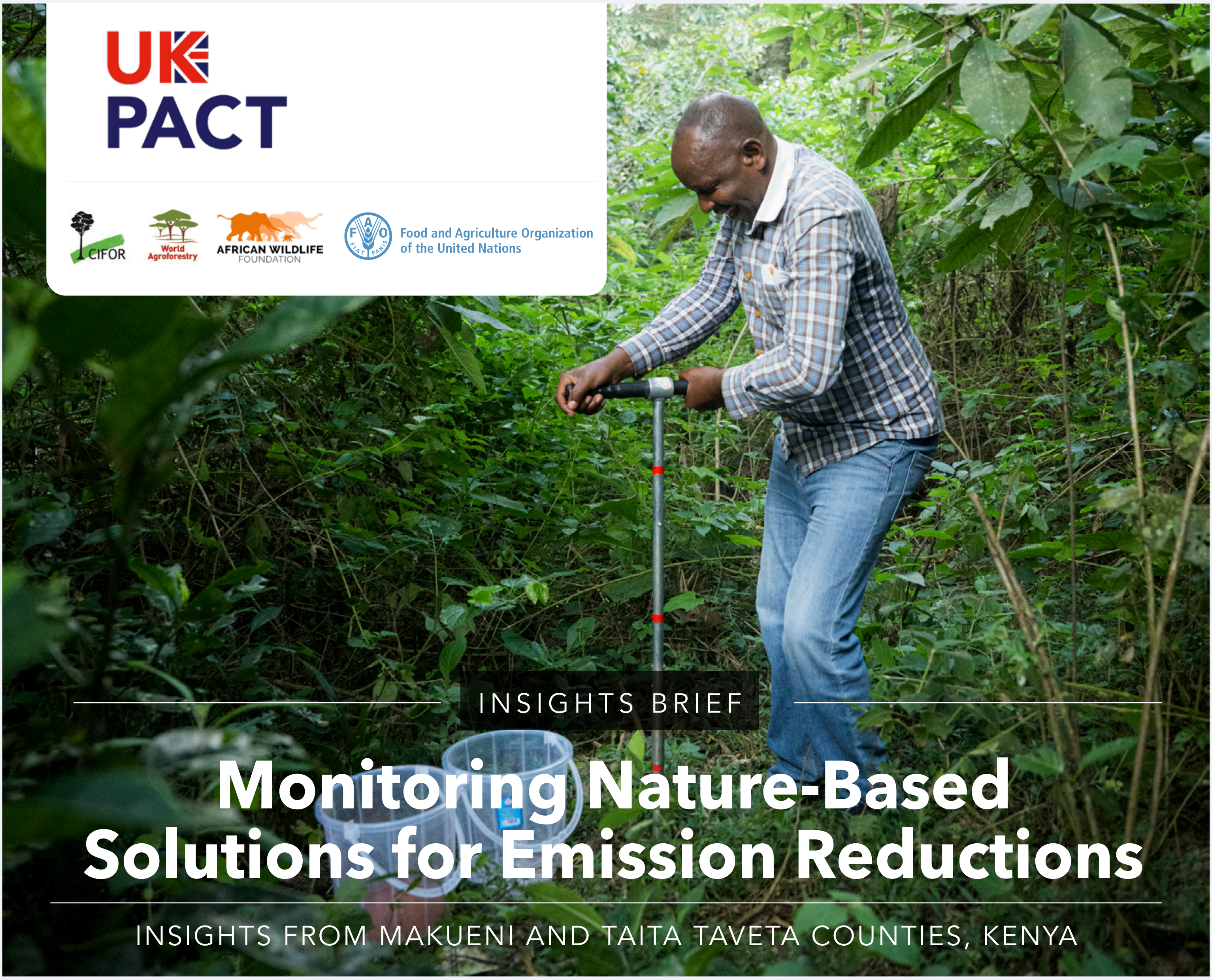

INSIGHTS BRIEF

Monitoring Nature-Based Solutions for Emission Reductions

INSIGHTS FROM MAKUENI AND TAITA TAVETA COUNTIES, KENYA

Context

This insights brief is produced under the UK PACT (Partnering for Accelerated Climate Transitions) programme. UK PACT works in partnership with countries with high emissions reduction potential to support them in implementing and increasing their ambitions for tackling climate change. Kenya was recognised as having such potential and presented a valuable opportunity to strengthen forest and landscape restoration (FLR) policy implementation at the community, county and national levels.

The objectives of the UK PACT's initiative, *'Delivering nature-based solution outcomes by addressing policy, institutional and monitoring gaps in forest and landscape restoration'*, to strengthen FLR in Kenya included:

- Increase capacity on implementation and monitoring of FLR.
- Implement evidence-based recommendations for reduced emissions at local, county and national levels.
- Domesticate national policies (i.e. the Forest and Landscape Restoration Implementation Plan (FOLAREP)) around FLR at the county level.
- Build capacity of Community Forest Associations (CFAs).
- Implement and incorporate gender-transformative, equitable and socially inclusive approaches into FLR implementation, activities and policies.

Citation: Winoweicki, L., Trautman, S., Magaju, C., Chacha, R., Bartongo, I., Vagen, T-G. 2025. Monitoring Nature-Based Solutions for Emission Reductions: Insights from Makueni and Taita Taveta Counties, Kenya. Bogor, Indonesia: CIFOR; Nairobi, Kenya: ICRAF.

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This insights brief begins by outlining the global challenges of land degradation and the corresponding international commitments. It highlights the central role of nature-based solutions (NbS), particularly FLR, as a pivotal strategy for combating land degradation and mitigating climate change.

It then outlines Kenya's FLR priorities, describes the monitoring of FOLAREP outcomes at national and county levels, and underscores the importance of robust land-health indicators. It highlights the use of the Centre for International Forestry Research and World Agroforestry's (CIFOR-ICRAF's) Land Degradation Surveillance Framework (LDSF) for the systematic landscape-level assessment of soil and ecosystem health and its integration with the Regreening App, emphasising the importance of citizen science for effective NbS monitoring.

Initial LDSF results for Makueni and Taita Taveta sites are presented and the co-created UK PACT NbS Dashboard is introduced, illustrating how clear, accessible evidence can enhance transparency, support adaptive management, and strengthen policy coherence and decision-making. The brief concludes with key insights for effective NbS monitoring drawn from the UK PACT experience.

Background

Land degradation is widely recognised as one of the greatest environmental challenges facing humanity. Its impacts are profound: degradation threatens biodiversity, undermines food production, compromises water security, and diminishes the resilience of communities in the face of climate change. Defined as the persistent decline in the productivity, ecological function, and ecosystem services of land, degradation is driven by multiple factors including deforestation, overgrazing, poor agricultural practices, unsustainable urbanisation, and climate-induced pressures.

The United Nations Convention to Combat Desertification (UNCCD) estimates that more than 25% of the world's land is degraded, affecting nearly 3.2 billion people. Degraded lands are not only less productive but also less capable of storing carbon, exacerbating greenhouse gas emissions and limiting the ability of ecosystems to buffer extreme weather events such as droughts and floods. Drylands are particularly vulnerable, with desertification and soil fertility loss threatening livelihoods and intensifying food insecurity.

In this context, ecosystem restoration has emerged as a central strategy for tackling land degradation and addressing climate change. FLR initiatives fall under the broader umbrella of NbS, actions that work with and enhance nature to address societal challenges. Examples of NbS include afforestation, reforestation, agroforestry, regenerative agriculture, and wetland rehabilitation. These interventions deliver multiple benefits, they improve soil health, increase vegetation cover, enhance hydrological function, and build community resilience. Importantly, they also contribute to global climate goals by sequestering and storing carbon.

International momentum around restoration has accelerated in recent years. The United Nations Decade on Ecosystem Restoration (2021–2030) highlights the urgency of scaling restoration to reverse degradation and recover ecosystem functions. Under the UNCCD's Land Degradation Neutrality (LDN) target, countries are expected to balance degradation with restoration, ensuring a net neutral or positive outcome. At the continental level, Africa has embraced ambitious restoration goals through the African Forest Landscape Restoration Initiative (AFR100), which seeks to restore 100 million hectares by 2030.

Nature-based solutions (NbSs) are adaptive interventions to protect, manage and/or restore natural or modified ecosystems and address social, economic and environmental (including climate) challenges whilst simultaneously benefitting human well-being and biodiversity.

NbSs are interventions that use nature and the natural functions of healthy ecosystems to address challenges.

Monitoring Nature-Based Solutions in Kenya

Kenya faces a pressing challenge in halting forest and landscape degradation, driven by deforestation, competing land uses, overgrazing, and climate change. The country's forest cover is shrinking by around 5,000 hectares each year, with consequences for biodiversity, ecosystem services, and the resilience of rural communities (Wavinya et al., 2024). In this context, FLR has emerged as a critical NbS, offering integrated approaches to restore degraded ecosystems, improve productivity, safeguard water resources, and strengthen livelihoods.

Two counties in Kenya's arid and semi-arid regions, Makueni and Taita Taveta, have become focal points for demonstrating how restoration can deliver tangible outcomes. These counties are especially vulnerable to climate change impacts but also present significant potential for restoring forests, rangelands, croplands, riparian zones, grasslands, and even urban and roadside areas.

To support this, the national Forest and Landscape Restoration Implementation Plan (FOLAREP) 2023-2027 has been domesticated at the county level. The FOLAREP aligns with Kenya's National Landscape and Ecosystem Restoration Strategy and underpins the country's commitment to restore 5.1 million hectares under the Bonn Challenge and AFR100 by 2030. The domestication of the FOLAREP in Makueni and Taita Taveta requires monitoring at the county level.

BOX 1.

WHY MONITORING MANAGEMENT PRACTICES MATTERS

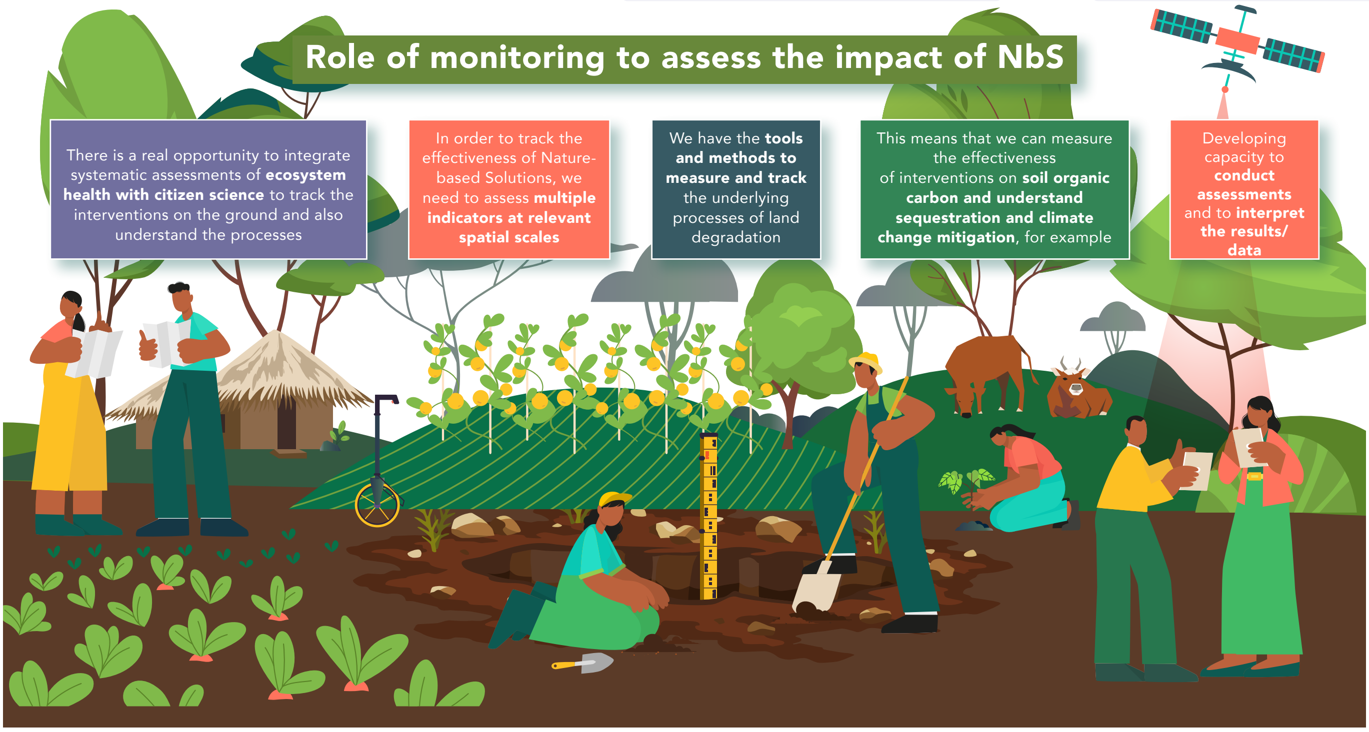
Restoration is not just about planting trees or rehabilitating land; it is fundamentally about changing land management practices in ways that sustain ecological and social outcomes over the long term. This requires monitoring to go beyond metrics and instead evaluate whether practices deliver meaningful, durable impacts. For example:

- Agroforestry interventions may increase tree cover, but information on tree species and survival rates, as well as monitoring is needed to verify improvements in soil and enhanced household income from diversified products.
- Soil and water conservation measures should be assessed for their ability to reduce erosion, improve infiltration, and sustain yields during dry seasons.
- Rangeland restoration should be evaluated according to improvements in pasture quality, including diversity and density of vegetation and reductions in bare ground.

There is a need for systematic monitoring protocols that capture plot-level data across landscapes. These plot-level data can provide critical information on the impact of land management on NbS indicators. It provides evidence for adaptive management, enabling interventions to be refined based on measured outcomes. This strengthens credibility and ensures that restoration contributes meaningfully to reducing emissions and enhancing resilience.

Forest and Landscape Restoration Implementation Plan (FOLAREP) 2023-2027

National Landscape and Ecosystem Restoration Strategy



Monitoring FOLAREP Outcomes at National and County Levels

National-level

The FOLAREP is Kenya's national FLR strategy, aiming to restore 5.1 million hectares by 2030. It provides:

- A restoration opportunity map and prioritisation framework;
- County-level targets for scaling restoration; and
- Linkages to regional and global FLR goals (AFR100, Bonn Challenge).

The goal of the FOLAREP is to '*accelerate actions towards restoring 5.1 million hectares of deforested and degraded landscapes by 2030 and contribute to the achievement of national aspirations and international obligations*'.

The overall objective of the FOLAREP is '*to restore 3.5 million hectares of degraded landscapes through integrated FLR approaches for improved ecological functionality and social economic benefits by 2027*'.

The FOLAREP Monitoring Framework was developed to provide a standardised set of indicators for tracking restoration progress, carbon sequestration, and land health improvement.

The Framework:

- Aligns with Kenya's reporting obligations under the Nationally Determined Contribution (NDC);
- Supports participatory monitoring through digital tools; and
- Builds on data from field assessments (e.g. LDSF) and satellite imagery.

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The Forest and Landscape Restoration Implementation Plan (FOLAREP) Monitoring Framework

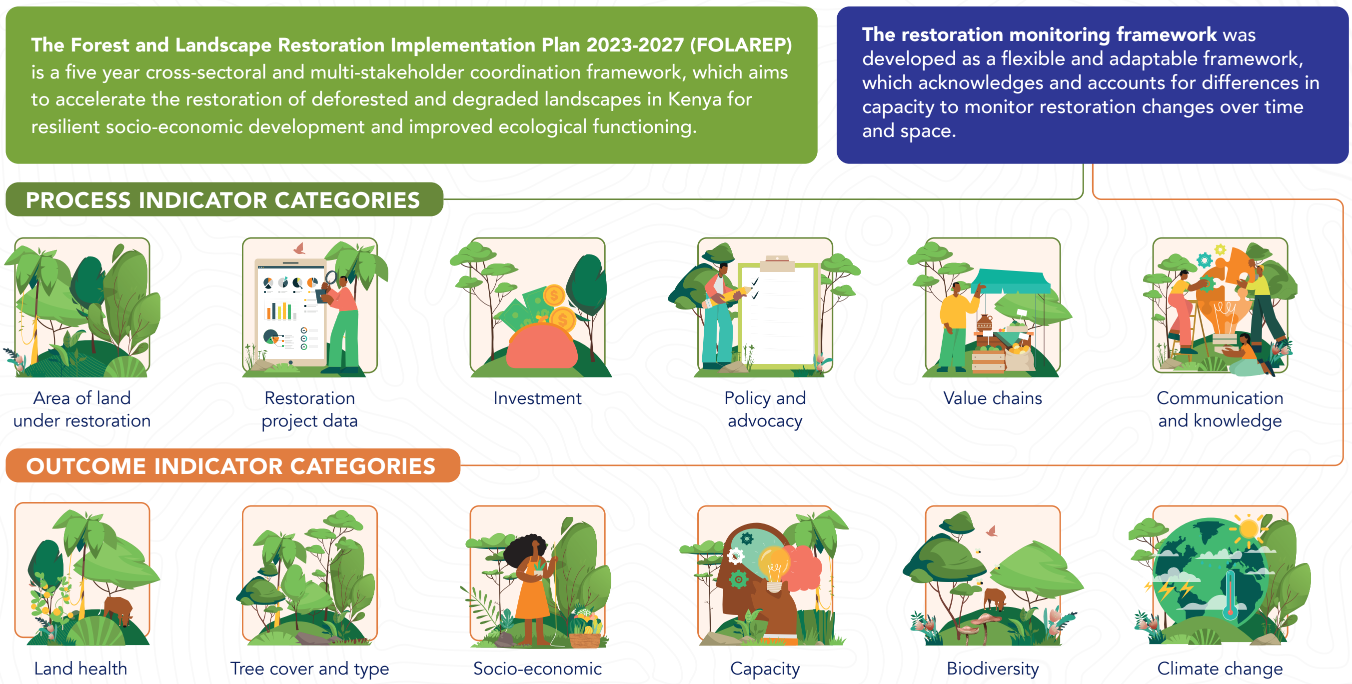

Figure 1. FOLAREP process and outcome indicator categories based on the monitoring and evaluation framework (Republic of Kenya, 2023)

County-Level

In June 2025, both Makueni and Taita Taveta Counties launched their FOLAREPs. Makueni set a target of restoring 200,000 hectares, while Taita Taveta committed to 226,420 hectares by 2033. Each plan is underpinned by a structured implementation matrix that outlines coordination, resource mobilisation, and a monitoring, evaluation, and reporting framework.

MONITORING OF KEY LAND HEALTH INDICATORS

One of the central contributions of FLR practices is their potential to mitigate climate change by sequestering carbon. Healthy soils and restored ecosystems act as major carbon sinks. However, quantifying this potential requires systematic monitoring of key indicators such as soil organic carbon (SOC), vegetation cover, and land-use change.

Without credible monitoring, restoration cannot be effectively integrated into national climate commitments or carbon markets. Evidence of emissions reductions builds trust among policymakers, investors, and communities. It enables restoration projects to access climate finance, including results-based payments for verified carbon sequestration.

By generating baseline data and tracking changes over time, monitoring frameworks demonstrate the alignment of restoration with NDCs and global climate and development goals. They also provide assurance to stakeholders that restoration is delivering measurable climate benefits.

BOX 2. **WHAT IS EVIDENCE?**

The Intergovernmental Panel on Climate Change (IPCC) defines evidence as data and information used in the scientific process to establish findings (IPCC, 2018). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) adds that evidence must consider type, quality, and consistency, as well as the level of agreement among experts (IPBES, 2018). The Centre for International Forestry Research and World Agroforestry (CIFOR-ICRAF) broadens this definition to include experiential insights, local knowledge, and context-specific data (Neely et al., 2021). In restoration, evidence must therefore be understood as multi-faceted, integrating scientific measurements, remote sensing, and local perspectives to create a comprehensive understanding (Mansourian et al., 2025).

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USING THE LAND DEGRADATION SURVEILLANCE FRAMEWORK TO MONITOR FOLAREP OUTCOMES

The LDSF is a comprehensive method developed by World Agroforestry (ICRAF) scientists, as a response to a lack of methods for systematic landscape-level assessment of soil and ecosystem health, using a robust and consistent indicator framework. The LDSF offers valuable diagnostics to help unpack the complexities of managing ecosystem health across landscapes, including the trade-offs involved, through:

- **Science-based field protocol** for measuring landscape-level ecosystem health: vegetation cover and structure, floristic composition, historic land use, land degradation, and soil characteristics (such as SOC for climate-mitigation potential and infiltration capacity).
- **Monitoring and evaluation framework** to track land-degradation processes and the effectiveness of restoration efforts over time.
- **Systematic data-collection** method ensuring consistency and comparability across sites.
- **Stakeholder engagement approach** that captures insights on land health, land use, and carbon stocks over time and place.

In Kenya's domesticated FOLAREPs in Makueni and Taita Taveta, the LDSF serves as the core biophysical monitoring approach, complementing institutional indicators set out in the county-level plans and enhancing monitoring through its integration with tools such as the Regreening App. CFAs and local stakeholders are being trained to use the Regreening App, which enables communities to record where restoration activities are taking place and track changes in the occurrence of exotic tree species.

BOX 3. WHAT IS AN INDICATOR?

An indicator is a specific, measurable characteristic or a compositive variable derived from one or more raw metrics, that provides information about the condition, trend, or change in land health over time. Indicators assess key aspects of ecosystems, such as soil health, vegetation cover, water availability, or biodiversity, and help determine whether restoration or land management practices are achieving the desired outcomes. Effective indicators are scientifically robust, practical for field measurement, and relevant to local environmental and social contexts. They enable a functional interpretation of land health.

The Land Degradation Surveillance Framework (LDSF)

The LDSF tracks the following key indicators:

- **SOC**: measures soil fertility and carbon sequestration potential, critical for emissions reduction.
- **Tree and shrub biodiversity**: captures species richness, vegetation structure, and ecological co-benefits of restoration.
- **Grass and rangeland condition**: tracks perennial/annual species composition, ground cover, and grazing pressure, central to dryland resilience.
- **Soil erosion prevalence and infiltration capacity**: monitors land stability, water regulation, and productivity.
- **Vegetation cover and land-use history**: provides insight into restoration dynamics, pressures, and shifts from degradation to recovery.

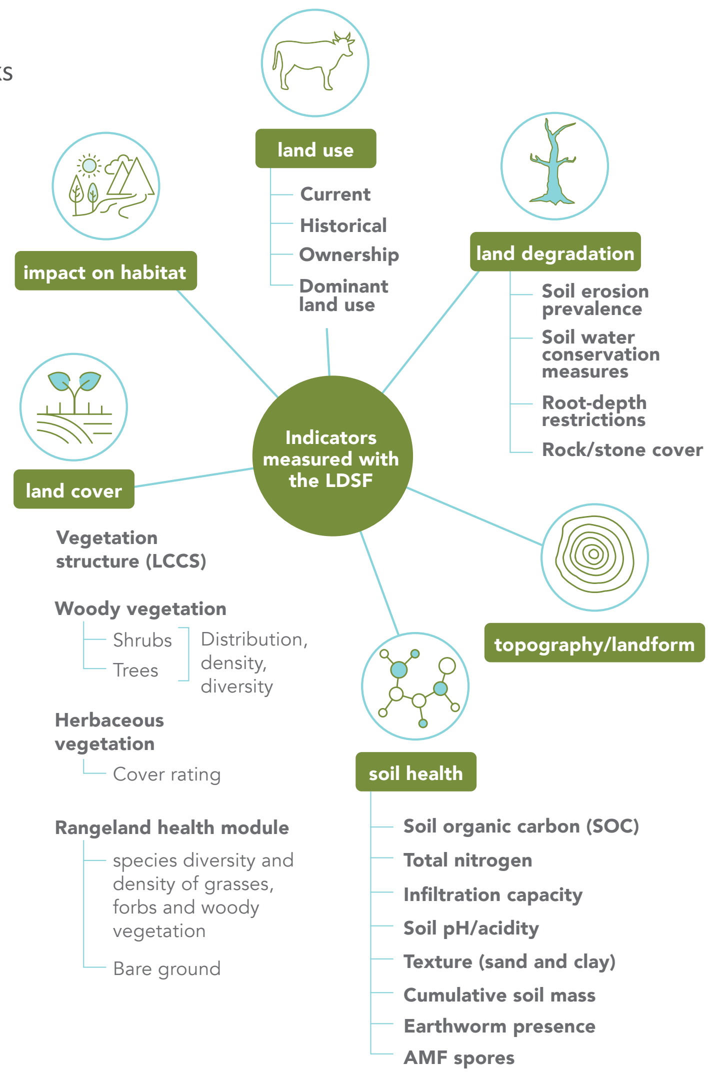


Figure 2: Full suite of indicators collected using the LDSF

The LDSF is a field-based tool that allows for systematic and science-based landscape-level assessment and monitoring of soil and ecosystem health across diverse landscapes across scales. The LDSF has a set of indicators focused on land cover, habitat, soil health, topography/landform, land use and land degradation that link with and enhance the FLR indicators.

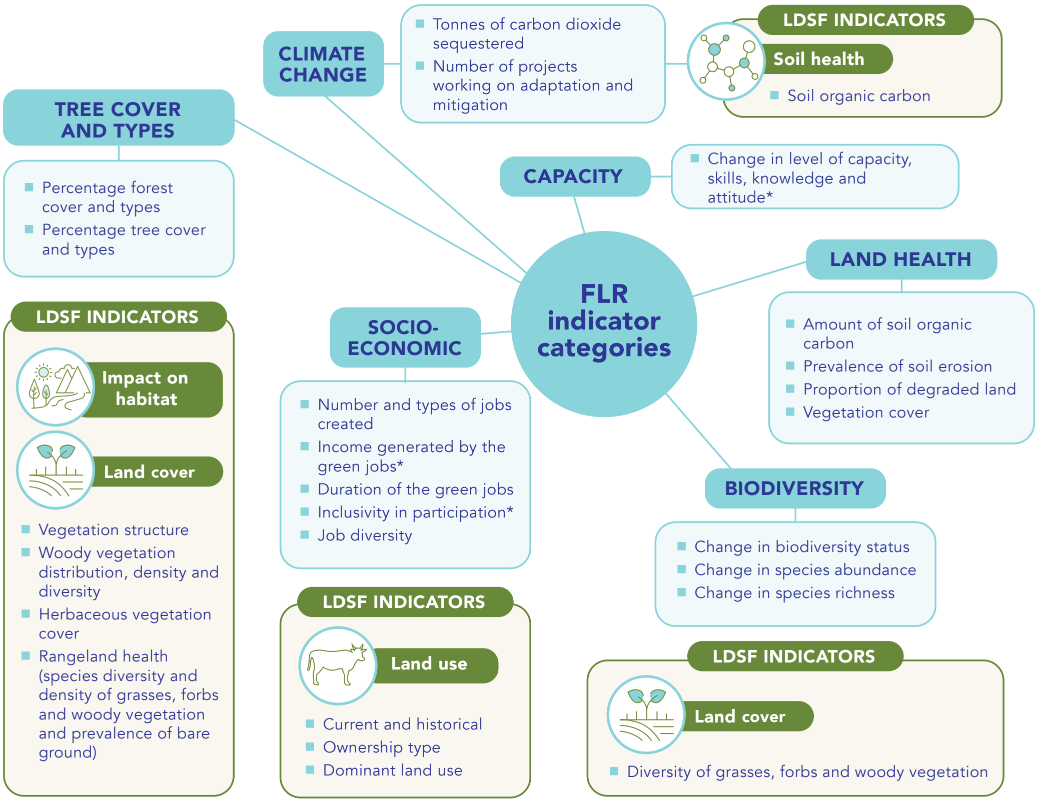
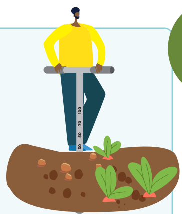


Figure 3. How LDSF indicators link with and enhance FLR indicators

Stakeholder Engagement and Capacity Building within the LDSF Process

The LDSF's hands-on approach builds stakeholder capacity and relationships through three steps:

STEP 1 In-field training



Stakeholders receive practical instruction in LDSF methodology, including:

- Navigation to randomised LDSF plots with global positioning systems (GPS);
- Digital and back-up paper data entry (e.g. Open Data Kit); and
- All LDSF field survey aspects such as:
  - ✓ Soil sampling;
  - ✓ Tree and shrub measurements (including biodiversity assessments);
  - ✓ Documenting land-use history and management practices;
  - ✓ Measuring infiltration capacity; and
  - ✓ Observing soil erosion.

STEP 2 Data analysis and management workshops

Small stakeholder workshops focus on analysing field data to understand degradation drivers, prioritise intervention areas, and monitor change with time.

The workshops build stakeholder capacity for data analysis and management which feeds directly into the development of a dashboard or tool with which to review the data.

The LDSF data analytics training teaches stakeholders how to:

- Normalise and clean data;
- Explore datasets with R statistics, tidy and visualise results, and apply mixed-effect models to assess land and soil health; and
- Develop databases and strengthen data-management skills.

Additional remote-sensing (RS) training introduces key GIS/RS concepts, open-source software, and basic RS data analysis.

STEP 3 Dashboard co-design

Data generated through the LDSF feed into online dashboards co-designed with stakeholders, enabling review of multiple data sources and supporting evidence-based decision-making.

Linking the LDSF and Regreening App for a Deeper Understanding

The Regreening App is a mobile-based Android application that enables users to collect data at the farm level on a variety of land restoration practices, aiding robust landscape-level monitoring (Regreening Africa, 2022). Linking the LDSF and Regreening App approaches allows for comprehensive understanding of what works where, guiding successful restoration interventions through near real-time data and citizen-science.

The benefits include:

- Creating consistency when comparing sites;
- Helping our understanding of impact over time;
- Supporting the development of robust predictive models; and
- Assessing the multiple aspects of soil health.

The integration of citizen science is beneficial as it closes learning loops, encourages participation and co-learning, and helps scale data collection.

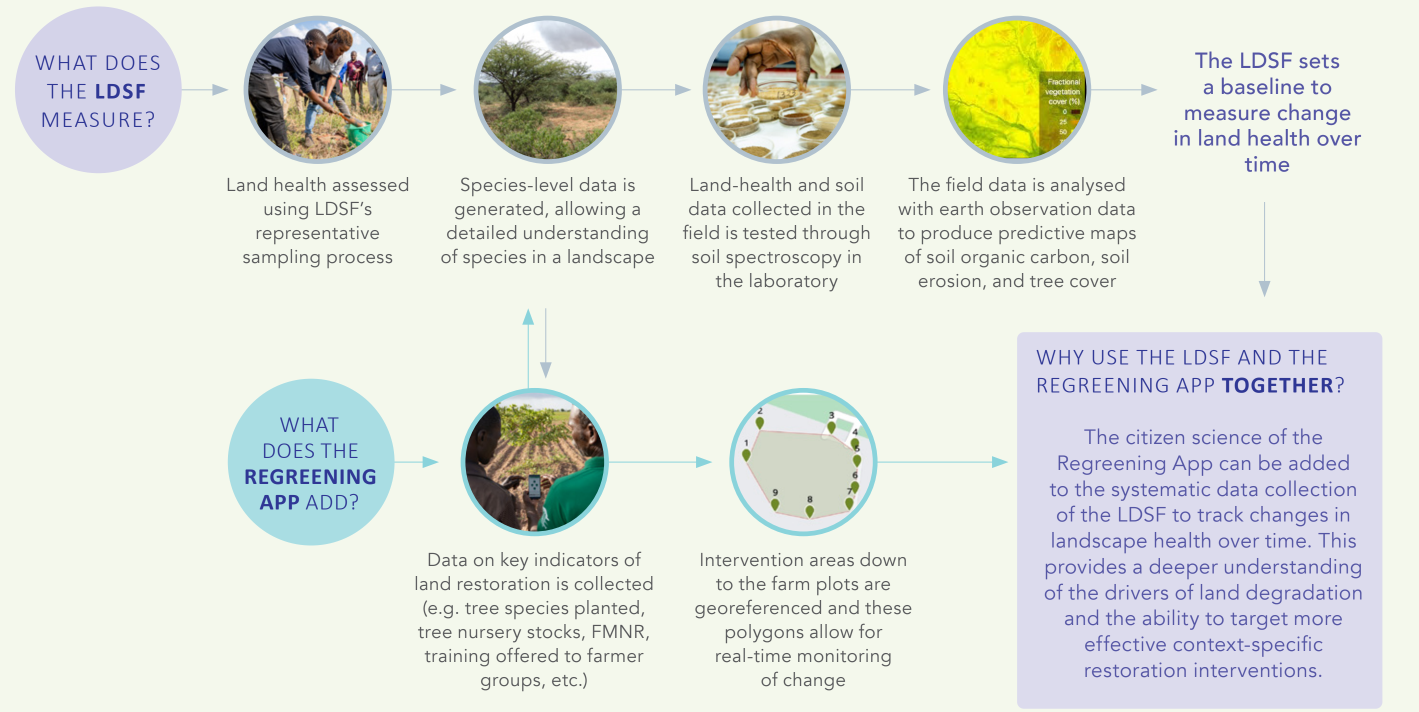


Figure 4: Details of what the LDSF measures and how the Regreening App data is linked to understand trends

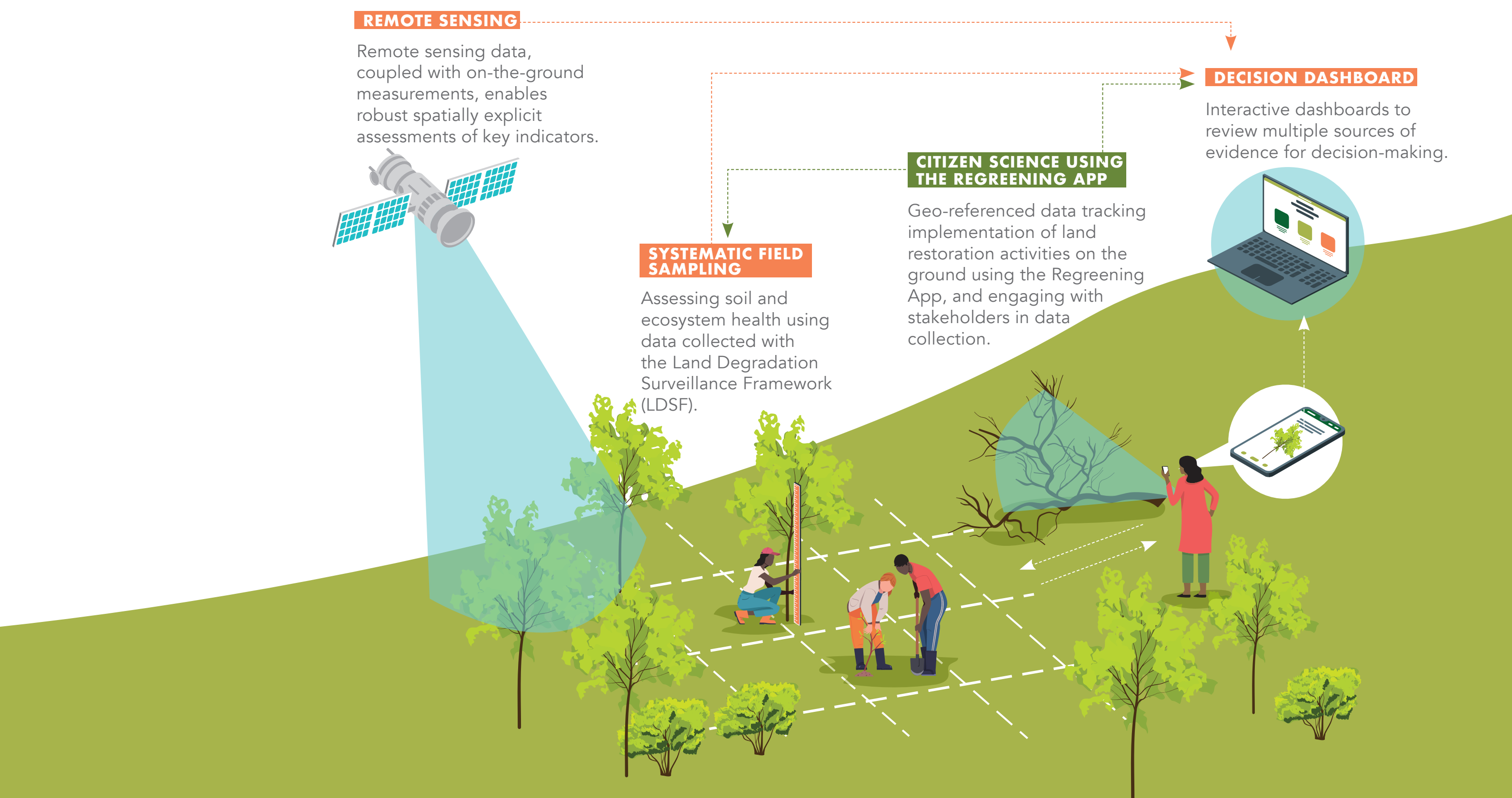


Figure 5. Systematic landscape monitoring approach linking the LDSF and Regreening App (Regreening Africa, 2022)

Assessing Variability in Biophysical Characteristics Across Four LDSF Sites

The LDSF Spatially Explicit Stratified Sampling Design

Landscapes are diverse, it is therefore critical that a sampling design captures the variability in biophysical characteristics at multiple scales (plot, landscape, regional). To cost-effectively sample a landscape, a stratified sampling is recommended. Intentionally dividing the landscape into relatively homogeneous units, based on a specific variable of characteristic (e.g. soil type, elevation zone, management practice, land use), so that each stratum is sampled.

Stratification increases statistical power and ensures a balanced sampling across the landscape. Once strata are identified, it is important to have a spatially explicit sampling design. Within the LDSF protocol the hierarchy is explicitly codified (subplots > plots > clusters > sites). LDSF clusters (1 km^2) are randomised within each stratum and each contain 10 randomly selected 1,000 m^2 sampling plots, within which field observations are made using systematic and standardised approaches. All measurements in the field happen in the sampling plots. This facilitates capturing variability at different ecological scales and supports the development of predictive models through integration with earth observation data. These models are locally relevant but can be scalable to regional or global levels.

Early Monitoring Results in Makueni and Taita Taveta

Four 100 km^2 LDSF sites were sampled, two in Makueni (Mbooni and Kalamba) and two in Taita Taveta (Lumo and Chawia) revealing critical insights for future actions:

- **Land use and erosion**: Land uses varied from rangelands in Lumo to perennial crops in Kalamba and agroforestry systems in Mbooni and Chawia. Erosion prevalence ranged widely, from low in Chawia to high in Lumo, underlining the need for site-specific soil and water conservation measures.
- **Tree biodiversity**: Species richness differed sharply, with only 6 tree species recorded in Lumo compared to over 90 in Chawia. While Kalamba and Mbooni had relatively high diversity, exotic species, particularly *Eucalyptus spp.*, dominated, raising concerns over the limited presence of indigenous species.
- **SOC**: SOC was significantly higher in forested and woodland areas (Chawia median: 27 g C/kg) than in rangelands (Lumo median: 9 g C/kg). This underscores the vital role of forest remnants in carbon storage and biodiversity conservation, as well as their importance in meeting climate mitigation targets.

The findings in Figure 6 highlight both opportunities and risks for FLR. Forest remnants like Chawia are biodiversity and carbon strongholds that must be conserved, while degraded rangelands such as Lumo demand urgent restoration. The widespread dominance of exotics indicates the need for targeted investment in indigenous species to secure long-term ecosystem resilience. The results provide actionable evidence for prioritising restoration interventions under the FOLAREPs.

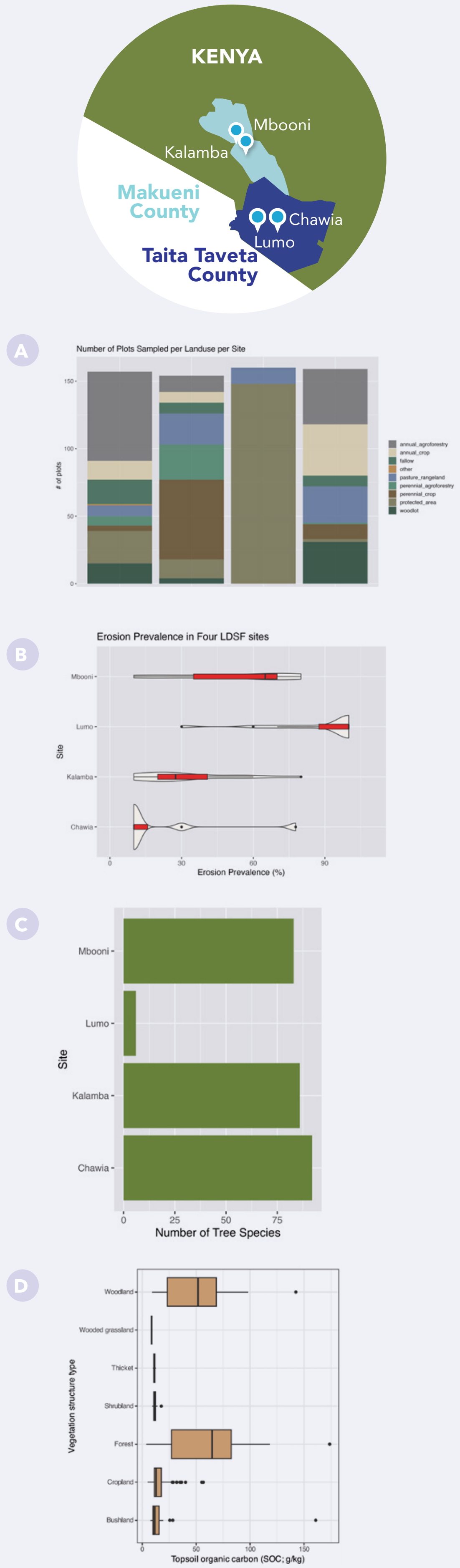


Figure 6. LDSF results for the Mbooni, Kalamba, Lumo and Chawia sites: a) land use types, b) erosion prevalence, c) tree species richness, and d) topsoil SOC

The Importance of Evidence Interpretation, Use and Uptake

Data is only valuable if it is understood and used. Too often, monitoring results remain locked in technical reports inaccessible to communities or policymakers. Effective communication of data requires:

- Co-design processes that involve stakeholders in determining which indicators matter most.
- Visualisations that simplify complex information.
- Dashboards that allow stakeholders to explore data interactively.

When data is communicated effectively, it enhances transparency, accountability, and collaboration. It strengthens multi-stakeholder platforms, enabling governments, non-governmental organisations, communities, and the private sector to engage in evidence-based dialogue and decision-making (Mansourian, 2025).

BOX 4. WHAT IS A DECISION DASHBOARD AND HOW IS IT BENEFICIAL?

A decision dashboard is an open-access, online platform designed to make information easy to access, explore, and use. By consolidating diverse datasets into a single, visualised interface, dashboards enable rapid analysis and effective communication for users and decision-makers alike. Each dashboard is tailored to its specific context and audience, serving as a central hub to systematise, store, and retrieve data. Beyond improving access, dashboards strengthen ownership of data and resources, build capacity to interpret complex information, and foster evidence-based planning and decision-making. Importantly, when dashboards are co-created with end-users from the outset, they ensure that stakeholders are actively engaged in the design and implementation process, making the tool both relevant and impactful.

Stakeholder engagement with evidence for improved decision-making

Engaging stakeholders with evidence is essential to building a culture of informed decision-making in complex development contexts.

When diverse stakeholders, including scientists, development practitioners, policymakers, and local communities, actively engage with evidence, they create the conditions for more inclusive, adaptive, and sustainable outcomes. Such engagement not only strengthens trust and collaboration but also ensures that decisions are informed by multiple knowledge sources, making them more resilient and responsive to dynamic challenges such as climate change and land degradation.

BOX 5. ADVANCING SOIL HEALTH MONITORING TO DELIVER ON THE NAIROBI DECLARATION AND COMPREHENSIVE AFRICA AGRICULTURE DEVELOPMENT PROGRAMME (CAADP) COMMITMENTS

The Nairobi Declaration, adopted at the Africa Fertilizer and Soil Health Summit in May 2024, calls for urgent action to rebuild soil health, restore degraded lands, and transform Africa's food systems. Central to this is the establishment of a systematic soil health monitoring system aligned with CAADP's monitoring and evaluation processes, supported by continent-wide metrics. Although soil health underpins productivity, resilience, and climate action, it is still missing from the CAADP Biennial Review framework, leaving countries unaccountable for progress. The new Kampala CAADP Strategy and Action Plan (2026–2035) offers a timely opportunity to embed robust soil health indicators, set clear targets, and align monitoring with agricultural development roadmaps. A holistic approach to soil health is needed, one that integrates land-use, social, and biophysical indicators into monitoring systems. By incorporating SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) metrics, baseline data, effective data management, and accessible dashboards, such systems can generate actionable evidence to guide farmers, policymakers, and partners (AUDA-NEPAD, 2025).

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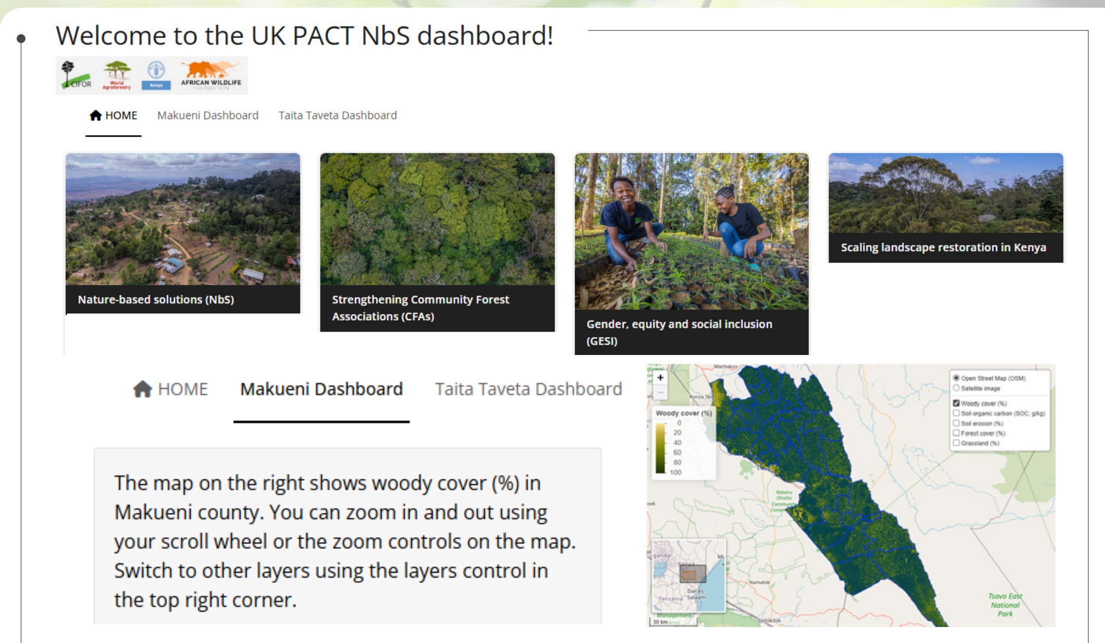
The UK PACT NbS Dashboard

As part of the UK PACT programme, CIFOR-ICRAF and partners facilitated a series of co-creation workshops in Makueni and Taita Taveta Counties to design an NbS indicators dashboard for monitoring FLR and broader NbS outcomes.

The first workshop (March 2025) brought together 40 stakeholders, including county government departments, national agencies, universities, civil society groups, and community organisations, from both counties. Participants worked to develop a shared understanding of NbS indicators, identify those already monitored locally, and discuss county-level reporting needs. A ranking exercise prioritised indicators for inclusion in the dashboard, with forest and tree cover change emerging as the top priority, followed by area restored/under FLR and biodiversity change. Soil health and species density/diversity were also highlighted as critical for local monitoring

A second workshop (June–July 2025) reviewed the first iteration of the dashboard and refined its design. Through group work and panel discussions, participants emphasised the importance of a user-friendly, visually engaging, and informative platform that effectively communicates project goals, tracks progress and showcases community involvement. Recommendations included clear organisation of indicators, integration of interactive maps, inclusion of multimedia elements, and accessible summary visuals.

The resulting NbS Dashboard is intended as a centralised, open-access tool for data integration, visualisation, and knowledge exchange. By aligning technical functionality with user needs, it enhances transparency, supports adaptive management, and strengthens policy coherence. Importantly, the co-creation approach ensured that end-users shaped both the content and design, embedding local ownership and ensuring the platform responds directly to county and national reporting requirements while also linking to international frameworks.



Visit the NbS dashboard

Figure 7. First iteration of the UK PACT NbS dashboard (Accessible here)

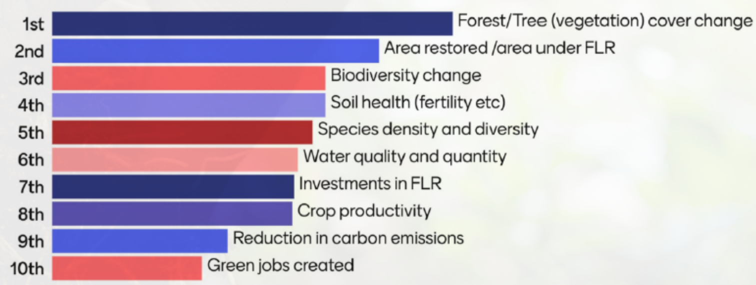


Figure 8. Prioritised NbS indicators

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Insights for Effective Monitoring of Nature-Based Solutions

Monitoring plays a pivotal role in ensuring that NbS deliver on their promise to reduce emissions, enhance climate resilience, restore ecosystems and support biodiversity and livelihoods. Kenya's experience with the UK PACT-supported FOLAREPs in Makueni and Taita Taveta offers valuable lessons for how monitoring can be designed and implemented to demonstrate impact and inform action.

MONITORING MEANINGFUL INDICATORS

Kenya's experience highlights the importance of tracking meaningful indicators to guide adaptive management. Effective restoration monitoring goes beyond counting the number of seedlings planted to assess whether interventions actually enhance carbon storage, improve soil fertility, and build resilience to droughts and floods. In Makueni and Taita Taveta, this means verifying if agroforestry interventions are increasing SOC, if soil and water conservation practices are reducing erosion, and if biodiversity conservation (e.g. indigenous species) is signalling stable ecosystems.

BUILDING EVIDENCE FOR EMISSIONS REDUCTION

Robust evidence is essential to credibly demonstrate how NbS contribute to mitigation. The LDSF provides baselines and long-term monitoring of SOC, vegetation cover, biodiversity, rangeland condition, and erosion prevalence. These indicators enable the quantification of sequestration and avoided emissions, strengthening the country's ability to integrate NbS into national climate strategies, carbon markets, and results-based finance. Monitoring also ensures that restoration is recognised as a measurable contributor to national and international climate targets.

CITIZEN SCIENCE

Citizen science has proven critical in scaling restoration monitoring in Kenya. Through training on tools like the Regreening App, CFAs and farmers record restoration activities, tree species composition, and land use changes. This locally-led data collection complements LDSF surveys and satellite imagery, producing rich, multi-source evidence of how NbS deliver carbon sequestration, avoided emissions, and resilience benefits. Citizen science makes monitoring more cost-effective, transparent, and democratic.

COMMUNICATION OF MONITORING RESULTS BUILDS OWNERSHIP.

The UK PACT NbS Dashboard demonstrates how co-creation processes can result in user-friendly data visualisation tools ultimately improving the translation of monitoring into action, policy coherence, and accountability.

ESTABLISH LONG-TERM FINANCING FOR COMMUNITY-LED MONITORING

National and county policies should earmark dedicated, multi-year funding to train and compensate local monitors (e.g. CFAs), maintain digital tools (e.g. Regreening App), and support continuous capacity development. Stable financing ensures consistent data flows, strengthens adaptive management, and safeguards emission-reduction claims over the long-term.

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