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KGID 2025 Green Growth: The Path to Sustainable Jobs

# Methodologies and Technologies to Improve Soil Carbon Sequestration and Biodiversity Management

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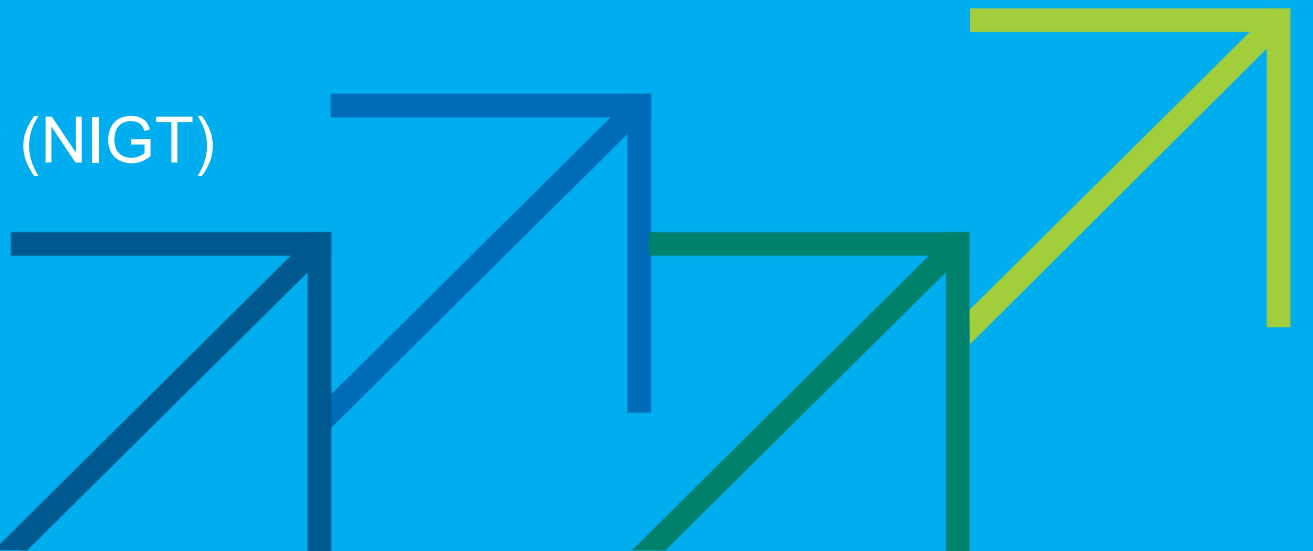

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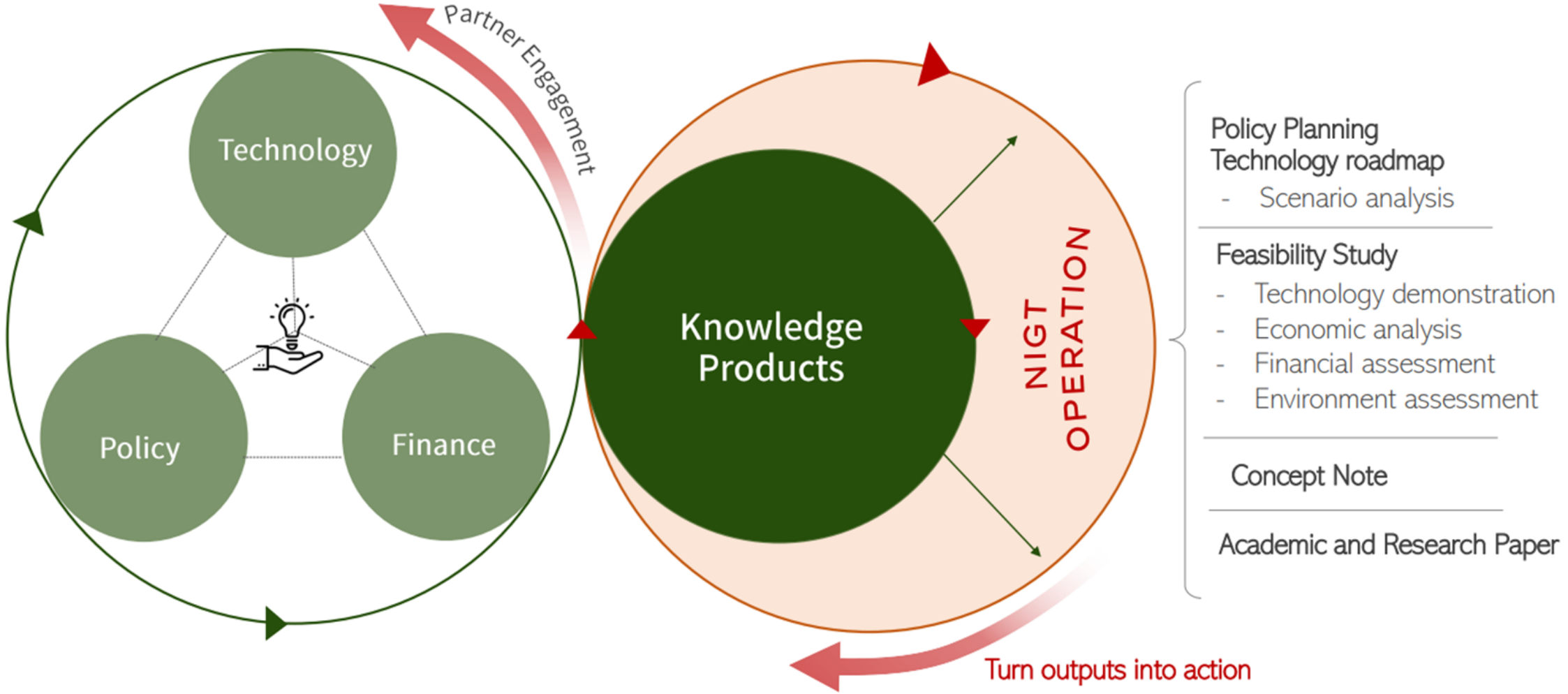
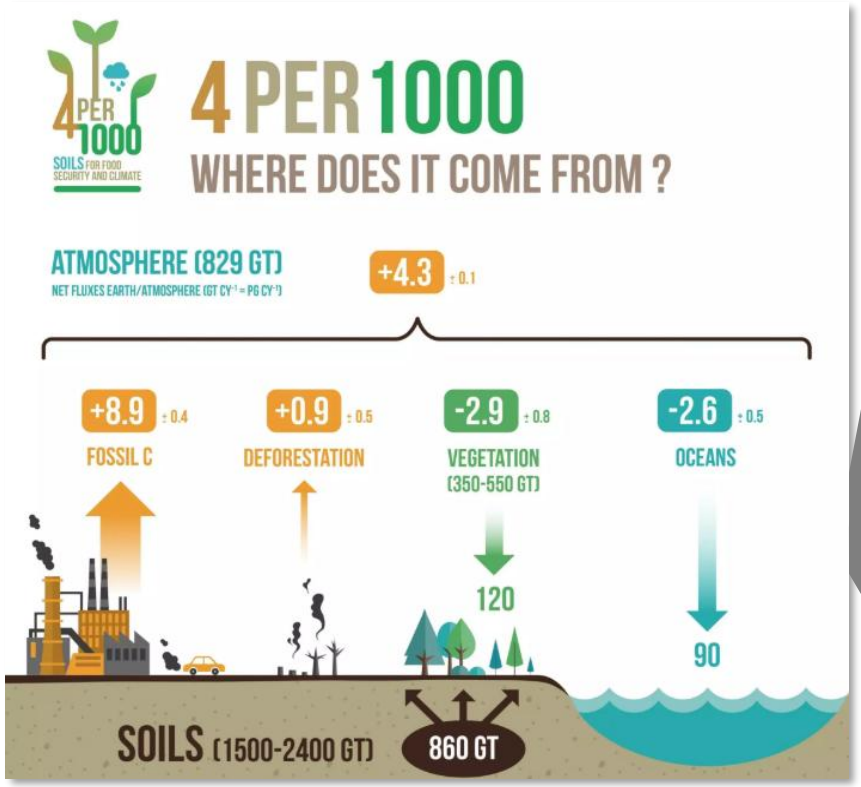
# National Institute of Green Technology : Missions and Key Roles

# Knowledge Products are key source of Partnership



# The importance of soil carbon as a key strategy for mitigation global $CO_2$ emissions

- **4 Per 100 Initiative:** highlights the land sector's role in carbon storage and its potential to combat climate change
- An annual increase of 4% of the world soil surface C stocks (860*0.004) would nearly compensate the annual $CO_2$ increase of the atmosphere.




**The 4 per 100 Initiatives**

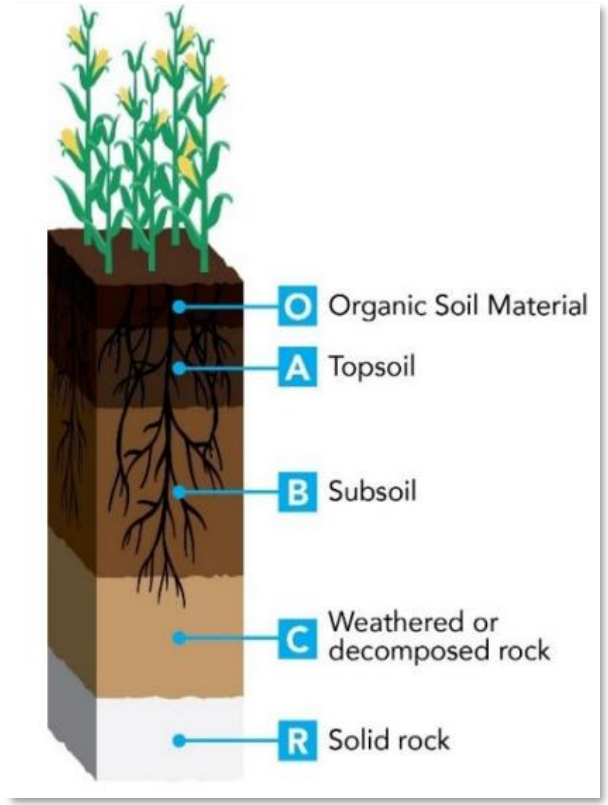
- $CO_2$ emissions from fossil fuel use: 8.9 Gt / yr
- Compared to the 2,400 Gt of carbon stored in the world's soil, it accounts for only 0.004% of the total (8.9 / 2,400= 0.004)

**A modest 0.4% annual increase in soil carbon stocks could offset fossil fuel emission, leading to carbon neutrality**

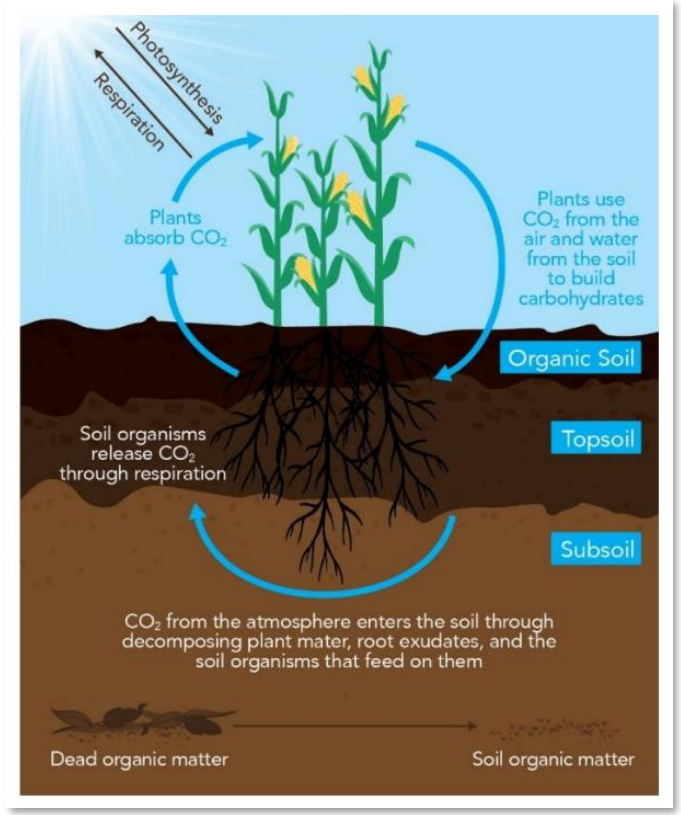
# Processes of Soil Carbon Storage

- The soil can act as a carbon sink or source, depending on the balance between soil carbon accumulation and soil carbon losses. → **Management directly affects the carbon cycle and sequestration within soils.**

## Soil Structure




## Soil Carbon Cycle




## Soil Carbon Stock

**(+) SOC Inputs**

- Organic Inputs (i.e. AGB, BGB, manure, compost etc)
- Soil Deposition

**(-) SOC Losses**

- Decomposition
- Organic removals (i.e. crop residues, roots)
- Erosion
- Leaching

**Soil Carbon Pool**
(Net Ecosystem Carbon Storage = Plant Carbon Storage – Ecosystem Carbon Respiration – Harvest Carbon Removal)

(Source) World Bank. 2021. Soil Organic Carbon MRV Sourcebook for Agricultural Landscapes.

# Key Common Management Practices that Impact Soil Carbon

- There are several proven pathways to enhance soil carbon sequestration (SCS), each offering different benefits, costs, and implementation challenges.
- Among the most prominent approaches include reduced or no- tillage practices, the application of organic amendments such as biochar and compost, and the restoration of grassland.

## Nutrient Management

| | |
|---|---|
| **Compost/manure**<br>**Crop residues/mulch**<br>**Biochar** | Promote plant growth<br>Increased biomass inputs to soil<br>Increased soil moisture |
| **Chemical fertilizers** | If applied in excess, increase soil respiration and $N_2O$ emission |

## Vegetation Cover management

| | |
|---|---|
| **Crop rotation**<br>**Cover crops**<br>**Intercropping**<br>**Mixed cultivation**<br>**Managed fire** | Increase plant and microbial diversity<br>Increased biomass inputs to soil<br>Reduced erosion<br>Increased soil moisture |

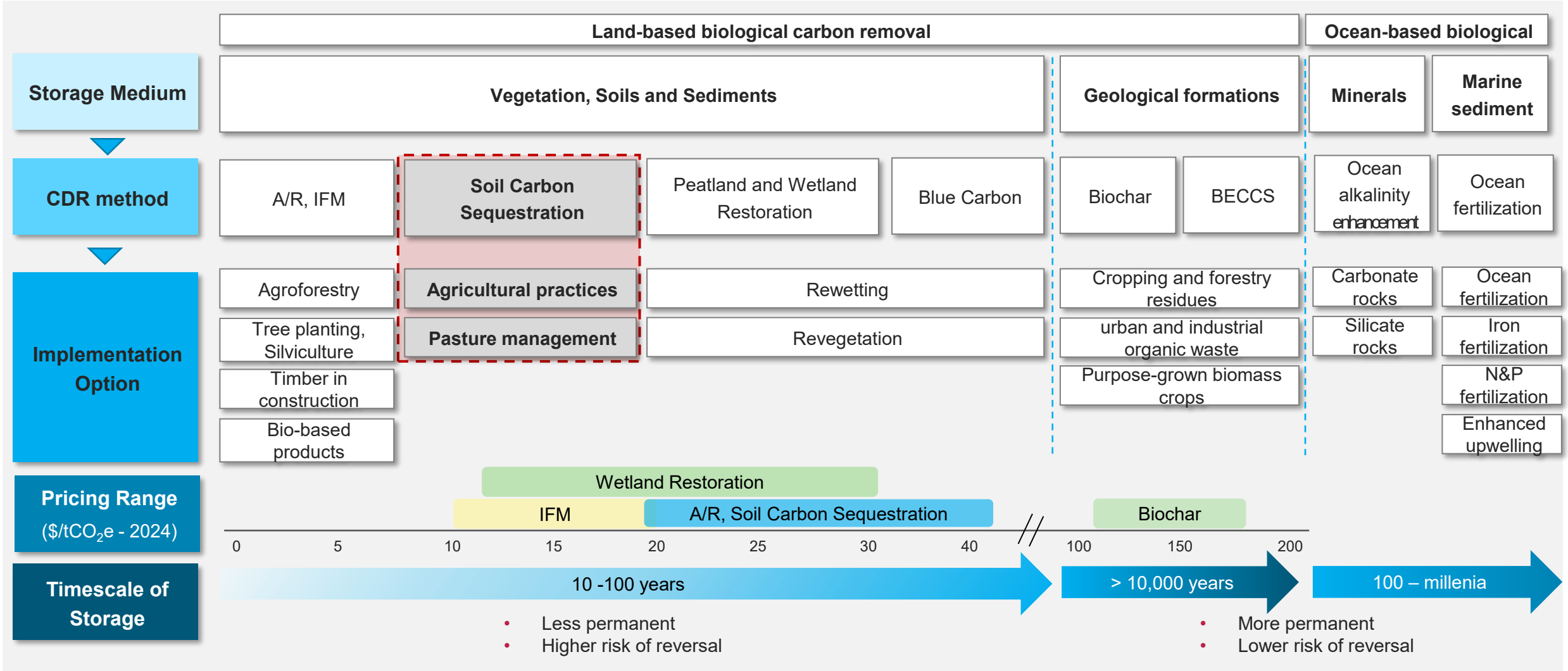
## Vegetation Cover management

| | |
|---|---|
| **Reducing evaporation**<br>**Reducing surface runoff**<br>**Improved irrigation techniques** | Increased plant productivity<br>Decreased decomposition<br>Reduced erosion<br>Increased soil moisture |

## Tillage and Grazing management

| | |
|---|---|
| **No-till**<br>**Reduced-till**<br>**Rotational grazing**<br>**Regenerative grazing**<br>**Reduction of livestock hours**<br>**Protection of vulnerable areas** | Reduced erosion<br>Increased soil moisture<br>Increased plant microbial diversity<br>Increased biomass inputs to soil<br>Reduced erosion<br>Increased soil moisture |

# Translating Management Practices into Nbs Frameworks




(Source) IPCC Factsheet CDR :WGIII 6A/ Abatable (2024) / Axelsson, K. et al., (2024). Oxford Principles for Net Zero Aligned Carbon Offsetting

# Payment Model for Carbon Benefits

Concepts

**Action-based**

- **Payment for Practice**
  - Fixed payments per hectare or per activity implemented.
  - Focuses on what farmers do, not on measured carbon outcomes.
  - *Example: Conservation agriculture project paid per hectare implemented.*
- **Payment for Practice: with Performance dividend**
  - Hybrid between input- and output-based systems.
  - Farmers are paid for implementing practices; additional bonuses if the program as a whole achieves carbon results.
  - *Example: Low-tillage program pays farmers upfront + community-level bonus when carbon gains are verified.*

**Result-based**

- Payment for performance or **results-based climate finance (RBCF)**
  - **Payments tied to measured carbon outcomes** (tons $CO_2$ reduced or sequestered) relative to baseline.
  - Doesn't require carbon market verification; used often in corporate "insetting" projects.
  - *Example: Company pays farmers per ton of carbon sequestered within its supply chain.*

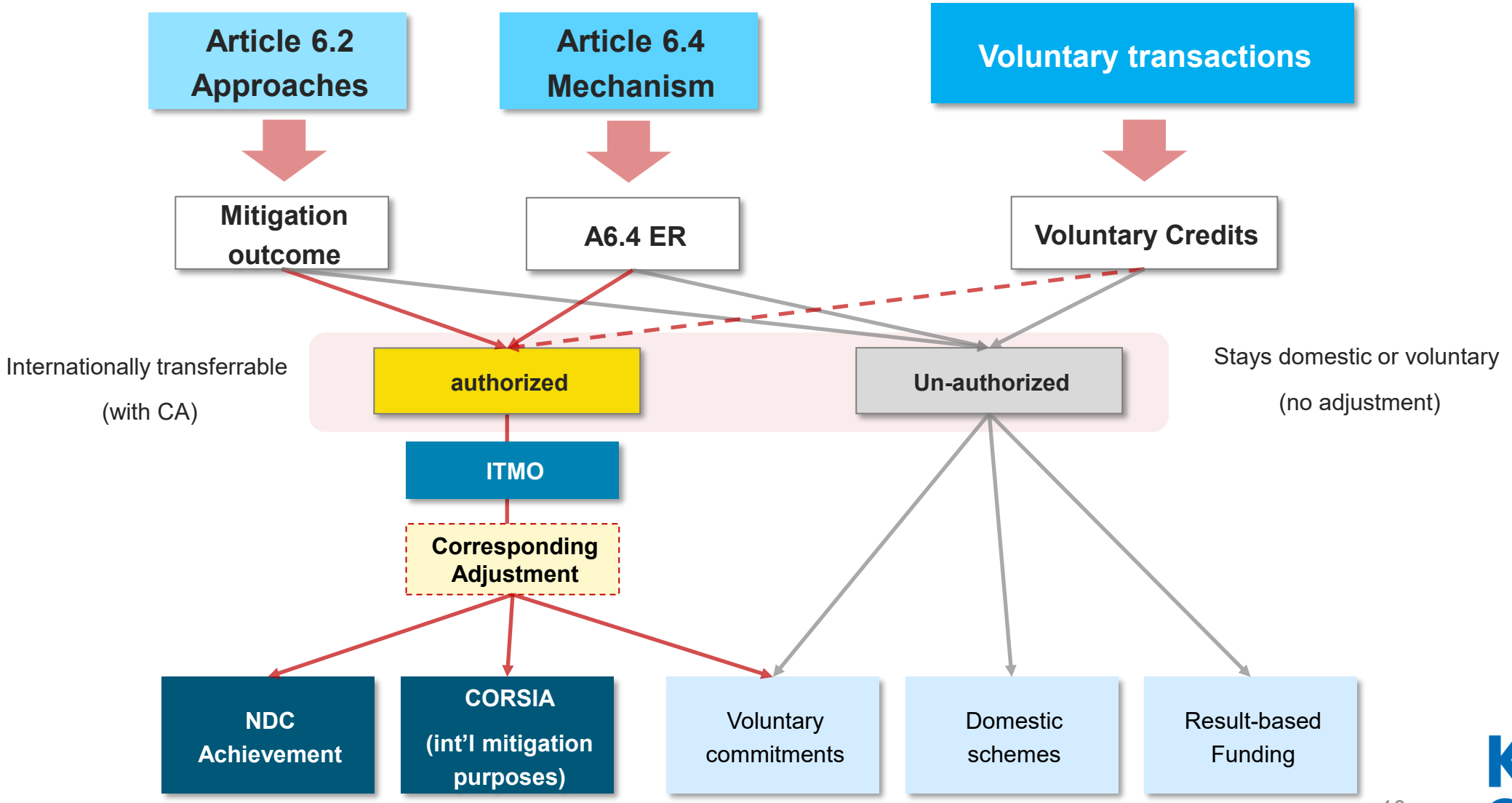
**Carbon market, voluntary or compliance**

- **Payments linked to verified carbon credits under approved methodologies**
- Requires strict monitoring and verification; credits can be sold on the carbon market.
- *Example: Agroforestry project sells verified credits to buyers for market-based payments.*

Capital Options

| Public Finance | | Hybrid | Specialized Carbon Finance | Equity | Debt Finance | Other sources |
|---|---|---|---|---|---|---|
| Subsidies & Grants | Concessional Loans | Green bonds | Forward Credit | Own equity | Commericial debt | Mirco-finance, impact funds |
| Donations Tax Credits | Loan Guarantees | PPP | Carbon streaming | VC or private equity | VC or private equity | Crowdfunding |
| | | Blended Finance | | | | |

# Interaction Between Article 6 Mechanisms and the Voluntary Carbon Market



# Certification Standards for Soil Organic Carbon (1)

- Parallel to this policy evolution, the voluntary carbon market (VCM) began growing in response to the limitations of regulated frameworks.
- VCMs offered a platform for land-use and soil carbon projects that were previously excluded from compliance markets like the CDM.

| Issuance Pathway | Specific Methodology | SOC Included? | Current Status | Key Covered Practices |
|---|---|---|---|---|
| Verified Carbon Standard A VERRA STANDARD | **VM0042** Improved **Agricultural** Land Management | - Yes<br>- Optional for AGB | Active | ✓ Reduced tillage<br>✓ Cover crops optimized fertilization<br>✓ Improved water, grazing management |
| | **VM0036** Methodology for Sustainable **Grassland** Management (SGM), v1.1 | Yes (allowed use of biogeochemical/direct measurement for SOC pool changes) | Active | ✓ Rewetting drained peat soil<br>✓ Restoring hydrology, blocking drainage |
| | **VM0033** Methodology for **Tidal Wetland and Seagrass** Restoration v.2.1. | Yes(Includes carbon in sediments and SOC in restoration accounting) | Active | ✓ Restoring tidal wetlands<br>✓ Restoring seagrass beds<br>✓ Hydrological rewetting |
| | **VM0044 Biochar Utilization** in Soil and Non-Soil Applications v1.2 | Including SOC | Active (removals/waste handling) | ✓ Biochar production and use (new/greenfield biochar facility, more than 50% of biochar applied in eligible soil/non-soil uses, production vio pyrolysis, gasification, or biomass boilers) |

# Certification Standards for Soil Organic Carbon (2)

| Issuance Pathway | Specific Methodology | SOC Included? | Current Status | Key Covered Practices |
|---|---|---|---|---|
| Gold Standard (Climate Security & Sustainable Development) | **Soil Organic Carbon Framework Methodology** | - Yes (Including SOC) | Active (module status varies) | ✓ Improved tillage practices<br>✓ Improved cropland management<br>✓ Improved grassland management<br>✓ Organic amendments, nutrient management |
| PLAN VIVO (For nature, climate and communities) | **Smallholder Agriculture Monitoring and Baseline Assessment** | - Yes (Including SOC) | On hold | ✓ Manure application<br>✓ External organic inputs such as mulch<br>✓ Tillage, leaching or erosion of soil |
| American Carbon Registry (at WINROCK INTERNATIONAL) | **Avoided Conversion of Grasslands and Shrublands to Crop Production** | - Including SOC | Inactive as of 12/31/24 | ✓ Maintain perennial grass/shrub cover to avoid cultivation, tillage<br>✓ Avoid soil disturbance that would oxidize SOC |
| | **Compost Additions to Grazed Grassland** | - Including SOC | Inactive as of 3/29/23 | ✓ Maintain perennial grass/shrub cover to avoid cultivation, tillage<br>✓ Avoid soil disturbance that would oxidize SOC |
| CLIMATE ACTION RESERVE | **U.S. Soil Enrichment Protocol** | - Yes (Including SOC) | Active | ✓ Fertilizer (organic or inorganic) application<br>✓ The application of soil amendments<br>✓ Tillage and/or residue management<br>✓ Crop planting and harvesting, grazing practices |
| | **U.S. and Canada Biochar Protocol** | - Quantity of Biochar produced | Active | ✓ Biomass acquisition, production, application |

# Certification Standards for Soil Organic Carbon (3)

| Issuance Pathway | Specific Methodology | SOC Included? | Current Status | Key Covered Practices |
|---|---|---|---|---|
| **Australia ACCU Scheme** | **The 2021 Soil Method** | - Yes (Including SOC) | Active | ✓ Applying nutrients through fertilizer<br>✓ Applying lime to remediate acid soils<br>✓ Undertaking new irrigation<br>✓ Converting from intensive tillage to reduced/no-tillage |
| **Japan J-Credit Scheme** | **AG-004 Biochar addition to mineral soil in cropland/grassland** | - Quantify increased carbon stored in mineral soil from biochar application | Active | ✓ Biochar application in cropland/grassland |
| **Paris Agreement Article 6.4 (PACM)** | Overarching guidance/standards for LULUCF and removal activities | - SOC enhancement | Underdevelopment | ✓ Land use, land-use change, and forestry broadly |

***Recent Development (as of early 2025)***

- PACM is Supervised by the *Article 6.4 Supervisory Body (SBM)* and *Methodologies Expert Panel (MEP)*
- ***SBM approved its 2025 work plan*** and updated procedures/standards, including a new *additionality* standard.

  ***CMA6 emphasized standards for removal activities and methodological applications.***
- *MEP's 2025 agenda focuses on land-based removals: non-permanence, reversal risk, and a new reversal risk assessment tool.*

***Soil organic carbon and agricultural land management are not yet formally included under Article 6.4.***

# Technical insights from Global Soil Carbon Methodologies

- **Technical Landscape – Heterogeneous but converging**

✓ Different registry systems (voluntary & compliance) are aligning toward a unified Article 6.4 framework.
✓ Methodological convergence is emerging, but MRV depth, baseline consistency, and reversal risk management still require harmonization for credit fungibility.

| Registry Type | Examples | Technical characteristics |
|---|---|---|
| **Voluntary Systems** | - **Verra VM-series (VM0042, VM0032 etc)** | Activity-specific, modular, conservative baselines |
| **National Systems** | - **Australia ACCU**<br>- **U.S. Soil Enrichment Protocol**<br>- **U.S. and Canada Biochar Protocol**<br>- **Japan J-Credit Scheme** | Aiming for Article 6.4 alignment; developing standardized MRV and reversal risk tools |
| **Emerging Framework** | - **GS' Soil Organic Carbon Framework**<br>- **AG-004 Biochar addition to mineral soil in cropland/grassland (Japan)** | Aiming for Article 6.4 alignment; developing standardized MRV and reversal risk tools |

- **Measurement & Quantification Approaches**

✓UNFCCC MEP likely to prioritize hybrid MRV systems that ensure environmental integrity while maintaining accessibility for smallholder and national-scale programs.

| Approach | Examples | Technical Implication |
|---|---|---|
| **Direct Soil Sampling** | - **Australia ACCU**<br>- **U.S. and Canada Biochar Protocols**<br>- **Japan J-Credit Scheme** | High accuracy but costly; limited scalability. Essential for model calibration. |
| **Model-Based Estimation (IPCC Tier 2-3)** | - **Verra VM-Series**<br>- **US Soil Enrichment Protocol** | Scalable and cost-effective; requires robust calibration and uncertainty management. |
| **Hybrid/ Article 6.4 Oriented** | - **Gold Standard Soil Organic Carbon Framework**<br>- Japans' Green Carbon's Carbon Farming (in development) | Balances accuracy and cost; favored under Article 6.4 for landscape and smallholder projects. |

# Case Studies: Grassland Stewardship in South Africa (GRASS)

## Project Overview

| | |
|---|---|
| Project Type | AFOLU, Agricultural Land Management (ALM) focusing on improved grazing and rangeland restoration |
| Location | Eastern Cape and KwaZulu-Natal provinces, South Africa |
| Proponent | Conservation South Africa |
| Investor | TASC SA (Pty) Ltd., Meat Naturally (Pty) Ltd. |
| Duration | 30 years (renewable up to 100 years) |
| Description | The GRASS Project promotes rotational grazing, grassland rehabilitation, and improved livestock management through community-led stewardship agreements, enhancing soil carbon sequestration and ecosystem resilience |
| Methodology | Verified Carbon Standard (VCS) Version 4.1 using VM0042 – Methodology for Improved Agricultural Land Management (IALM) |
| Credits Expected | 221,482 tCO2e (Annual Projected Emissions Reductions) |
| Credits Issued | 431,994 VCUs for MRV2 period (2023–2024) |

| | |
|---|---|
| Development | The initiative is implemented through the Herding for Health (H4H) model, a community-driven framework developed by Peace Parks Foundation, Conservation International, and Meat Naturally Africa. This model integrates farmer training, professional Ecoranger employment, and rangeland restoration to improve soil carbon, biodiversity, and climate resilience. Activities include rotational grazing, land restoration, erosion control, and herd health management. |
| Price per Credit | Voluntary market estimate: USD 5–8 per $tCO_2e$ |
| Benefit-Sharing | The project uses a community benefit and ownership model through the Meat Naturally Shareholders Trust, where participating farmers are majority shareholders. Profits generated by the implementing social enterprise, Meat Naturally Africa, are distributed back to the farmers annually, supporting both livelihoods and continued landscape restoration. |

## Project Overview

**Project Proponent**

- Meat Naturally Africa
  - Leads overall coordination of the project, facilitate community arrangement

**Technical Partner**

- TASC South Africa
  - Provides scientific oversight and monitoring, supports MRV

**Community Institution**

- Local Grazing and Farmer Associations
  - Represent participating farmers, enforce grazing plans etc

**Local Governance Authorities**

- Traditional Councils and Leaders
  - Provide custodial guidance over communal lands, conflict resolution etc

**Community Implementation Agents**

- Ecorangers
  - Locally trained herders responsible for daily monitoring, livestock management, communication between farmers and project partners

**Government and Regulatory Body**

- Department of Agriculture, Land Reform and Rural Development (DALRRD)
  - Supports alignment with natural agricultural policies, oversees land tenure governance under customary law

**Primary Beneficiaries**

- Farmer communities and livestock owners

# Case Studies: Grassland Stewardship in South Africa (GRASS)

## Project Activities

| Activity Type | Carbon Sequestration | Soil/Environmental Benefits | Livelihood & Climate Benefits |
|---|---|---|---|
| AMP Grazing | ↑ SOC via deeper roots & grass regrowth | ↓ erosion<br>↑ vegetation & infiltration | ↑ forage stability, drought resilience |
| Rangeland Restoration | ↑ long-term SOC through biomass recovery | ↓ runoff<br>↑ soil structure | ↑ grazing capacity<br>↓ land degradation |
| Fire & Invasive Control | Protects existing SOC stocks | ↑ biodiversity, nutrient cycling | ↓ wildfire risk<br>↑ forage quality |
| Herd Health & Improvement | ↓ $CH_4$ intensity per animal | ↓ disease, ↑ efficiency | ↑ productivity, income & market access |
| Community Stewardship | Sustains SOC through joint management | ↑ sustainable land use & equity | ↑ governance, social cohesion |
| Water & Soil Conservation | ↑ soil moisture & biomass | ↓ sedimentation,<br>↑ hydrological balance | ↑ drought resilience, stable livelihoods |

## Challenges & Opportunities

**Legal**
Complex land tenure and traditional governance systems create uncertainty in rights and stewardship compliance.

**Technical**
Droughts, erratic rainfall, and wildfire risk reduce grass recovery and carbon permanence; field data collection is logistically difficult.

**Outreach**
Community adoption may vary due to socio-economic diversity and local norms. Variable farmer participation and limited capacity for rotational grazing in remote communities.

**Scale-up Options**
Carbon credit issuance delays and price volatility impact community reinvestment cycles and expansion potential.

## Key Takeaways from GRASS Project

**Triple Impact**
- Enhances **soil carbon & methane mitigation**
- restores **ecosystems**
- strengthens **rural resilience**

**Science-based & credible**
- Uses **VCS + CCB frameworks** for measurable, high-integrity climate outcomes

**Replicable Model**
- Demonstrates how regenerative agriculture+community governance can scale as nature-based climate solutions in Africa and beyond.

# Summary and Implications of Case Studies

| Appropriate Context | Ecosystem / Land Type | Methodology | Representative Projects | Suitable Financing Mechanisms | Appropriate Context |
|---|---|---|---|---|---|
| **Large communal rangelands requiring improved grazing and land stewardship** | Semi-arid and sub-humid grasslands (communal and private) | VM0042 – Improved Agricultural Land Management (IALM) | Grassland Restoration and Stewardship in South Africa (GRASS) | Verified Carbon Standard (VCS) revenues, community equity models, and donor co-financing for initial training and governance | Large communal rangelands requiring improved grazing and land stewardship |
| **Vast pastoral landscapes managed through conservancy networks** | Dryland savannas and rangelands with high community dependence | VM0032 – Sustainable Grassland Management (SGM) | Northern Kenya Grassland Carbon Project (NKCP) | Blended finance: donor grants + carbon revenues via Verified Carbon Units (VCUs); revolving trust funds | Vast pastoral landscapes managed through conservancy networks |
| **Smallholder mixed farming systems focused on soil health and productivity** | Croplands and agroforestry mosaics (<2 ha holdings) | VM0017 – Sustainable Agricultural Land Management (SALM) | Kenya Agricultural Carbon Project (KACP) | BioCarbon Fund ERPA off-take, development agency grants, and farmer group payments | Smallholder mixed farming systems focused on soil health and productivity |

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