several palm trees. The sky is filled with heavy, grey clouds, suggesting an overcast day. The overall tone of the image is somewhat muted, with a greenish-grey tint.

www.sinc.earth
youp@sinc.earth

ENHANCED WEATHERING AGRICULTURE PROGRAM WORKSHOP

Climate Finance and Policy Pathways for Innovative Mitigation and Agricultural Resilience in Uganda

Building resilient agriculture while advancing Uganda's low-carbon development agenda

5 August 2026

Alfred Ruhambisa

Ministry of Finance, Planning and Economic Development | Uganda

Uganda's Climate and Development Context

Uganda's Development Ambitions

- Vision to grow Uganda into a US\$500 billion economy
- Agriculture remains central to economic transformation
- Food security and agricultural productivity are macroeconomic priorities

23–24%

of GDP

65%+

of labour force
employed

~70%

of households
supported



Climate Risks Are Increasing

- More frequent droughts
- Unpredictable rainfall
- Flooding and landslides
- Soil degradation
- Declining agricultural productivity

Climate resilience is no longer solely an environmental issue - it is a fiscal, economic and development priority.

Why Climate Finance Matters



Climate Change Affects

- National economic growth
- Food prices
- Household incomes
- Fiscal stability
- Public investment returns

The Government therefore seeks climate finance that:

- ✓ Protects agricultural productivity
- ✓ Reduces emissions
- ✓ Strengthens resilience
- ✓ Attracts private investment
- ✓ Supports green industrialization

Uganda's Climate Policy Framework

A strong policy foundation:

01

National Climate Change Act (2021)

02

Nationally Determined Contribution (updated)

03

National Development Plan IV

04

National Adaptation Plan

05

Green Growth Development Strategy

06

National Biodiversity Strategy

07

Climate Change Budget Tagging

08

Public Investment Management reforms

The Ministry of Finance is increasingly integrating climate into:

Budgeting

Investment Planning

Fiscal Policy

Debt Sustainability

Public Financial Management

Current Climate Finance Landscape



Domestic

- Government budget allocations
- Environmental levies
- Agricultural financing programmes
- Uganda Development Bank green financing



International

- Green Climate Fund
- Global Environment Facility
- Adaptation Fund
- Climate Investment Funds
- Bilateral development partners
- Multilateral Development Banks



Private Sector

- Commercial finance
- Carbon markets
- Sustainable agriculture investments
- Impact investors

Financing Gaps

Despite progress, Uganda faces significant financing gaps.



Limited fiscal space



High adaptation costs



Limited access to concessional finance



Smallholder farmers face financing constraints



Limited private investment in nature-based solutions



High perceived investment risks

This calls for innovative financing mechanisms.

INNOVATIVE MITIGATION OPPORTUNITIES →

Why Innovative Mitigation?

Traditional Mitigation Focuses On



Energy



Transport



Forestry



Agriculture Presents New Opportunities To



Remove carbon



Improve soils



Increase productivity



Strengthen resilience

Enhanced Weathering: One Aligned Pathway

Spreading crushed silicate rock on farmland accelerates natural CO₂ mineralisation while improving soil health - connecting directly to Uganda's existing climate and agricultural plans.



Mitigation

Generates verifiable carbon removal that can count toward Uganda's updated NDC targets and national mitigation goals.



Adaptation

Improves soil water-holding capacity and buffers smallholders against drought - reinforcing the National Adaptation Plan.



Sustainable Agriculture

Raises soil pH, nutrient availability, and yields - supporting productivity goals within the Green Growth Development Strategy.

CONCLUSION

Key Takeaway: Feeding Uganda's NEAT Country Platform

Uganda is developing a Country Platform structured around priority sectors NEAT: Nature, Energy, and Agro-industrialisation and Tourism. Dialogues like this workshop generate the evidence base that shapes the platform and its investment pipeline.



Nature

Natural capital, ecosystem restoration and enhanced weathering as a mitigation pathway



Energy

Clean, reliable energy to power industrial and agricultural transformation



Agro-industrialisation

Climate-resilient agriculture and value addition, including soil-based carbon removal



Tourism

Nature-based tourism sustained by healthy landscapes and ecosystems



KEY TAKEAWAY

This is not a stand-alone technical discussion. It is direct input to national policy, the evidence and partnerships built here will help define how Nature, Energy, Agro-industrialisation and Tourism are financed and prioritised under Uganda's Country Platform.



Thank You

MINISTRY OF FINANCE, PLANNING AND ECONOMIC DEVELOPMENT | UGANDA

Article 6, carbon markets, and what they mean for African enhanced weathering

In July 2026 I filed two amendments to the Article 6.4 rulebook. This is what they say — and what they would mean for a smallholder farmer in Uganda.

A plain-language guide to the Paris Agreement, Article 6.4, and two drafting choices that would price African carbon removals down — for reasons that have nothing to do with the carbon.

*Rulebook status
current to 30 July 2026*

~10,000 yrs

how long the carbon stays put

Still open

the buffer rule that sets the price

Judge the field

not the flag above it

Nduta Njenga · EWAP Kenya Lead, University of Exeter · Energy lawyer and climate-finance practitioner · LLM International Energy Law & Policy, CEPMLP, University of Dundee

Sources: UNFCCC A6.4-SBM018-A13, in force 10 Oct 2025 · draft Tool: Reversal risk assessment, A6.4-MEP014-A07, 1 July 2026 · Kanzaki, Planavsky & Reinhard (2023), PNAS Nexus.

Enhanced weathering speeds up something rocks already do — and once the carbon is in solution, it stays put.

1 Crush the rock

Volcanic rock ground to a fine dust, much like the lime farmers already spread.

2 Spread it on fields

Rain, temperature and soil do the rest, exactly as they do in nature.

3 The carbon is locked away

It becomes dissolved bicarbonate and travels to the sea for around ten thousand years.

Proven next door — with the rock Uganda is made of

Kisumu, Kenya: 56 women farmers spread rock dust once. Maize rose 71% in the first year and 79% in the second — no re-application.

+71%

yr 1

+79%

yr 2

Nephelinite is the rock of Mount Elgon, on our border. Same rock family, same volcanic belt. Double-win: The harvest comes first; the carbon is a second income on top.

DOES THE TEMPERATURE MATTER?

A Swiss trial in December 2025 measured far less removal — in cool vineyard soils. It questions how much, not how long. Tropical soils weather faster, which is why field data from here is now the most valuable evidence in the sector.

Sources: Kanzaki, Planavsky & Reinhard (2023), PNAS Nexus 2(4):pgad059 · Kisumu smallholder maize trial, 56 women farmers, nephelinite at 20 t/ha, +71.17% and +79.24% — CDRXIV preprint, Sept 2025, not yet peer-reviewed · Swiss vineyard trial, Environmental Science & Technology, Dec 2025 · ICVCM reversal-risk tiering.

Article 6 of the Paris Agreement lets countries trade carbon — and Article 6.4 is the route that gives an African tonne a stamp the world trusts.

A carbon credit is a receipt. It says one tonne of carbon dioxide was kept out of the air or taken back out of it. A market lets that receipt be bought and sold — so the money moves to where the work is done.

1 Article 6.2

Two governments deal directly.

Fast — and only as trustworthy as the two who signed it.

2 Article 6.4

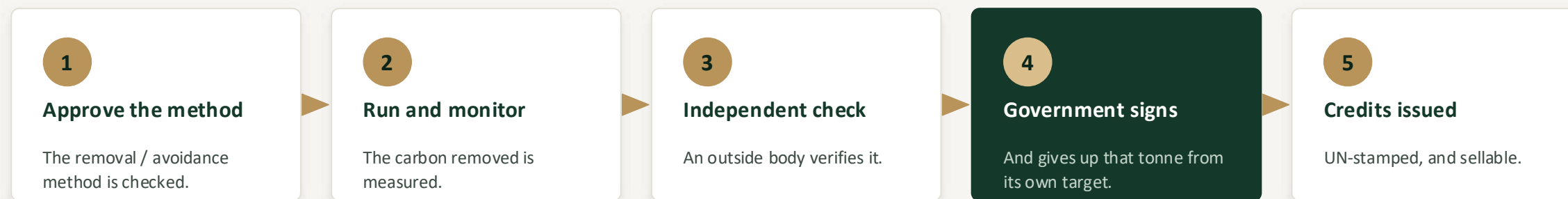
One UN market, with an official inspector.

One rulebook, one Supervisory Body. Successor to the Clean Development Mechanism. Its credits carry a UN stamp.

Hold on to 6.4. That is where the whole fight is.

Sources: UNFCCC, Paris Agreement (2015), Articles 2, 4 and 6 · Paris Agreement Crediting Mechanism (PACM), Article 6.4.

Five steps turn a tonne into a UN-stamped credit — and the step that decides everything is the one your own government signs.



Why step four decides everything. When Uganda authorises a tonne, it gives that tonne away — it can no longer count it towards its own climate target. A real cost, and the reason the ministry is a partner in this rather than a bystander.

WHERE THE RULEBOOK STANDS TODAY

New

The rules on keeping carbon stored came into force in October 2025 — and they name enhanced weathering by name.

Barely used

Only a handful of projects have ever been credited, all of them transferred cookstove programmes.

Wide open

No removal method has been approved. Our rules are being written before we arrive.

Sources: UNFCCC A6.4-SBM018-A13, in force 10 Oct 2025, para. 6(d) and fn. 7 · PACM issuance register and draft annual report to CMA 8 (A6.4-SBM022-AA-A01) — issuance approvals to date are transitioned CDM cookstove programmes; no removal methodology approved.

Every seller must leave credits in a shared insurance jar. Nobody has yet decided how many ours would be.

The buffer, in plain words

Selling a removal credit is a promise the carbon will stay put. So every project leaves a share of its credits in a shared jar. You cannot sell what is in the jar.

Where the drafting has got to

The first draft of the tool that sets the jar went public on 1 July 2026. It already gives different countries different numbers — but only for clean cooking. The ERW pathway is still blank.

Which is why a submission filed now can still move it.

WHAT OTHERS WITHHOLD, FOR A SIMILAR PROMISE

Isometric	None	<i>weathering treated as very low risk</i>
Puro.earth	10%	<i>the default rate</i>
Gold Standard	20%	<i>flat, for all land use</i>
American Carbon Registry	+ up to 8	<i>added from a governance score</i>
Verra (land use)	12–60%	<i>above 60% a project fails</i>

Nothing at one end. Sixty tonnes in a hundred at the other.

Sources: UNFCCC A6.4-SBM018-A13, Eq. 8 and fn. 15 · draft Tool: Reversal risk assessment, A6.4-MEP014-A07, 1 July 2026 — regional and national defaults for non-renewable-biomass activities only; human-induced factors and removal modules not yet drafted · Isometric Standard v2.0 (2026); Puro.earth General Rules; Gold Standard GS4GG; ACR Risk Tool v2.0 (2024); Verra AFOLU NPRT v4.2. PACM has proposed no figure for any removal pathway.

One registry already sets part of a project's jar from its country's governance score. Nothing about the field.

What one registry does today

The American Carbon Registry adds up to 8 extra percentage points to a project's jar for “social and political risk”, taken from the World Bank's governance scores.

Voice and accountability · Political stability · Government effectiveness · Regulatory quality · Rule of law · Control of corruption

Not one of those six was designed, or tested, to predict whether carbon leaves a field.

I looked for a study proving they do. I did not find one. That absence is the argument.

JUDGE THE DRIVER, NOT THE PASSPORT

Imagine a motor insurer that ignored your driving record and priced your premium on the crime rate printed on your passport.

That is what a governance score does to a Ugandan field. Two identical projects — same rock, same soil, same monitoring — credited differently because of the flag above them.

Real risk should be priced at the rock and the project. That is what I asked for.

Sources: American Carbon Registry, Tool for Reversal Risk Analysis v2.0 (19 Nov 2024): social and political risk at an assumed maximum of 8%, from five-year averaged World Bank Worldwide Governance Indicators. ACR is a non-UN registry serving voluntary and compliance markets, not PACM — the risk is that PACM adopts a design already normalised elsewhere. No validation study linking governance indices to observed carbon reversals was located as at July 2026: a search finding, not a proof of non-existence.

Two amendments. Neither lowers the bar — both ask that it rest on evidence, applied to every country alike.

1 Use the best data you have in hand

THE PROBLEM

As drafted, forest projects need a finished national monitoring system. Many African countries are still building one — so a gap in the plumbing becomes a closed door.

WHAT I ASKED FOR

A ladder instead. Use the best data you hold; where you have none, a cautious default set so high it can only under-count.

Data hierarchy · Conservative default · Non-exclusion · Non-regression

2 Judge the field, not the flag

THE PROBLEM

As drafted, the jar is left to a tool whose human-induced part is unwritten — and a governance score is the ready-made way to fill it.

WHAT I ASKED FOR

Treat every country the same, unless there is published proof of a real difference. Price real risk at the rock, not the flag.

Uniformity · Evidentiary exception · No proxies · Transparency

One principle, twice: keep the bar high, make it rest on evidence, and apply it equally everywhere.

Sources: Njenga, N., submission on form A6.4-FORM-METH-007 v01.0, July 2026, Comments 1 and 2 · UNFCCC A6.4-STAN-METH-005 (leakage), in force 16 May 2025, paras. 15–16 — applies only to REDD+ activities within the scope of Article 5.2, and so not to enhanced weathering; revision deferred to 2027 · draft Tool: Reversal risk assessment (A6.4-MEP014-A07).

Uganda is not at the starting line. It is already inside the Article 6.4 door — and it already has the rock.

UGANDA

THE ROCK

Mount Elgon is a nephelinite volcano — the same rock family as the Kisumu trial, in the same 600 km belt.

THE LAW

Climate Change Act 2021 and the Climate Change Mechanisms Regulations 2025 set the route: no objection, approval, then a ministerial letter of authorisation.

THE GATE

The Ministry of Water and Environment is the designated national authority — and Uganda's host-Party form is already filed with the UNFCCC.

AND IN TANZANIA

- Carbon Trading Regulations 2022, as amended — with a 61% gross revenue share written in.
- Has already authorised a tonne, with a corresponding adjustment, under Article 6.2.
- A Tanzanian sits on the Supervisory Body that will decide the buffer.

Two in every three working people here farm, on about a hectare each. The jar decides how much of the second income ever reaches those fields.

Sources: UNFCCC national authorities register · Uganda Climate Change Act 2021 and Climate Change Mechanisms Regulations 2025, SI No. 9 of 2025 (SI Supplement No. 3, 24 Jan 2025) — procedural steps per law-firm commentary · Mount Elgon nephelinite volcanism, J. Geol. Soc. 128(2) · Tanzania Carbon Trading Regulations 2022 (GN 636) as amended by GN 721 of 2023, reg. 34(3) · UNFCCC Supervisory Body membership 2026 · ILO modelled estimates, 2023.

One field, two incomes — and the rule I filed against decides how much of the second one arrives.

The harvest — yours for certain

The rock dust feeds the soil. That gain arrives in the first season, whatever happens to the carbon price.

The carbon payment — a bonus on top

A share of the credits can come back to you. How large a share depends on the jar.

1 What you do

Spread the dust, like liming. Let researchers sample your soil. Keep simple records.

2 What you get

A bigger, steadier harvest first. A share of carbon income second.

3 What should protect you

Never pay to join. A contract in your own language, clear on how the money is shared.

That is why a rulebook written eight thousand kilometres away matters to one acre here.

Sources: Kisumu smallholder maize trial, 56 women farmers, nephelinite at 20 t/ha, +71.17% and +79.24% in successive seasons from a single application — CDRXIV preprint, Sept 2025, not yet peer-reviewed. Carbon-income and benefit-share points illustrate how projects can be structured and are not a promise of any specific sum: no enhanced-weathering operator publishes a benefit-share percentage.

Keep the bar high. Judge the field, not the flag. Use the best available evidence — from farmers.

- 1 Article 6 is the trading part** and 6.4 is the route that gives an African tonne a trusted stamp
- 2 Weathering does two jobs** more food now, and carbon locked away for millennia
- 3 One rule is still open** and one live precedent would price our tonne down for the flag
- 4 I filed two amendments** both asking for evidence, applied to every country alike
- 5 The evidence is here** almost none exists for tropical Africa — so the panel reaches for a proxy

THE ASK

- 1. Co-sign it** with NARO and Makerere and farmer representatives named
- 2. Supply the evidence** weathering rates and monitoring data from the partner sites
- 3. Help draft the text** regulators move faster when handed workable wording

The clock: the Supervisory Body meets 5–9 October, in Bonn.

INTO THE AFTERNOON Scientists — what field data could we contribute? Government — what would make authorisation worthwhile? Developers — how do we share income fairly? Farmers — what would make you comfortable taking part?

Sources: UNFCCC Article 6.4 Supervisory Body, SBM 023, 5–9 October 2026, Bonn · Methodological Expert Panel, September 2026 · COP31 / CMA 8, Antalya, 9–20 November 2026 · Njenga, N., submission on form A6.4-FORM-METH-007 v01.0, July 2026.

CONTACT



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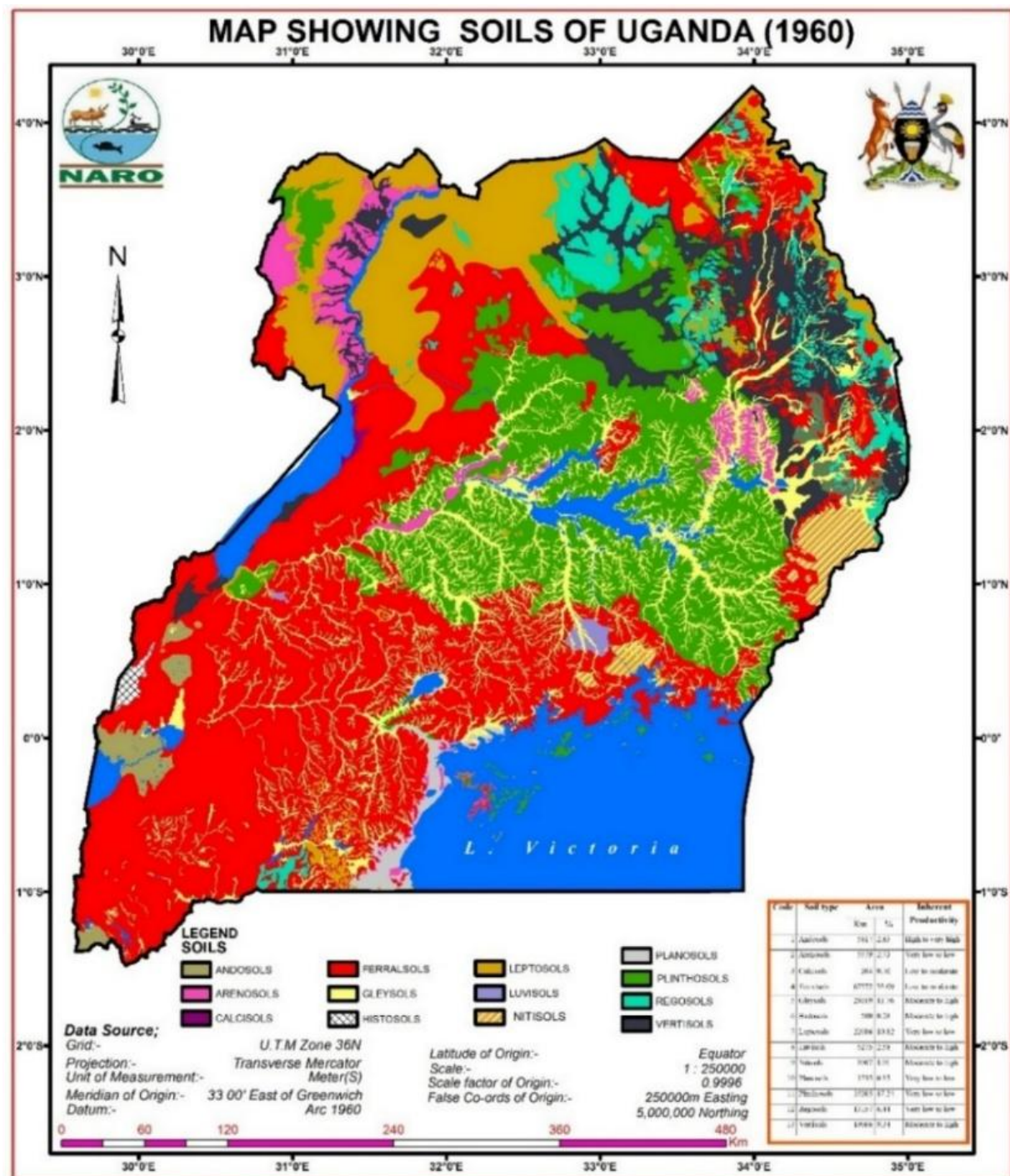
Filed the July 2026 submission to the Article 6.4 Supervisory Body and Methodological Expert Panel on the reversal-risk and leakage drafting.



Uganda's Soils, Laboratory Capacity, testing and Monitoring

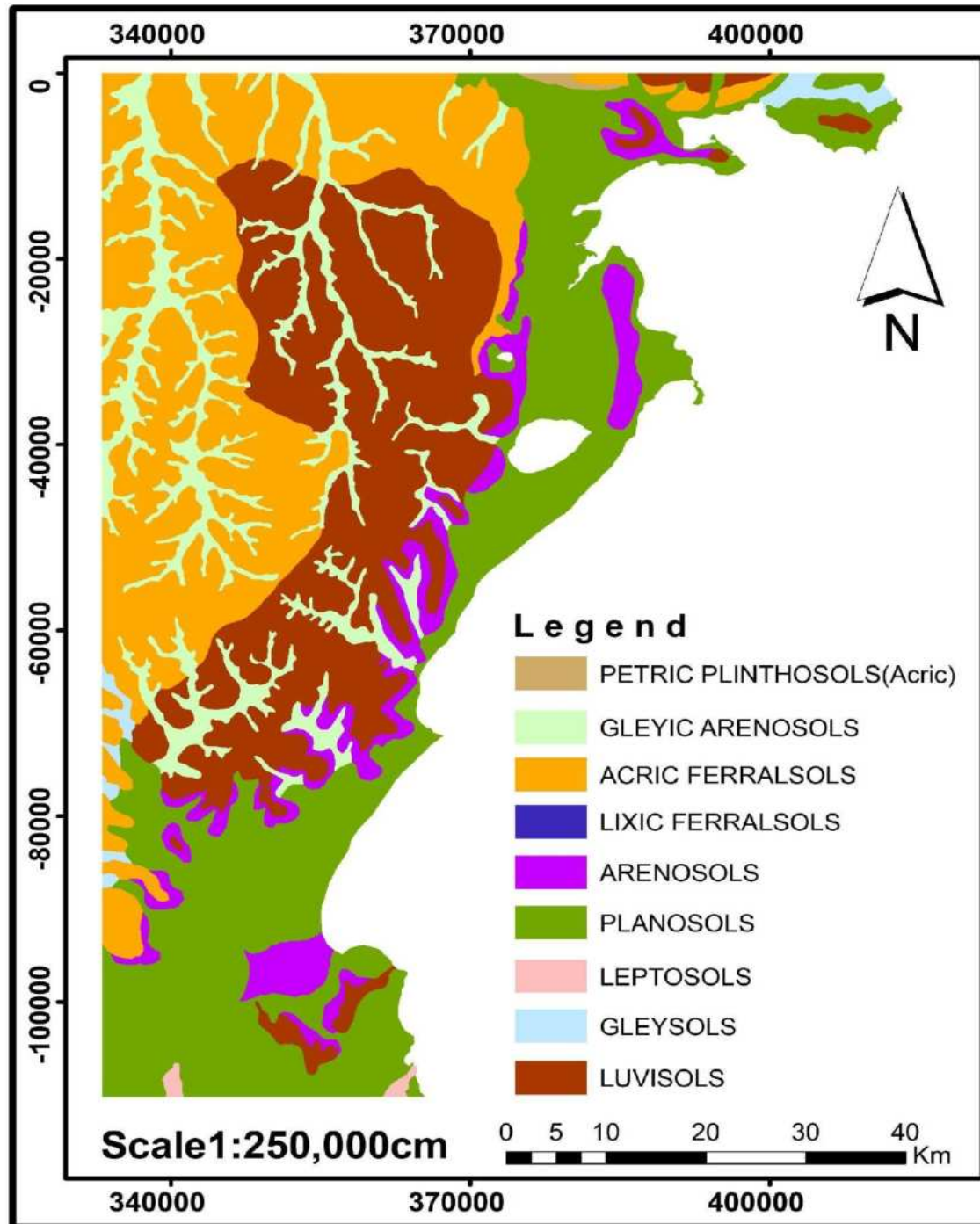
Crammer Kayuki Kaizzi
Soils, Environment and Agrometeorology
Programme
NARO - NARL

MAJOR SOIL TYPES FOUND IN UGANDA AND THEIR CHARACTERISTICS

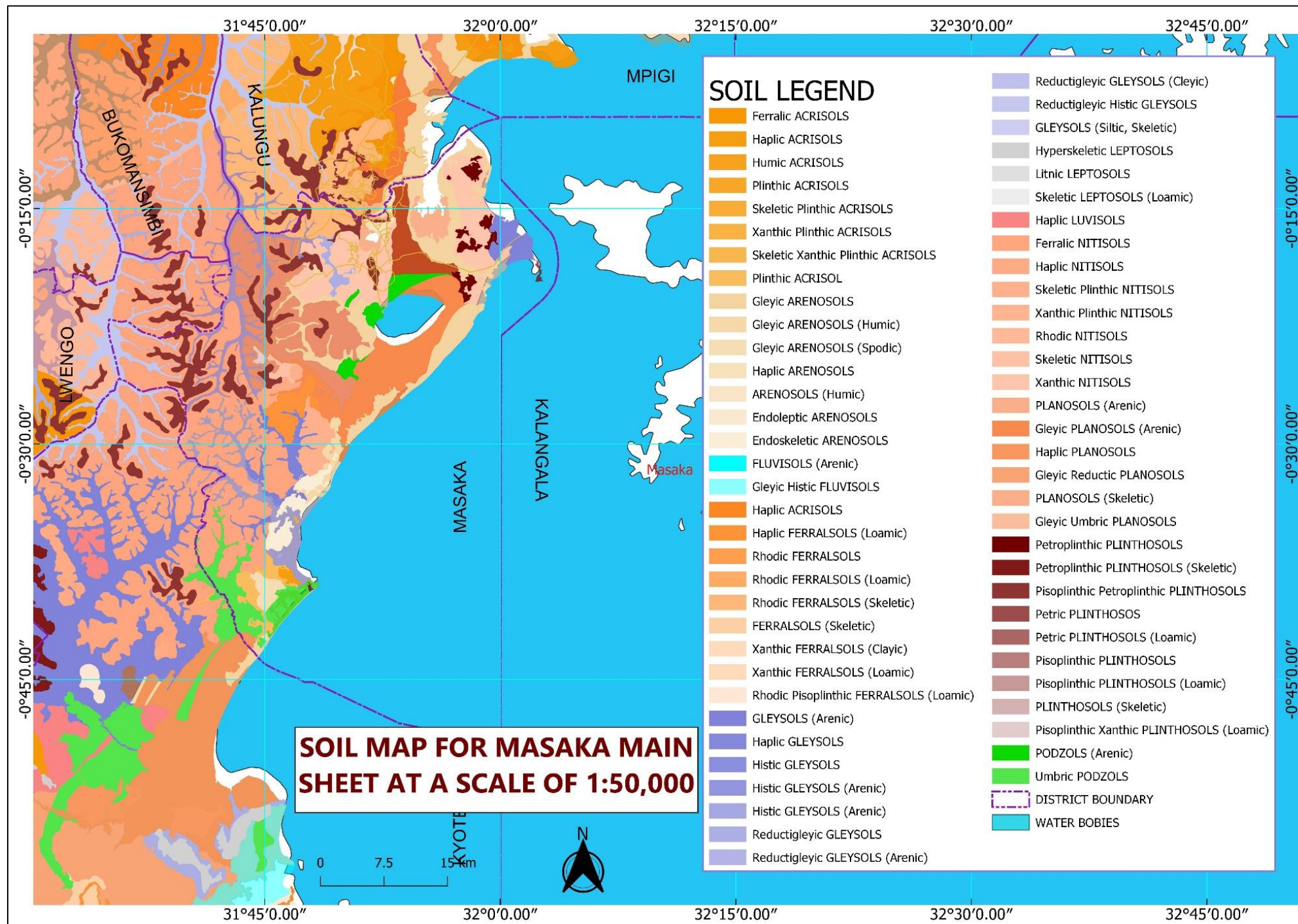


Major soil types, coverage area (ha) and per

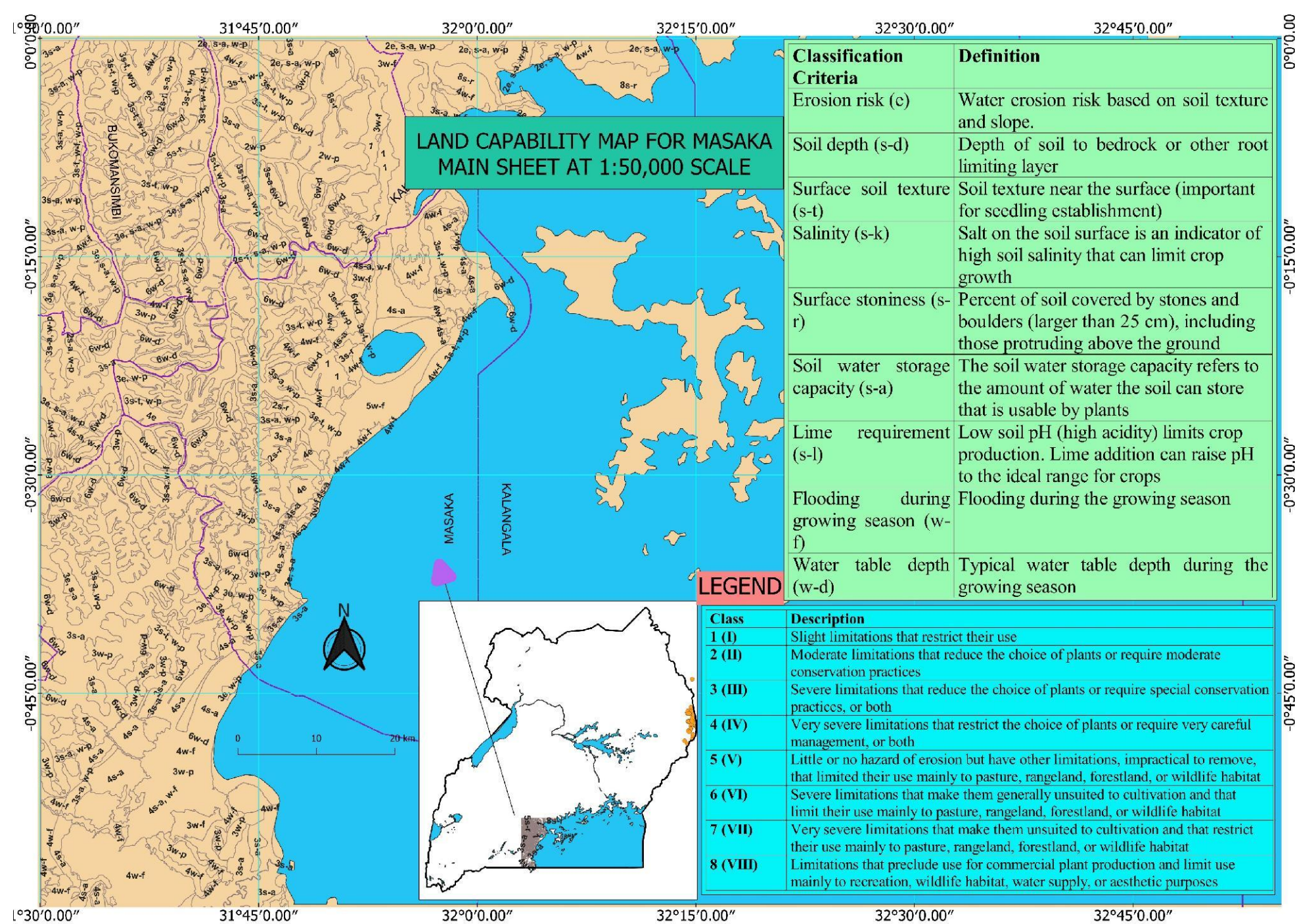
Soil type	Area coverage		Inherent Productivity rating
	Ha	%	
Andosols	581,400	2.85	High to very high
Arenosols	557,900	2.73	Very low to low
Calcisols	20,400	0.10	Low to moderate
Ferralsols	6,757,200	33.09	Low to moderate
Gleysols	2,401,900	11.76	Moderate to high
Histosols	58,000	0.28	Moderate to high
Leptsols	2,208,600	10.82	Very low to low
Luvisols	527,500	2.58	Moderate to high
Nitisols	390,700	1.91	Moderate to high
Planosols	173,500	0.85	Very low to low
Plinthosols	3,520,500	17.24	Very low to low
Regosols	1,315,700	6.44	Very low to low
Vertisols	1,906,600	9.34	Moderate to high



MASAKA SOIL SHEET AT 1:250,000



Updated
Soil Map
for Masaka
Sheet at
1:50,000



Secondary product:

Land Capability Map for Masaka Sheet at 1:50,000

Laboratory Capacity

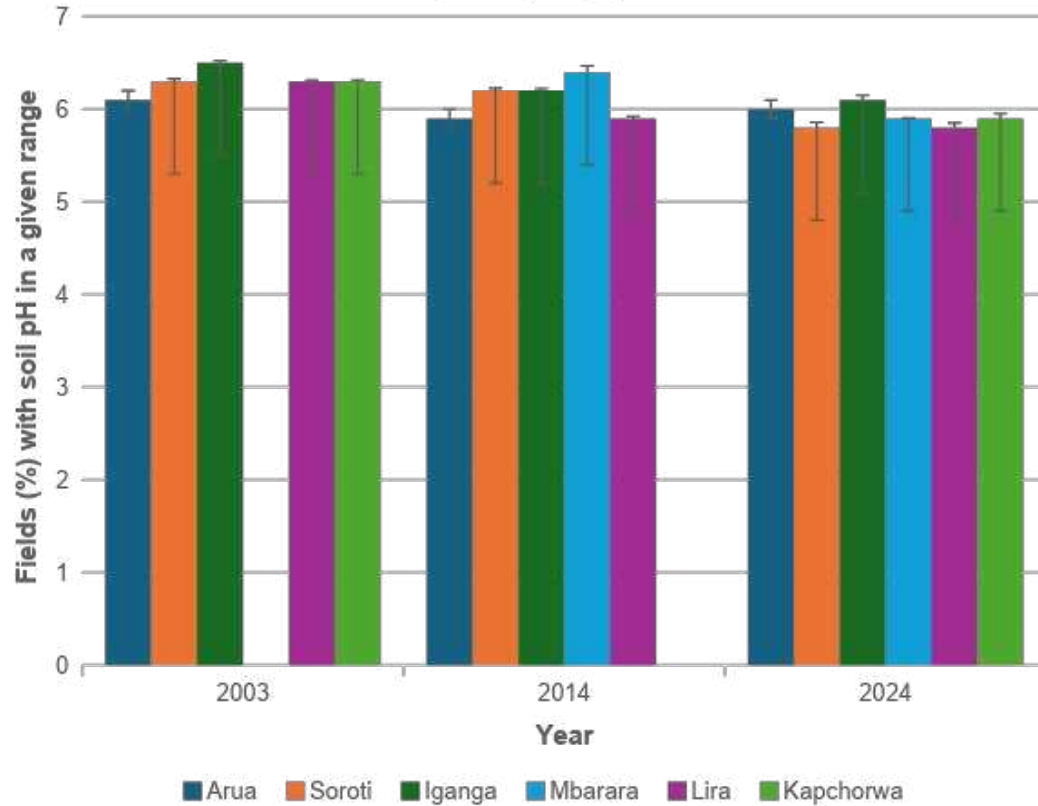
- Soil and Plant Analytical Laboratory at NARL
- Soils Laboratory at Makerere
- Other Laboratories - NIR Soil Scanning

SOIL, AND PLANT TISSUE ANALYSIS

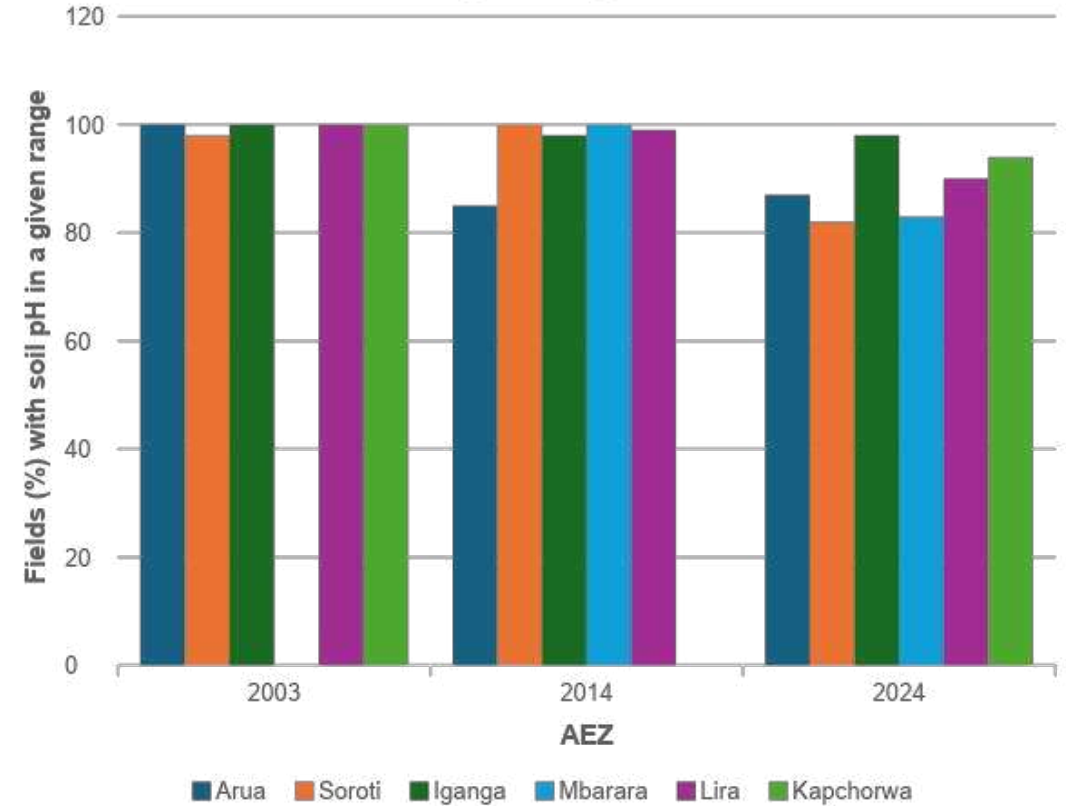
Category	Type of Analysis
A1	Routine
	Includes bases [Ca, Mg, Na, K], P, Texture, SOM, pH
A2	Specialized soil analysis
	Exchangeable cations [Ca, Mg, K Na]
	Aluminum Exchangeable Acidity
	Buffered Cation Exchange Capacity (CEC)
	Effective CEC (ECEC)
	Total Nitrogen
	Mineral Nitrogen (Ammonium and Nitrogen)
	Boron
	Electro Conductivity
	Salinity
	TDS (Total Dissolved Solids)
	Trace Elements [Fe, Mn, Cu, Zn]
	Heavy Elements [e.g Ni, Ba, Co etc]
	Toxic Elements [Hg, Pb, As, etc]
	Chlorides, sulphates
	Sulphates

SOIL MONITORING

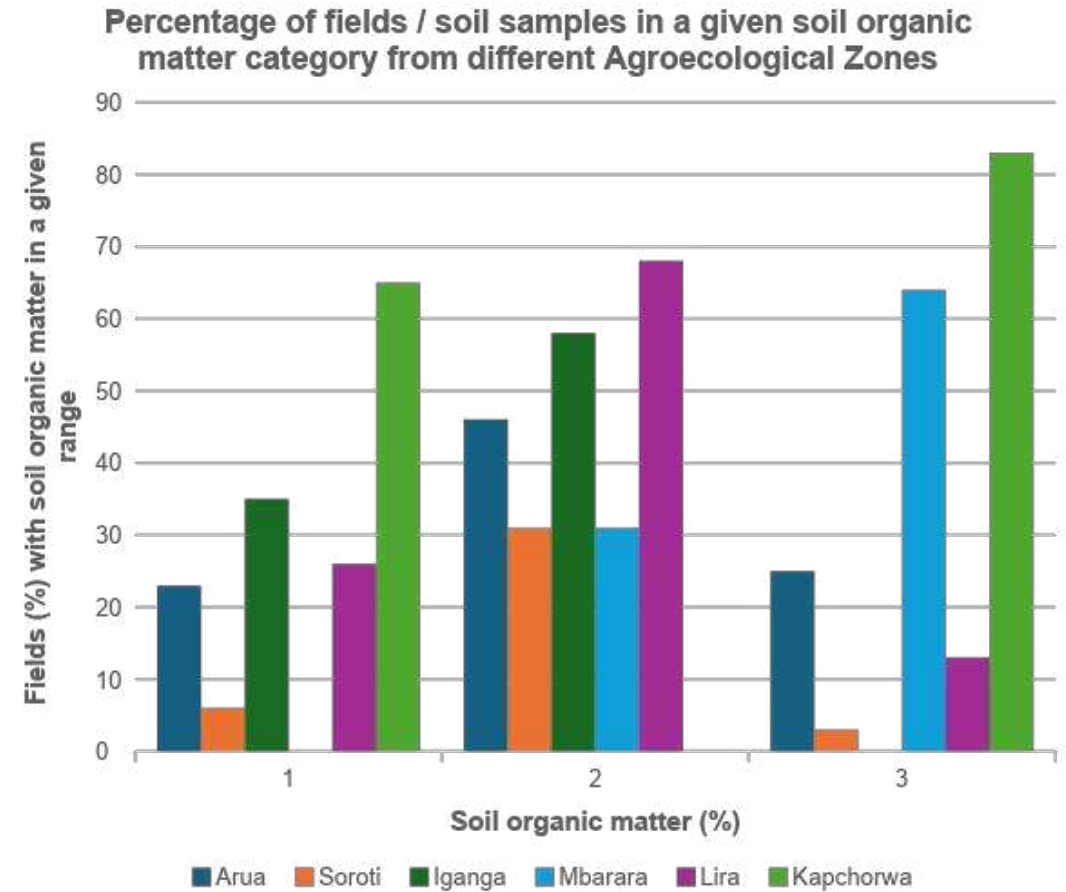
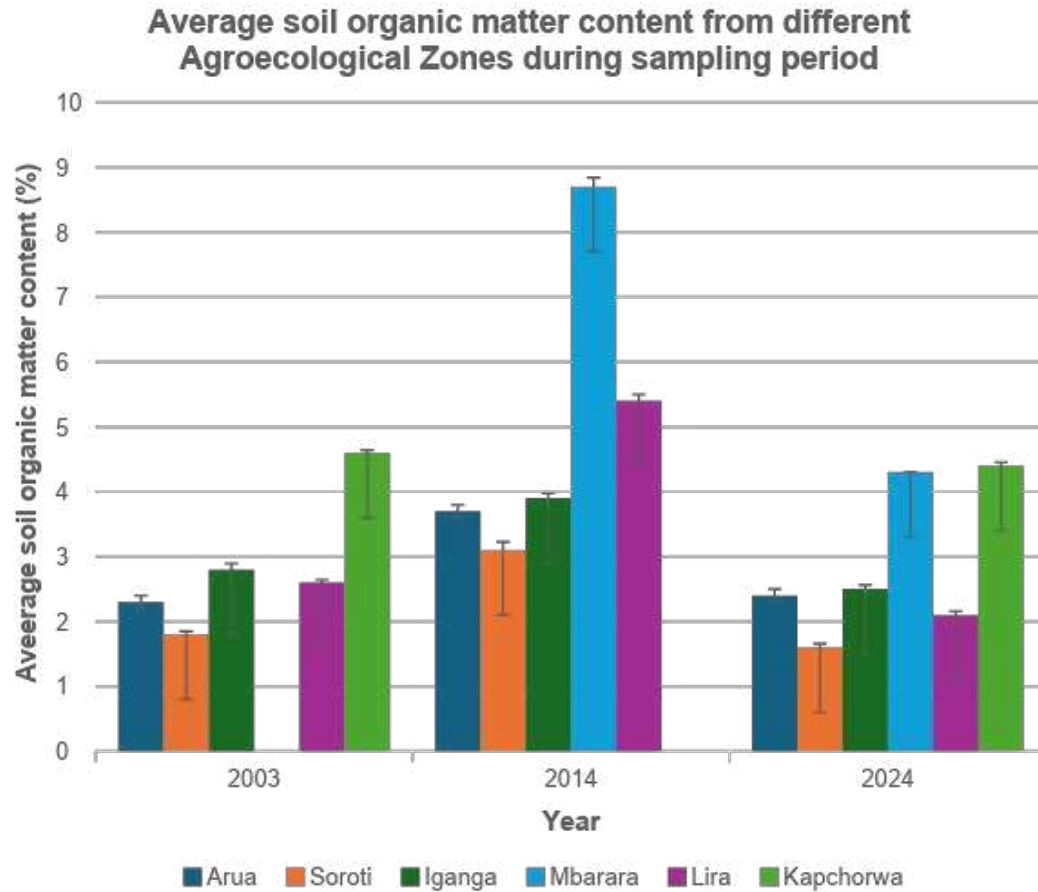
Average soil pH from different Agroecological Zones during sampling period



Percentage of feild / soil samples pH range 5.2 - 7.5 from different Agroecological Zones



SOIL MONITORING



MONITORING

[Enabling Planetary-scale Food Security]
**Boosting small farmer resilience,
income, and soil health globally –
through enhanced rock weathering
based regenerative durable carbon
removal.**



 **MATI**

 **PRIZE**
GRAND WINNER 2025

30k+ Farmers

Partnered across India, Tanzania & Zambia

300k+ Tons

ERW basalt rock dust already spread

Mati Carbon Snapshot

Building for smallholders by restoring soil health, boosting income and resilience, and delivering durable carbon removal through ERW.

7 Countries

Commercial scale in India and R&D phase elsewhere

- New trials
- Mature R&D
- Commercial Ops + R&D

PROVEN SCALE

500+ villages
with deployments across various districts

25,000+ acres
of farmland treated

8 agroecology zones where feedstock was deployed in various crops like rice, maize, teff, casava etc

\$3.5 million in increased farmer income in 2025

2050 Ambition

35 Countries and ~100 Agro Ecology Zones

CUSTOMERS



FUNDERS AND BACKERS



ACADEMIC PARTNERS



INDEPENDENT VALIDATORS



PROPRIETARY TECH STACK



Proven Hard Tech + Science Capabilities

Built Ground-Up to collect in-field soil profile and smallholder agro-ecology and resilience data at scale

117,692

Soil Samples Collected

158,134

Farmland Plots Registered

36,894

Farmers Registered

115,467

Acres of Land Enrolled

Proprietary Data Infrastructure



Field Capture

Offline-first apps built for zero connectivity rural environments

✓ Farm App

✓ Warehouse App

✓ HSE Module

7

Countries



Lab & Processing

State-of-the-art ICP-MS Analysis with randomized sampling protocols

✓ Lab App

✓ Rock Sampling

✓ Quality Module

100k+

Samples



AI/ML Intelligence

Automated data verification and carbon modelling at field scale

✓ Verifier Dashboard

✓ CDR Modelling

✓ ML auto-QA

20+

MRV Papers



Verified Output

End-to-end Traceability from field sample to certified credit

✓ Customer Module

✓ Full Traceability

✓ AA pre-rating

AA

BeZero
Rating

State-of-art Lab Infrastructure (India - 2 sites)



Enhanced Rock Weathering (ERW)

One reaction → Two pathways

▶ A nature-based adaptation intervention funded by the carbon market

1

CARBON PATHWAY BENEFITS

Basalt spread
on cropland



CO₂ + rain react
with silicate minerals



Bicarbonates drain
through watersheds



Stored in ocean
as HCO₃⁻ for >10,000 yrs

what leaves the field →



2

AGRONOMIC PATHWAY BENEFITS

pH Correction
Al toxicity eliminated



Nutrients Released
Ca, Mg, K, P + micro-nutrients



Silicon Deposited
Disease & drought resistance



Farmer Outcomes
Higher yields, lower costs

← what stays in the soil

H⁺ consumed by
weathering reaction.
Nutrient uptake unlocked.

Calcium, Magnesium,
Potassium, Phosphorus
+ Iron, Manganese, Zinc,
Copper

Cell walls strengthened.
Pest & disease resistance.
Water-use efficiency
improved.

Higher yields.
Reduced input costs.
Greater climate resilience.

Need: The Planetary Scale Urgency

► Soil degradation & Ecological urgency

40%degraded
soil globally

40% of Earth's soil degraded already,
and further 95% projected to be degraded by 2050.¹

► Smallholder resilience & Food security urgency

0.8%only of global
climate finance

Smallholders produce ~35% of the world's food²
but receive only 0.8% of global climate finance annually³.

1. <https://earth.org/95-of-the-earths-soil-on-course-to-be-degraded-by-2050/>

2. <https://www.fao.org/newsroom/detail/small-family-farmers-produce-a-third-of-the-world-s-food/en>

3. <https://www.ifad.org/en/w/opinions/the-75-billion-climate-finance-gap-an-imperfect-but-important-figure-for-small-scale-farmers>

4. <https://www.mckinsey.com/industries/agriculture/our-insights/what-climate-smart-agriculture-means-for-smallholder-farmers>

Mechanism to Outcome: How ERW translates soil chemistry into boosted soil health and smallholder income/resilience



pH Management

- Acidity buffering
- Mitigates aluminium toxicity
- Liming benefit where lime is unaffordable / inaccessible



Nutrient Replenishment

- Slow release of Ca, Mg, K, Si, and P

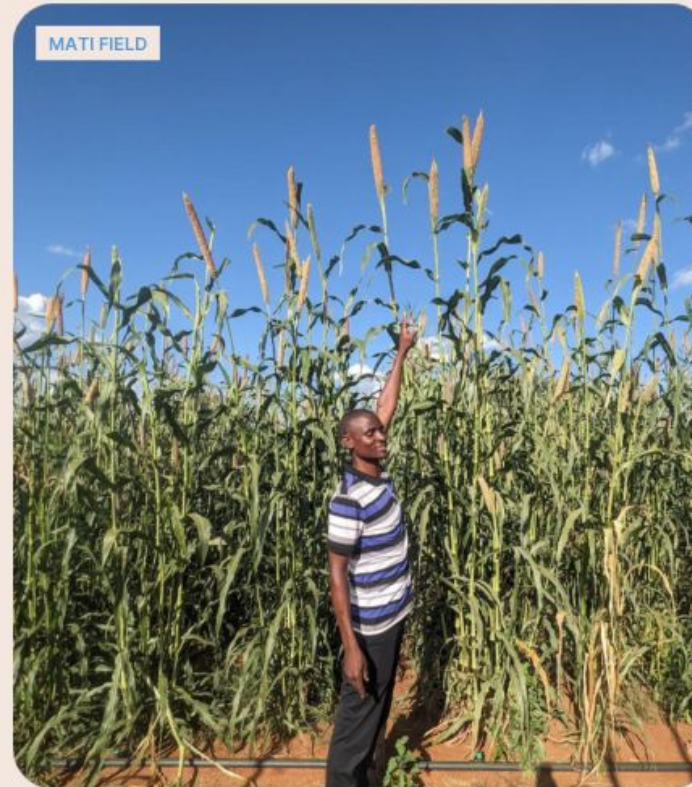


Addition Si

- Silicon uptake shows promise for drought and pest tolerance
- Supports plant structural strength and root health

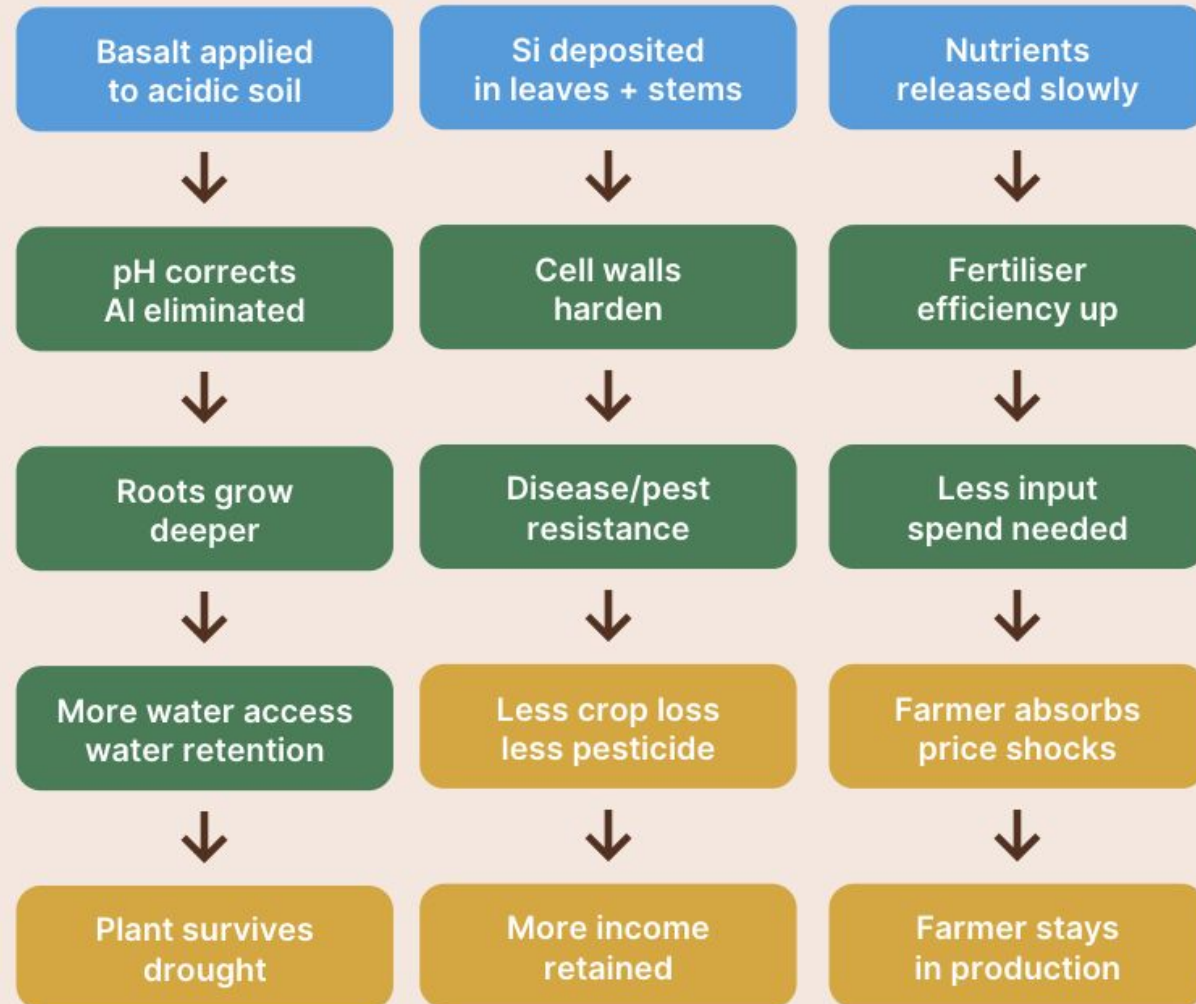
Mati Field yield increase average 20%

Image from Zambia/Millet field (Average income \$1,600/annum)



Resilience Compounds – Increased water retention and drought resistance; Retained income; Farming Livelihood Continuity; Higher adaptive capacity

Each resilience mechanism reinforces the others. The result is a farming system that absorbs shocks rather than collapsing under them.



Rainfed Maize in Zambia with stark difference due to moisture retention following Mati Carbon deployment

Enhanced Rock Weathering

Adaptation Outcomes Funded by the Carbon Market

Crushed basalt applied to smallholder cropland corrects soil acidity, releases nutrients, and builds crop resilience — while permanently removing CO₂. The carbon market funds everything. The farmer pays nothing.

YIELD INCREASE:

30%

AVERAGE YIELD INCREASE

leading to stronger crop structure and more uniform maturation.

CROP HEIGHT AND DENSITY:



83% reported increase in density



92% reported increase in height

Proven at Scale

30,000+ farmers | 25,000+ acres | 220,000+ tonnes basalt

\$50M XPRIZE Carbon Removal Grand Prize winner

Peer-reviewed: Jordan et al., 2026 (Royal Society)

Operations in 7 countries. Expanding into 15 African countries

Why This Matters for Adaptation

- The adaptation finance gap is \$187–359bn/year.
- Less than 1% reaches smallholders directly.
- ERW delivers measurable adaptation outcomes: yield resilience and income uplift, funded by carbon credit revenue.
- Aligned with GGA Targets 3 and 6 under the UAE Framework for Global Climate Resilience.



35% ADDITIONAL HOUSEHOLD INCOME

Average additional net income addition per farmer

ERW provides significant benefits in comparison to existing adjacent Agronomic interventions and subsidy models

How ERW Compares to Typical Donor Interventions

	ERW	Liming	Fertiliser Subsidy
Who pays?	Carbon market	Farmer / trader	Govt / donor
Ongoing cost to donor?	None	Recurring	Recurring
Agronomic Inputs	✓ Macro and micro-nutrients and plant available Si	X Ca/Mg only	X NPK only
Carbon removal	✓ Lasting carbon removal ✓ Carbon reduction	X Classified as CO2 emissions source under IPCC	X None

Why ERW intervention would become self-funding virtuous cycle

Once zone-specific agronomic evidence exists, the carbon market funds all ongoing deployment. Carbon credit revenue covers the full cost. The donor's role is catalytic and time-bound to fund the evidence generation.

Zero farmer behaviour change required. No training, no certification, no monitoring burden.

A time-bound, catalytic investment that unlocks a permanently self-funding intervention

What ERW Delivers — From a Single Application



Soil restoration

pH correction, nutrient replenishment, structure



Increased resilience

Drought, heat, disease & pest resistance



Increased productivity

+30% yield, 100% positive response



Increased livelihoods

20% uplift in household income, zero cost



Ecosystem services

Carbon removal, water regulation, soil biodiversity, reduced agrochemicals



Unlocks other inputs

Recovers fertiliser value wasted on acidic soils

Catalytic, time-Bound high-value use of grant capital

To reach self-funding, climate and agronomic testing must be completed across diverse agro-ecological zones. Grants generates the evidence — the carbon market funds ongoing operations.

US\$0.5–1M

Phase 1: Agronomic Trial
Secondary data analysis. In field feasibility study. Government alignment and permitting. Agronomic trials

US\$1–1.5M

Phase 2: MRV Basics
Multi-season factorial trials, baselines, farmer engagement, analytics, synthesis. MRV basics to prove viability

US\$2–3M

Phase 3: MRV Proof
Multi-season MRV trials, with solid and liquid phase multi-season data sets to certify and establish MRV in new region.

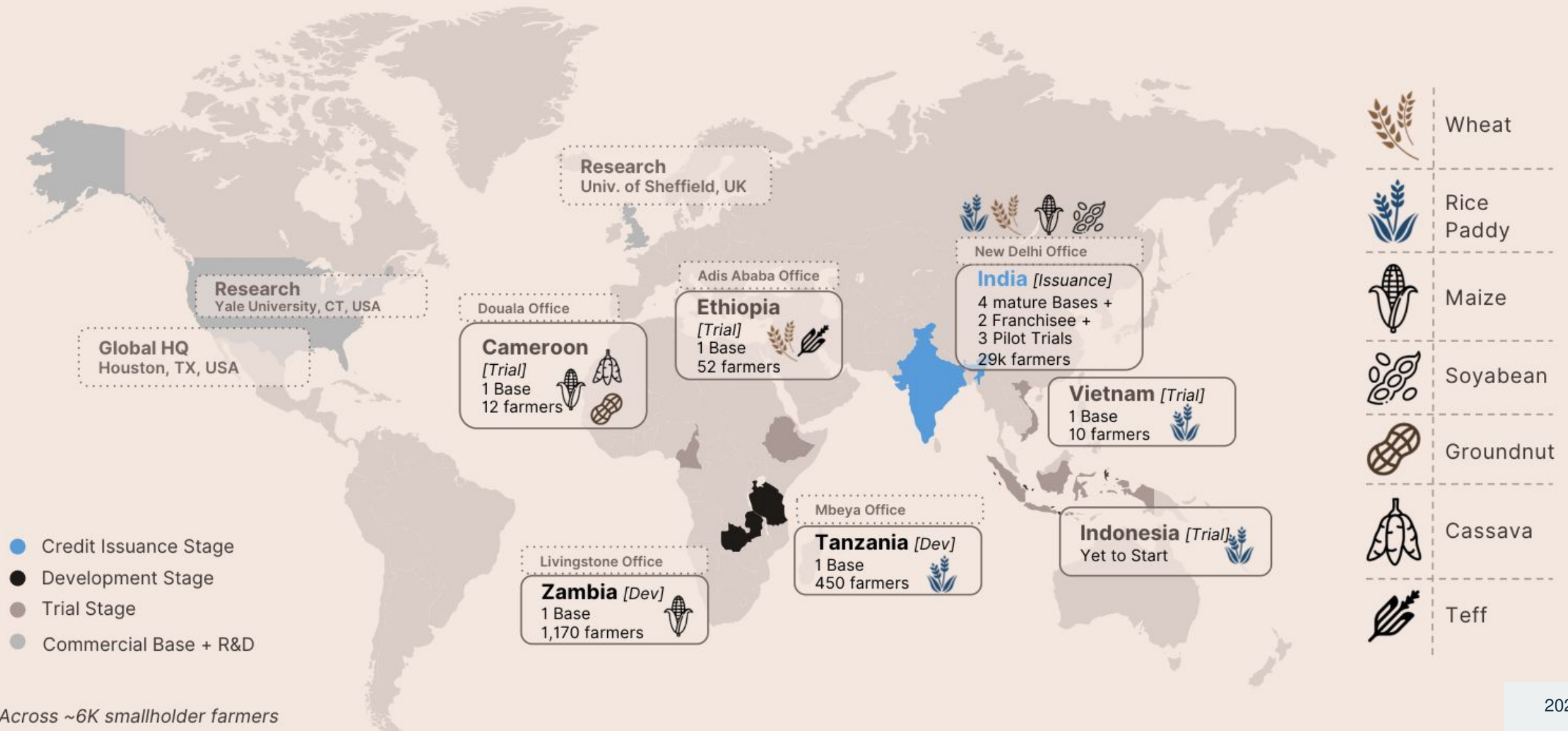
Other intervention requires ongoing donor funding. ERW is funded by the carbon market once the evidence exists. Grant is the catalyst.

ERW Differentiation against other Carbon Removal pathways and Co-benefits

▶ ERW uniquely combines scalability, durability, and strong agricultural co-benefits.

	 Scale-Up Potential	 Cost per ton of CDR	 Permanence	 Co-Benefits
 ERW	 Abundance of Rock to scale geographically	 \$100–150/tCO ₂ at scale	 10 ³ –10 ⁵ year timescales	 Improves soil fertility, nutrient supply, and crop productivity while reducing soil acidity.
 Bio-Char	 Limited biomass availability & competing biomass uses	 \$100–300/tCO ₂ depending on system	 Carbon stability varies by feedstock & conditions	 Improves soil water retention, nutrient holding capacity, and soil microbial activity.
 Regenerative Agriculture	 High potential due to applicability	 ~\$20–100 / tCO ₂	 Lower permanence; high reversal risk.	 Improves soil structure, biodiversity, water retention, and climate resilience for farmers.

Demonstrated Scale & Impact: \$3.5M in farmer* income uplift by 2025; Reach across 7+ countries, 7+ crop value chains, 30K+ Farmers





XPRIZE Grand Winner

April 2025

Among 1,300 carbon removal teams, Mati was awarded the Carbon Removal XPRIZE Grand Prize. Awarded by the Musk Foundation for our breakthrough science, scalable model, and unwavering commitment to farmers.



Mati secures BeZero's Pre Rating



'AA' Pre-Rating

Only ERW provider globally to achieve AA Pre-Rating in BeZero

Reflects confidence in Mati's MRV rigor, governance, and long-term impact, providing independent validation for buyers and partners.

Customers



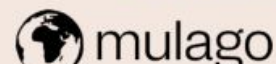
Research Partners



Ecosystem Partners



Funding Partners



Forbes named Mati's CEO / Founder among the world's Top 50 Sustainability Leader

Science-first approach with demonstrated credibility and granular traceability to deliver certified credits

- ▶ 50K field samples collected & processed & 100K plots of farmland covered

Digital-first MRV



SOIL SAMPLING

Rigorous protocols for randomized sampling



ROCK SAMPLING

Composition parameters aligned with compliance



LAB TESTING

Robust measurements of CDR using ICP MS



CUSTOM APPS

End-to-end traceability



CARBON MODELLING

CDR permanence prediction



FRANCHISE MANAGEMENT

Creating village entrepreneurs to launch ERW ventures



LOGISTICS MANAGEMENT

Tracking-led route optimization

Academic Partners



Yale University



Leverhulme
Centre for Climate Change
Mitigation



UNIVERSITY of
WASHINGTON



University of
Sheffield



In-Country Research Partners

Zambia, Tanzania, Ethiopia, Vietnam, Indonesia, Cameroon etc.



Mukuni
Development
Trust



ĐẠI HỌC CẦN THƠ
Can Tho University

Scientific Credibility

Our Team members have authored/co-authored **20+** widely cited, globally recognized **MRV publications**



Association for the Sciences of
Limnology and Oceanography



ACS Publications
Most Trusted. Most Cited. Most Read.



Digital Infrastructure Built to Scale ERW Across Smallholder Agriculture

► **Highly granular & scalable** enabling future franchise licensing model

MatiC Components

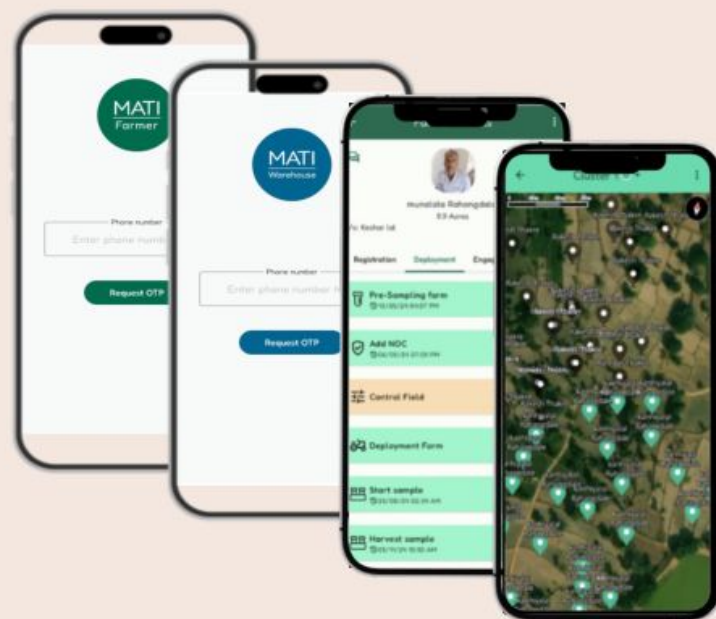
- i Farm App
- ii Warehouse App
- iii Lab App
- iv Verification Module
- v Customer Module
- vi Quality Module
- vii HSE Module
- viii Franchise System

**MatiC
Tech Stack**

Mati Farm

Mati Warehouse

Mati Lab



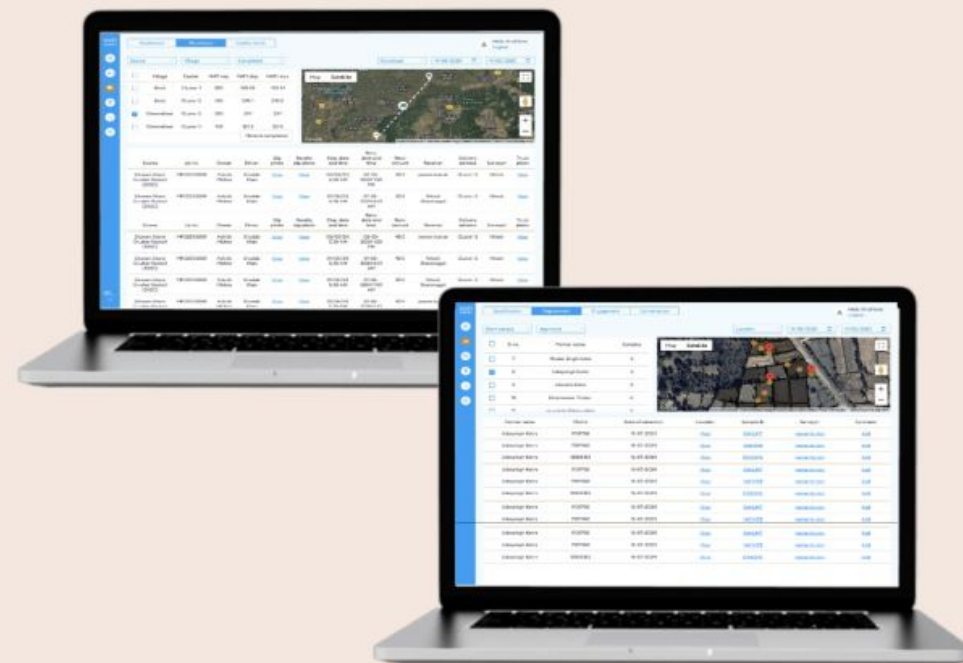
Proprietary data capture apps that work offline in rural infrastructure

Verification Module

Franchise Module

Customer Module

Finance Module



Verifier Dashboard with AI & ML to automate data verification for MRV

Key Staff & Leadership

MANAGEMENT TEAM



Shantanu Agarwal
Founder & CEO
 Serial Entrepreneur,
 B. Tech IIT Roorkee,
 MBA Harvard



Dr. Jake Jordan
Chief Science Officer
 PhD, Geological and Earth
 Sciences
 The University of Texas



Rwitwika Bhattacharya
Climate Justice Lead
 Ex-World bank. MPP,
 Harvard University,
 Founder: Swaniti initiative



Tom Mills
Policy Head
 Strategy & Policy Leader,
 Stripe Climate Fellow,
 MBA, MSc- Oxford



Ashish Kumar
Finance & Strategy
 Ex-Shell Foundation, Dalberg
 B. Tech IITR, MBA Oxford



Sitali Clifton
Director, Zambia
 Secretary and Business
 Manager, Livingston



Maneesh P Chandran
Operations Lead
 Tata Coffee, Indian Institute
 of Forest Management



Samridhi Singh
People & Expansion
 National University
 Singapore (NUS)

SCIENTIFIC ADVISORS



DR. NOAH PLANAVSKY
Isotope Geochemist
 Director, Yale metal geochemistry
 Center



DR. REBECCA NEUMAN
Hydro-biogeochemistry expert
 Associate Professor, University of
 Washington



DR. DAVID J. BEERLING
 Founder/Director of Leverhulme
 center for climate change
 mitigation



DR. INDRA SEKHAR SEN
*Biogeochemist & Earth system
 Scientist*
 Associate Professor, IIT Kanpur

One Intervention, Three Scalable Outcomes

**Smallholder Farmer
Income & Resilience**

ERW
One
Intervention

**Durable
Carbon
Removal**

**Soil Function
Regeneration**



Soil Regeneration

Corrects pH, replenishes nutrients, adds silicon, and improves soil structure in a single application



Farmer Income & Resilience

Higher yields and reduced fertiliser costs directly improve smallholder livelihoods and food security



Durable Carbon Removal

Silicate weathering permanently sequesters CO₂ as stable bicarbonates — measurable and verifiable

**Funded by the carbon market – delivering
adaptation outcomes**

**Join us in
the mission.**

























