Regreening Africa

Funded by European Union CIFOR World Agroforestry

REGREENING AFRICA CONSOLIDATED ENDLINE REPORT

AUGUST 2023




Foreword

Landscape restoration has received significant attention in recent years through the African Forest and Landscape Restoration Initiative (AFR100), as part of the Bonn Challenge, a revitalisation of the Great Green Wall across the Sahel and Horn of Africa and declaration of the United Nations Decade on Ecosystem Restoration 2021-2030. Renewed interest in restoring landscapes arose from the recognition that degrading land cannot provide ecosystem services such as healthy soils, carbon storage, water, and food. Climate change has amplified the urgency for change. Restored landscapes are more resilient to changing climates as they retain more water, have greater diversity of plants and food, and have healthy soil that enhances productivity.

With over 65 percent of agricultural land in sub-Saharan Africa degraded, the challenge is how to enable restoration actions that are low-cost, impactful, sustainable over time, benefit the people who manage and are dependent on the land, and that can be invested in.

Regreening Africa has taken up this challenge and, over the past five and a half years, the programme has promoted the practice of agroforestry with complementary soil and water conservation measures. Value chain and policy options were also pursued to create incentives and an enabling environment for practice change. Farmer Managed Natural Regeneration (FMNR) was a central practice of the programme, complemented by tree growing through planting and grafting.

Through a collaboration between research, development, community, and policymakers, Regreening Africa aimed to cover 1,000,000 hectares of land and benefit over 500,000 households. Its objectives included decreasing soil erosion, increasing soil organic carbon, and to improve total farm income of those engaged in the restoration actions.
While of critical importance, Regreening Africa was not only about this ambitious implementation. The programme was one of 'Research in Development' where research and learning were integrated. Monitoring, evaluation, and learning were central to the programme, both to understand progress in implementation and adaptively manage interventions, as well as learning from the process to inform wider practices and policies.

The report you are about to read shares results from the endline survey and other data sources, highlighting the achievements of Regreening Africa in terms of reach, uptake, and impact over four years of implementation. Important insights on the potential benefits from the restoration process are also shared, reiterating the value of investing in 'regreening' the land. Using the best science available, the results presented here offer evidence of what worked well, where improvements are needed, and the impact of restoring landscapes.

I hope you find the insights valuable, and I trust that the lessons learned will inform wider practices and policies.

Ravi Prabhu
Director of Innovation, Investment and Impact
CIFOR-ICRAF

Acronyms and abbreviations

AFR100	African Forest and Landscape Restoration Initiative
CAPI	Computer Assisted Personal Interview
CIFOR	Centre for International Forestry Research
ELD	Economics of Land Degradation
EO	Earth Observation
FAO	Food and Agriculture Organization of the United Nations
FIES	Food Insecurity Experience Scale
FMNR	Farmer Managed Natural Regeneration
GHG	Greenhouse Gas
GPM	Global Precipitation Mission
ICRAF	World Agroforestry
LDN	Land Degradation Neutrality
LDSF	Land Degradation Surveillance Framework
MDD-W	Minimum Dietary Diversity - Women
MPI	Multidimensional Poverty Index
NDVI	Normalised Difference Vegetation Index
NGO	Non-governmental organisation
PCA	Principal Component Analysis
PPP	Purchasing Power Parity
RAI	Regreening Action Index
SAMIRA	Seasonal AutoRegressive Integrated Moving Average
SATVI	Soil Adjusted Total Vegetation Index
SDG	Sustainable Development Goals
SLM	Sustainable Land Management
SOC	Soil Organic Carbon
ToC	Theory of Change
UNEP	United Nations Environment Programme
UNCCD	United Nations Convention to Combat Desertification
WEAI	Women's Empowerment in Agriculture Index

Citation:
Tesfaye Woldeyohanes, Hilda Kegode, Karl Hughes, Ibrahim Outtara, Tor-Gunnar Vågen, Leigh Ann Winowiecki, Jasper Kleinsmann, Ravi Prabhu, Mieke Bourne. 2023. Regreening Africa Consolidated Endline Survey Report. World Agroforestry. Nairobi, Kenya.

Contents

Executive summary

BACKGROUND

Africa faces extreme degradation of over half of its agricultural land. Halting and reversing land degradation is critical to regain lost ecological functionality that underpins life-sustaining ecosystem services, such as the provisioning of food, fresh water, fibre, and the regulation of climate, natural disasters, and pests. Indeed, restoration is fundamental for meeting the triple goals of tackling the climate crisis, reversing biodiversity loss, and improving human wellbeing. The United Nations General Assembly declared 2021 to 2030 as the decade of "ecosystem restoration," signalling a global consensus on the urgency to restore degraded lands.

By incorporating trees into cropland, communal land, and, where appropriate, pastoral areas, regreening efforts make it possible to reclaim Africa's degraded landscapes. Regreening Africa (Phase 1 - 2017 to 2023) is part of a larger global and regional effort to reverse and halt land degradation. Phase 1 was implemented in eight African countries: Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal, and Somalia. Funded by the European Union, this first phase of Regreening Africa was led by World Agroforestry (ICRAF), in partnership with five international non-governmental organisations (NGOs) — World Vision, Oxfam, Care International, Catholic Relief Services, and Sahel Eco. It sought to (a) directly reverse land degradation across one million hectares of agricultural land in eight countries in Sub-Saharan Africa to benefit 500,000 households; and (b) catalyse a much larger scaling effort to restore tens of millions of hectares of degraded land across the continent.

This report presents findings from Regreening Africa's baseline and endline surveys, as well as several other data capture tools.

SUMMARY OF METHODS

Baseline and endline surveys were administered in all of Regreening Africa's direct scaling sites. A total of 9,835 households were intervened at baseline. Of these, 7,683 were reinterviewed at endline. The 2,152 households that were not reinterviewed are primarily located in areas where security issues emerged during the life of the programme, e.g., in Ethiopia's Tigray region and in several of Niger's direct implementation sites. Among other things, survey data was used to estimate the extent to which Regreening Africa's two central targets were achieved–regreening practices adopted by 500,000 households on one million hectares of land.

The original plan was to assess programme impact by comparing households targeting earlier on in the programme with those targeted in its last year. However, the above security issues and pressure to realise the programme's ambitious targets led to the abandonment of this strategy. Instead, this report documents changes in the status of various socioeconomic and biophysical indicators between the baseline and endline periods, following Regreening Africa's Theory of Change (ToC) for its direct implementation sites.

Given that data were collected from the same households and individuals during the baseline and endline surveys, we complement this with an analysis of changes in key adoption indicators against key changes in selected impact indicators. This type of analysis is referred to as first difference estimation. The validity of our results rest on two key assumptions:

1. Regreening Africa made a significant contribution to the uptake of regreening practices in the direct implementation sites; and
2. the absence (or, otherwise, only partial influence) of factors that influenced both regreening practice uptake and changes in the impact indicators of interest.

KEY FINDINGS

The following table summarises Regreening Africa's endline results, following the main steps of a simplified ToC.

TOC STEP	ENDLINE HIGHLIGHTS	
Provision of contextually appropriate restoration support	• Farmer receipt of agroforestry related training, extension, or support significantly improved over the programme period, increasing from 14% to 50% across all eight countries. Over 160,000 households in the direct scaling sites were reached during the programme period. • Both male and female household members received such training, with men in more than 129,000 households and women in more than 76,000 households being reached.	• Most of the training provided, focused on tree planting and the management of already established trees. • Upscaling support was mainly provided by project or NGO staff (37%) or government affiliated personnel (16%) in all countries.
Households & communities scale up both ecologically and socioeconomically impactful restoration activities	• Overall, household engagement in regreening practice rose from 55% to 88% over the life of the project, with significant variation across countries. For example, households upscaling regreening practices in Ghana rose from 7% to 70%, while in Ethiopia, it only rose from 23% to 34% in the surveyed sites, which were limited to two woredas (districts) - Sire and Shashogo.	• A total of 152,251 households in direct scaling sites across all countries were exposed and scaled up regreening practices on their land use areas, representing 65% of the direct scaling target. • The most popular regreening practices upscaled were the management of existing trees and tree planting, with tree planting efforts being scaled up more intensely in Ethiopia, Ghana, Kenya, Rwanda, and Somalia.
More optimal integration of trees into farming systems and wider landscapes	• Over the programme period, tree establishment by planting or FMNR occurred in various land use areas, with a near doubling of the numbers of trees newly established, rising from 67 to 129 trees. • Tree density also increased from an average of 43 trees per hectare at baseline to 120 trees per hectare at endline.	• It is estimated that 189,562 Hectares of land were regreened across all the direct scaling programme sites, representing 47% of the target. • In Eastern Africa, there was an increase in the number of exotic trees compared to native trees, especially in Rwanda. In West Africa, households were more likely to upscale indigenous tree species.
Improved soil, land health & other ecosystem services	• Changes in the status of two key land health indicators, soil organic carbon (gC kg^(-1)) and soil erosion prevalence (%), were compared between the baseline and endline periods. • Overall, a relative increase of 3% in Soil Organic Carbon (SOC) compared to baseline was observed, with significant variation across countries and programme sites within countries. Similarly, although no large changes in soil erosion prevalence were observed overall, some implementation sites within countries saw a significant reduction in erosion prevalence.	• Further examination revealed a positive and statistically significant association between changes in the number of trees scaled up on-farm, changes in tree cover, and the greening score (a remote sensing derived indicator that measures the deviation in actual detected green cover from predicted tree cover based on historical trends while controlling for measured changes in precipitation) on the one hand, and changes in SOC on the other. However, this was not the case for soil erosion.

TOC STEP	ENDLINE HIGHLIGHTS	
Sustainable increases in productivity & farm income	• Over the project period, the overall percentage of households reporting the use of tree products obtained from on-farm and from the communal land doubled. • The most accessed and used product was fuelwood, with the percentage of households reporting access to fuelwood on-farm significantly increasing over the project period. Similarly, the percentage of households reporting the use of fruits and nuts increased from 19% to 37%.	• The sale of tree-related products increased from 8% to 20%, with significant variation across countries. Notably, in Ghana and Mali, there was a noticeable increase in the percentage of households selling fruits and nuts, rising from 8% to 30% and 14% to 28%, respectively. However, the overall average income per household from tree products did not change, remaining at USD 82 purchasing power parity (PPP), with considerable variation across countries. However, it is worth noting that the number of households earning additional income from trees significantly increased from less than 600 to over 1500 over the project period. • Further assessment using first difference estimation revealed that households that intensified their consumption of tree products and earned additional income from trees experienced improved dietary diversity and gains in asset holdings.
Out-scaling of successful practice to magnify impact	• Implementing partners worked to outscale regreening practices beyond the initially identified sites by leveraging other programmes within or outside their institutions using diverse approaches.	• In Mali and Rwanda, over 5300 and 3300 households, respectively, were exposed to and took up regreening activities on an additional 25,000 and 600 hectares, respectively. Only Mali and Rwanda were surveyed in leveraging sites.
Stakeholder engagement and policy influencing	• Each country identified policy and/or institutional challenges that could be addressed through the programme. Engagement activities targeted changes in behaviour or actions of individuals in institutions, tracked through outcome mapping.	• Key achievements were observed in all countries. These included the formation of environmental committees at district level in Ghana, integration of FMNR in district development plans in Ethiopia, the development of a restoration plan and agroforestry strategy in Kenya, and access to land for women in Mali. In Niger, a presidential decree on FMNR granted greater tree user rights to communities. In Rwanda, an agroforestry task force was established, and in Senegal, different communes joined the association of green communes to support FMNR, and grazing areas for transhumant cattle herders were established. In Somalia, FMNR was mainstreamed into government policy documents.

** Key impact indicators of Regreening Africa's LogFrame*

1 Introduction and purpose

WHY LAND RESTORATION?

In Africa, land serves as the foundation for food and nutritional security, human well-being, economic growth, and development. An estimated 83 percent of people in Sub-Saharan Africa directly depend on land for their livelihoods. However, approximately 46 percent of the land area in Africa is already degraded, affecting over 485 million people, and resulting in an annual cost of over US$ 9 billion[1]. Moreover, over 65 percent of agricultural land is degraded.[2] According to the FAO Global Forest Resource Assessment, Africa is the only continent witnessing an increase in deforestation and forest conversion to agricultural land,[3] with 55 percent of degraded land at risk of further degradation and desertification, according to the Economics of Land Degradation (ELD) and the United Nations Environment Programme (UNEP).[4] It is therefore the continent with the largest challenge of degradation but also with high potential for restoration.

Land restoration is of utmost importance to restore the lost ecological functionality that sustains life-supporting ecosystem services, including the provisioning of food, fresh water, and fibre, as well as the regulation of climate, natural disasters, and pests. It plays a crucial role in achieving the triple goals of tackling the climate crisis, reversing biodiversity loss, and improving human wellbeing, as envisioned in the Paris Agreement,[5] Kunming-Montreal Biodiversity Framework,[6] and the Sustainable Development Goals (SDG).

The United Nations General Assembly's declaration of 2021 to 2030 as the decade of "ecosystem restoration" underscores the global consensus on the urgency of restoring degraded lands. This urgency is driven by multiple interconnected factors. Firstly, land degradation poses significant risks to health, livelihoods, and wellbeing of approximately 3.2 billion people worldwide, incurring an estimated annual cost of US$490 billion, much higher than the cost of prevention.[7] If left unchecked, it will lead to a detrimental cycle of forest, tree, and biodiversity loss, contributing to poverty, hunger, unemployment, instability, and conflict. Secondly, the unprecedented and accelerating rate of biodiversity loss and species extinction threatens the wellbeing of present and future generations.[8] Lastly, around 24% of Greenhouse Gas (GHG) emissions come from agriculture, forestry, and other land uses,[9] exacerbating climate change and its impacts due to deforestation, land degradation, and unsustainable land use practices.

1. https://agnes-africa.org/wp-content/uploads/2020/07/Policy-brief-2_Land-Degradation_Final_09032020.pdf
2. Mansourian, S., & Berrahmouni, N. 2021. Review of forest and landscape restoration in Africa. Accra. FAO and AUDA-NEPAD. https://doi.org/10.4060/cb6111en
3. FAO. Global Forest Resources Assessment 2020: Key Findings. http://www.fao.org/3/CA8753EN/CA8753EN.pdf
4. https://www.eld-initiative.org/fileadmin/ELD_Filter_Tool/Publication_The_Economics_of_Land_Degradation_in_Africa__Reviewed_/ELD-unep-report_07_spec_72dpi.pdf
5. https://unfccc.int/process-and-meetings/the-paris-agreement
6. https://www.cbd.int/gbf/
7. Global Environmental Facility. Land Degradation Neutrality. https://www.thegef.org/topics/land-degradation-neutrality
8. IPBES. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. 56 pages. https://ipbes.net/global-assessment

Regreening Africa is responding to the global land degradation crisis by scaling up Farmer Managed Natural Regeneration, tree growing, soil and water conservation practices, and other land restoration options in eight African countries.

REGIONAL AND GLOBAL COMMITMENTS

There is considerable global commitment to reverse and halt further land degradation. Initiatives like the Bonn Challenge aim to restore 150 million hectares of degraded land by 2020 and a further 200 million hectares by 2030.[10] The New York Declaration on Forests strives to halve deforestation by 2020 and to end it by 2030.[11] Under the United Nations Convention to Combat Desertification (UNCCD), [12] at least 129 countries have committed to achieving Land Degradation Neutrality (LDN), with specific LDN targets. [13] The Kunming-Montreal Global Biodiversity Framework [14] target 2 calls for 30 percent of degraded ecosystems to be under restoration by 2030. Finally, SDG target 15.3 focuses on combating desertification, restoring degraded land and soil, and addressing issues related to desertification, drought, and floods. There are also several important regional initiatives such as the AFR100 [15] which aims to restore 100 million hectares by 2030, and a similar initiative in Latin America and the Caribbean, the 20X20, [16] targeting 20 million hectares. A reinvigorated Great Green Wall [17] aims to restore large-scale land from Senegal to Djibouti.

INTRODUCING REGREENING AFRICA

Regreening Africa contributes to this broader global and regional effort to reverse and halt land degradation. It aims to contribute to achieving AFR100 targets and catalysing local and nation actions that complement initiatives like the Great Green Wall.[18] Running for five and a half years from 2017 to 2023, Phase 1 of Regreening Africa was implemented in eight African countries: Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal, and Somalia, with funding from the European Union. Led by World Agroforestry (ICRAF), Phase 1 was a unique research in development programme and was implemented by a consortium of non-governmental organisations, including World Vision, Oxfam, Care International, Catholic Relief Services, and Sahel Eco. It sought to (a) directly reverse land degradation on one million hectares of agricultural land to benefit 500,000 households in eight countries in Sub-Saharan Africa; and (b) catalyse a much larger scaling effort to restore tens of millions of hectares of degraded land across the continent. The ELD contributed to one of the programme's objectives by strengthening national capacity in the eight African countries to assess the costs of land degradation and the economic benefits of investments in sustainable land management.

Regreening Africa is one of the few multi-country, multi-stakeholder large-scale research in development restoration programmes implemented in Africa before the start of the restoration decade. As such, it offers a unique opportunity to generate lessons for enhancing the cost-effectiveness of restoration efforts to be intensified and scaled-up further going forward.

Regreening Africa focuses on incorporating trees into various land-use types, including croplands, communal lands, and appropriate pastoral areas, along with complementary soil and water conservation and soil improvement practices. It leverages science and research to monitor the impact of implementation and simultaneously enhances social inclusion, livelihood improvement efforts, and the creation of a sustainable enabling policy environment for land restoration at national and sub-national levels.

The goal of Regreening Africa's first phase was to improve smallholder livelihoods, food security, and resilience to climate change in Africa while restoring ecosystem services. Its specific objectives were:

1. To strengthen national capacity to assess the costs of land degradation and the economic benefits of investment in Sustainable Land Management (SLM) in eight African countries (implemented by ELD).
2. To equip eight countries with surveillance and analytic tools on land degradation dynamics, including social and economic dimensions, to support strategic decision-making and monitoring for scaling-up tree-based restoration.
3. To support eight countries in the accelerated scaling-up of tree-based and complementary restoration practices by smallholder farmers, along with the development of associated value chains.

9. UNFCCC. (2007) Impacts, Vulnerabilities and Adaptation in Developing Countries. https://unfccc.int/resource/docs/publications/impacts.pdf
10. https://www.bonnchallenge.org/about-the-goal
11. https://forestdeclaration.org/about/new-york-declaration-on-forests/
12. https://www.unccd.int/convention/about-convention
13. https://www.unccd.int/actions/achieving-land-degradation-neutrality
14. https://www.cbd.int/gbf/
15. https://afr100.org/
16. https://initiative20x20.org/restoration-projects/restoring-1-million-hectares-degraded-land-mexico
17. https://thegreatgreenwall.org/about-great-green-wall
18. https://www.unccd.int/actions/great-green-wall-initiative

PURPOSE OF ENDLINE REPORT

This report provides highlights from Regreening Africa's endline survey and other data capture tools, focusing on the last two objectives. The work associated with the first objective was spearheaded by the ELD Initiative, and relevant findings can be accessed through the ELD website.[19]

The purpose of this endline report is threefold:

1. To document changes in exposure to interventions promoting regreening practices, as well as changes in the adoption of these practices and extent to which the programme's targets were realised.
2. To assess whether changes in regreening practice adoption are associated with downstream impacts, such as improved soil health and household food security.
3. To document the programme's contribution to strengthening the enabling environment in support of the large-scale adoption of regreening practices.

19. ELD Website: https://www.eld-initiative.org/en/knowledge-hub/regreening-africa-1

REPORT STRUCTURE

This report begins by describing changes to Regreening Africa's impact assessment strategy and the data collection methods used in both the baseline and endline periods. The subsequent sections are structured around a simplified version of Regreening Africa's Theory of Change for its direct intervention and leveraged-based out-scaling work (Figure 1).

Section 3 reviews data on changes in exposure to agroforestry-related training and extension. **Section 4** builds on this by presenting the extent to which targeted farming families undertook regreening actions over the programme period, using an innovative 'Regreening Action Index' as a primary analytical tool. Additionally, regreening efforts undertaken on communal land and changes in access to fuelwood are included. **Sections 5** then describes changes in the prevalence of tree species found on-farm.

The following sections of the report focus on indicators pertaining to both the ecological and socioeconomic changes taking place over Regreening Africa's implementation period:

- **Section 6** focuses on ecological changes, where innovative remote sensing and field data collection techniques are used to present changes in two key land health indicators - soil erosion prevalence and SOC. The report assesses the extent to which these changes are associated with changes in regreening practices.
- **Section 7** presents changes in tree product use and income.
- **Section 8** focuses on household food security and asset wealth status.

Section 9 then presents the work undertaken under Regreening Africa to out-scale regreening activities in its non-direct implementation sites and the estimated numbers of households and hectares leveraged as a consequence. **Section 10** reviews the programme's activities related to policy and practice influence. Finally, **Section 11** provides a summary of the key findings.

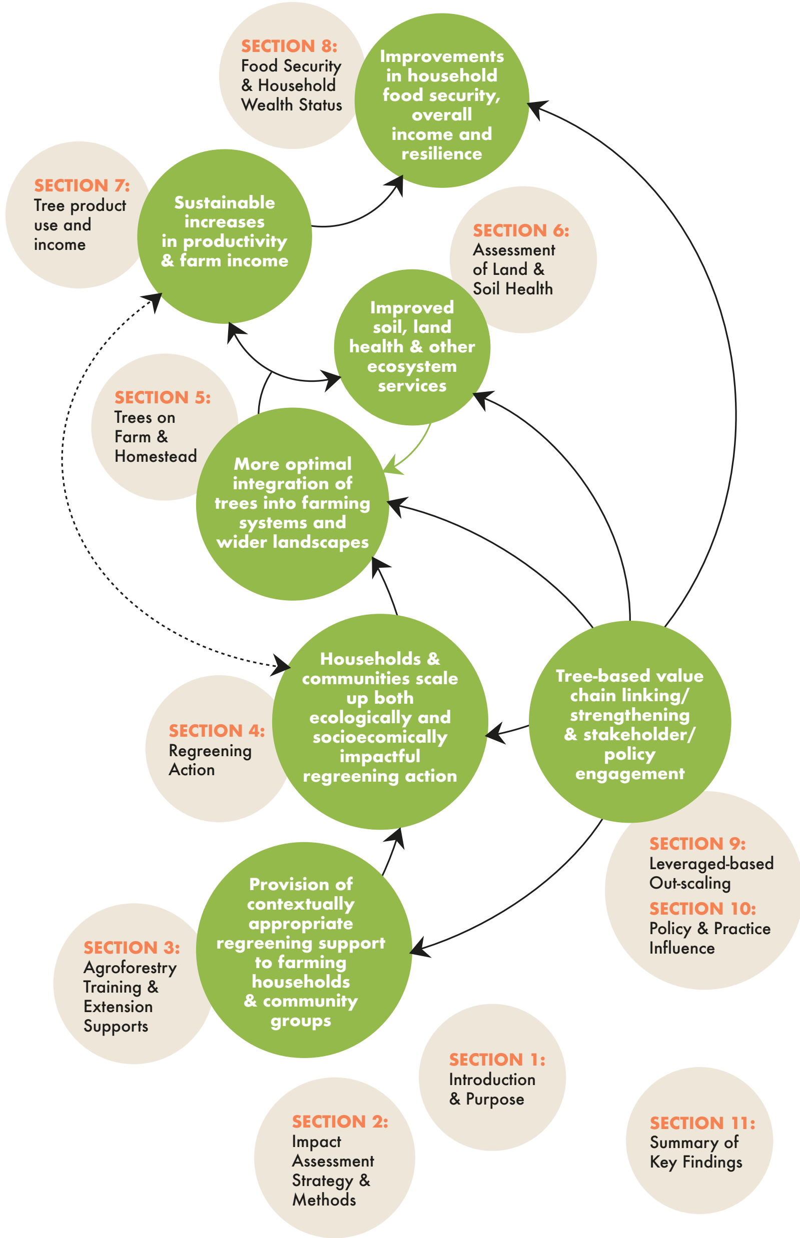


Figure 1: Simplified Theory of Change with endline report sections

2 Impact assessment strategy and methods

ESTIMATION APPROACH

Regreening Africa's impact assessment strategy for its direct implementation sites was originally based on a phase-in impact evaluation design. This design aimed to take advantage of the incremental scaling approach in different villages over the project's life. For villages where there was flexibility in the timing of entry, we randomised such timing. Specifically, we created at least two groups in seven out of the eight Regreening Africa countries: one set of villages that would be entered in the first year of the project (i.e., the Year 1 cohort) and one in its last year, i.e., the Year 4 cohort. We then collected baseline data from households located in both the Year 1 and Year 4 villages. Endline data collection was planned in the last year of Regreening Africa's implementation, ideally before implementation started in the Year 4 villages.

However, unforeseen challenges disrupted this plan. Security issues in Ethiopia and Niger forced the relocation of implementation sites. Pressure from partners to realise ambitious programme targets, coupled with high staff turnover and a lack of follow-up to ensure the planned randomised staggered programme rollout, undermined the phase-in impact evaluation design.

Without a control group for counterfactual estimation (i.e., what would happen if Regreening Africa was never implemented), the analysis primarily focused on changes observed in the programme's direct implementation sites, following a simplified version of its theory of change. Attribution of observed changes to the programme's activities is more plausible when examining indicators related to the uptake of regreening practices. However, it requires assuming that such uptake was significantly due to the programme's activities, rather than other external factors.

Assuming that there is a link between changes in regreening practice and the rollout of the Regreening Africa programme in its direct intervention sites, these changes can be compared in practice among individual households with changes in more downstream indicators of interest, e.g., those relating to soil health. If such changes are positively associated, i.e., co-vary together, there is evidence that the uptake in such practices was responsible and, in turn, something which the Regreening Africa programme contributed to. This causal estimation approach is known as the first difference estimation strategy[20]. Nevertheless, this approach is not without limitations, as it may not account for all factors influencing both regreening practices and downstream outcomes. For example, households establishing trees on their cropping field could also be upscaling other soil health amendments, e.g., compost application. Hence, for the results of the first difference estimation approach to be valid, we must assume the absence, or otherwise only partial influence, of such omitted variables.

20. https://documentation.sas.com/doc/en/etscdc/14.2/etsug/etsug_panel_details16.htm#:~:text=The%20first%2Ddifferenced%20(FD),regression%20of%20the%20differenced%20variables

SURVEY WORK

Baseline surveys were conducted in all countries except Somalia between May and September 2018. The baseline aimed to establish household and biophysical characteristics in targeted sites prior to programme intervention. Endline surveys were conducted between February and November 2022, with Somalia's survey taking place in December 2019 for the baseline and August 2021 for the endline, with a modified tool, considering its unique administrative and agroecological context. Figure 2 shows the baseline and endline survey locations and number of households interviewed in each country.

In both surveys, data collection was carried out by male and female enumerators, who were trained over a period of 3 to 4 days including 2 to 3 days indoor sessions and one-day pretest of the survey tool and feedback session. Enumerators were recruited through a competitive process in each country and were typically young college graduates, some of whom had prior experience collecting household data using digital applications. Enumerators were mostly drawn from the localities in which the programme was being implemented and were competent in either English or French and in the local languages in which the surveys were administered. The household survey had several modules including household land ownership and farming practices, tree types, tree tenure and management in different land use areas, tree product use and income from sales or tree products, household social capital, household demographics, and household livelihood activities engaged.

The baseline survey included 9,835 households, but 2,152 households (22 percent attrition rate) were lost to follow-up in the endline survey, primarily due to security issues. The final number of households surveyed at the endline was 7,683. For example, in Ethiopia security issues compelled the implementing partners to move away from earlier identified intervention sites in Tigray and to target and work in newer sites in Oromia and Amhara regions instead. Data were collected from the newer sites in December 2022. For one of the sites, Ambassel in Amhara, uptake survey data were collected in March 2020 and December 2022.

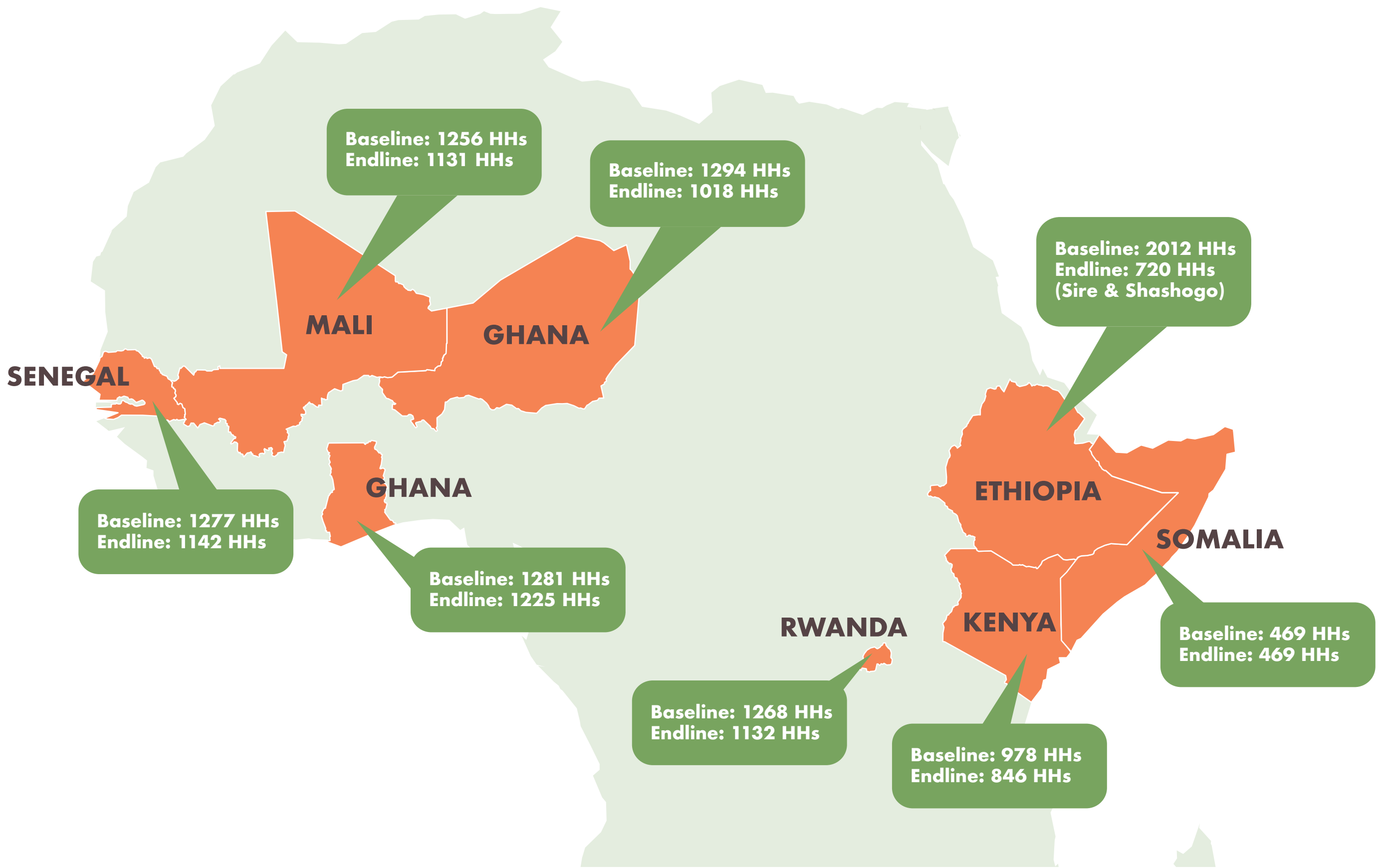


Figure 2: *Numbers of households interviewed at baseline and endline by country*

Apart from the direct implementation sites, implementing partners also identified other projects/sites which they could influence and through which they could realise their set targets. Since approaches to these leverage activities were varied, there was no single evaluation plan to assess impact. The Regreening Africa app was used in certain cases to measure leveraged adoption, but for sites in Rwanda and Mali, household surveys to determine exposure and adoption were carried out in January and March 2023, respectively, using the uptake survey tool.

In both baseline and endline surveys, data were collected using SurveyCTO, a computer assisted personal interviews (CAPI) tool. Enumerators interviewed respondents in a face-to-face setting and entered responses into an offline application on tablets or smartphones provided to them. Data were sent every evening once an internet connection was available and assessed for quality. SurveyCTO allows data to be collected and sent digitally to a central server from which it can be accessed, downloaded, and processed. It, therefore, eliminates the time-consuming and error-prone need to transfer data from paper to a computer programme.

PROGRAMME TARGETS

Tables 1 and 2 show the programme targets for the number of households practising regreening and the number of hectares under regreening that were set for each country. The total number of households targeted for each country are shown in the last column and were split into a direct target that would be achieved by working in direct scaling sites identified by implementing partners and leverage targets that were to be achieved by influencing other projects to outscale regreening practices.

The initial targets for Ethiopia were 120,000 households and 200,000 hectares, but due to security challenges primarily in the Tigray region, the programme sites had to be moved and baseline households could not be revisited at endline. Therefore, sites with 45,005 households and 52,459 hectares were included in the survey where both baseline and endline data were collected i.e., Sire and Shashogo woredas or uptake surveys and extrapolation were possible. Niger committed to an additional 38,190 hectares as part of a fund top-up. Overall, the targets covered by the surveys were 313,543 households and 544,624 hectares.

Results in this report include information from the household surveys and subsequent analysis only. Data on reach across the full programme area reported by implementing partners and data collected by the Regreening App are included in the Final Report and Annual reports.

***Table 1:** Household targets*

COUNTRY	TOTAL HH DIRECT TARGET	TOTAL HH LEVERAGED TARGET	OVERALL HH TARGET FOR 5 YEARS
Ethiopia	120, 000 (of which the area covered by survey was 45,005)		45,005
Ghana	20,000	20,000	40000
Kenya	10,000	40,000	50,000
Mali	49,601	30,399	80,000
Niger	28,750	11,250	40000
Rwanda	21,000	49,000	70,000
Senegal	50,000	30,000	80,000
Somalia	9,788	10,069	19,857
Total	**309,139** (234,144 covered by the survey)	**190,718** (79,399 covered by surveys)	**499,857** (313,543 covered by the survey)

***Table 2:** Hectarage targets*

COUNTRY	TARGET HA DIRECT	TARGET HA LEVERAGE	ADDITIONAL HA TARGETS FROM ADDITIONAL FUNDS	OVERALL HA TARGET FOR 5 YEARS
Ethiopia	200,000 (of which 52,459 were in the survey sites)			52,459
Ghana	45,000	45,000		90,000
Kenya	20,000	130,000		150,000
Mali	99,199	60,801		160,000
Niger	61,500	28,500	38,190	128,190
Rwanda	21,000	79,000		100,000
Senegal	100,000	60,000		160,000
Somalia	5,665	7,225		12,890
Total	**552,364** (404,823 covered by the survey)	**410,526** (139,801 covered by surveys)	**38,190**	**1,001,080** (544,624 covered by the survey)

ADOPTION CRITERIA AND ESTIMATION APPROACH

The three important indicators highlighted in this report are:

household exposure

uptake of regreening practice by exposed households

hectarage under regreening practices

Household exposure

Exposure measures programme performance in terms of reaching the communities through different regreening related training, information provision, advisory and extension support activities. Households were asked if, during the course of the programme (4 year period), they had received any training, demonstration, advice on how to:

- naturally regenerate trees (FMNR),
- establish and manage nurseries,
- plant trees,
- graft, and
- care for and manage existing trees on household's farm and different land use areas.

The sources of such exposure were diverse and are not used as a basis for analysis in this report.

Uptake of regreening practice

Uptake of regreening practice is an estimate of the number of households that have been exposed and are practising different regreening practices during the programme period. For this indicator, any household undertaking any of the following practices was considered to be practising regreening – tree planting, FMNR, established a nursery, managed a nursery, grafted trees or managed existing trees through pruning, thinning, coppicing, applying manure or chemical fertilisers, watering, fencing, or weeding.
The number of households exposed, and number of households exposed and taking up regreening practices were estimated using demographic data provided by implementing partners or obtained from relevant government documents like census reports.

To estimate the number of households exposed and households exposed and practising regreening at village or village cluster, sampling weights were applied to adjust for differences in numbers of households residing in each village/cluster. We then estimated weighted sample proportions of households exposed, and exposed and practising, and used these sample statistics to estimate the reach and adoption for the larger population living in targeted sites where direct scaling work was done. In Ethiopia, Niger and Rwanda, the implementing partners also carried out direct scaling work in other villages besides those from which baseline and endline data were collected, but within the same administrative units. For these additional villages, the number of households exposed and taking up regreening practices was estimated by extrapolation using the resulting proportions calculated for the sites with baseline and endline data.

Hectarage under regreening practices

Estimating land under new regreening practices[21] involved first estimating the average land holding per household, which was then multiplied by the total number of households in the direct implementation programme area to obtain total land area per site and per country.

The second step involved estimating the number of households that were exposed and established (planted or regenerated) trees within the programme period.

Third, we estimate the hectare equivalent of land covered by trees using an average of the lower bound spacing (10 x 10 metres) or 100 trees per hectare for homesteads, cropping lands and other land use areas including grazing areas, orchards, and fallow lands, and upper bound spacing (5 x 5 metres) or 400 trees per hectare[22] for private woodlots and forests. The spacing is adjusted upwards or downwards to account for the different niches (e.g., trees in a private forest and woodlot are more likely to be closely spaced than those on cropping fields). This result is then used to calculate the proportion of land under new trees and better management of existing ones in each programme area.

Finally, the resulting average proportion of land under new trees was multiplied by the total number of households that were exposed and established trees in the direct implementation sites and the average land size. To obtain the actual area covered by trees in additional intervention villages, the proportion estimated in the third step is multiplied by the average land size estimated in the first step and by the estimated number of households residing in the additional villages that were exposed and established trees.

21. Note that this estimation captures only land area under the holdings of smallholder farmers and not communal lands under restoration initiatives

22. Tengnas, Bo, Francis Mbote, Kyra Fahlstrom, Habib Ibrahim, Jan Beniest, Frank M Place, S Minae, et al. 1994. Agroforestry Extension Manual for Kenya. Nairobi.

3 Agroforestry training and extension support

The Regreening Africa ToC first assumes that women and men residing in the direct intervention sites were significantly exposed to agroforestry-related training and extension support through Regreening Africa. If this was true, we would therefore expect surveyed women and men to report greater participation in agroforestry-related training or exposure to tree-related extension support at the end of the programme as compared with the beginning. We, therefore, first observe how such exposure changed between the baseline and endline periods (Figure 3).

We see clearly that exposure increased in all countries, rising from 14 percent of households to 50 percent overall. However, the degree of this increase varies considerably across the eight countries. Ghana saw the biggest increase – 10 to 74 percent, followed by Somalia. The increase was smallest in the surveyed sites in Ethiopia – from 33 to 40 percent. It is interesting to note that the households surveyed in Ethiopia had received higher levels of training and advisory support at baseline as compared to the other countries.

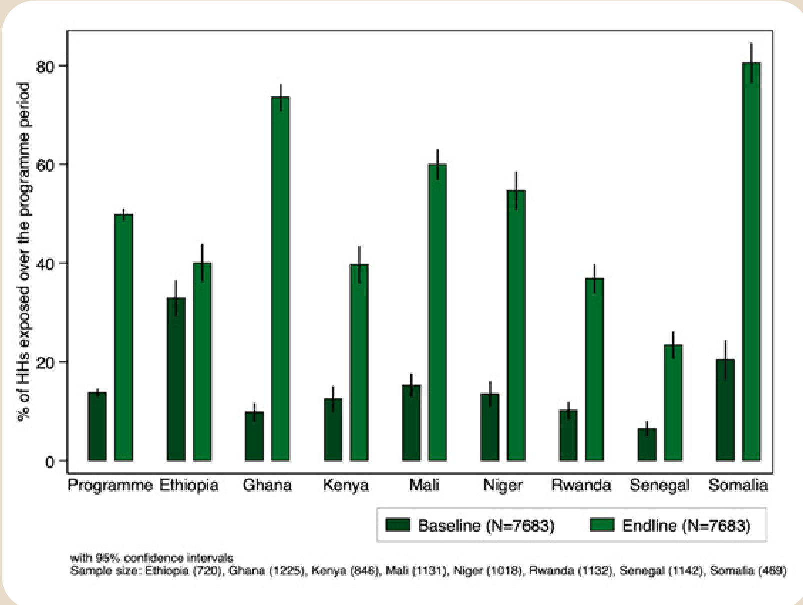


***Figure 3:** Percentage of households exposed to agroforestry training and extension at the baseline and endline*

We also captured data on who in the household was exposed to regreening-related training and extension, thereby enabling us to present sex disaggregated results (Figure 4). More male members of the households accessed training and extension services compared to female members. However, we still observe an increase in the percentage of both male and female household members exposed to regreening practice from baseline to endline in all countries. Like in Figure 3, the largest increase for both male and female household members is observed in Ghana with exposure of female members rising from 4 to 47 percent and male members rising from 8 to 61 percent. In Mali, 52 percent of households had male members exposed and 25 percent female members exposed, while Senegal had the least exposure at 19 and 9 percent for male and female members, respectively, at the endline.

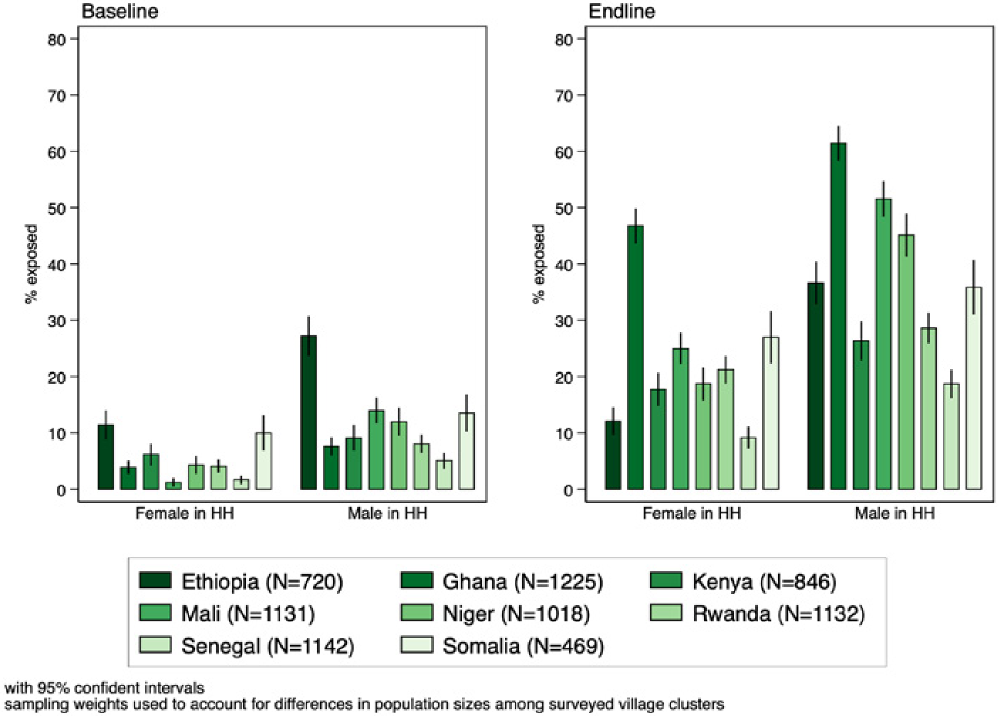


Figure 4: Percentage of households exposed to agroforestry training and extension disaggregated by sex for both baseline and endline periods

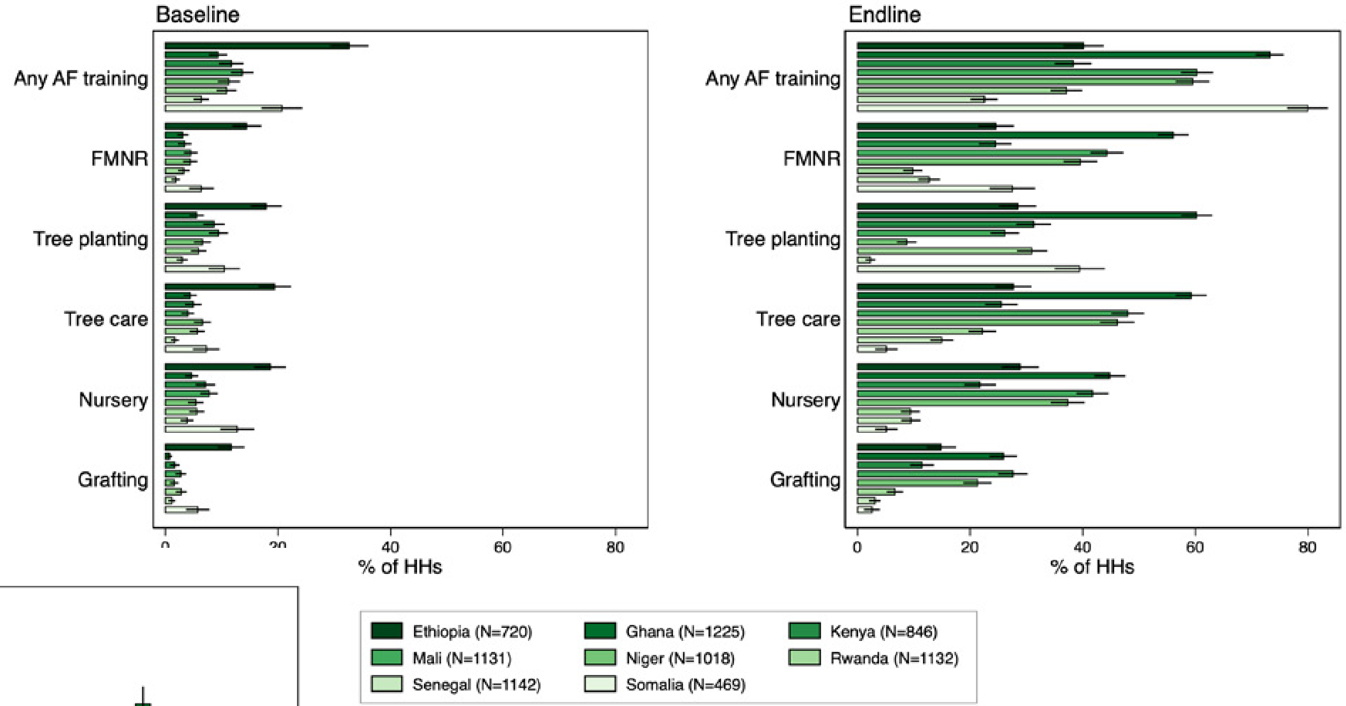


Figure 5: Percentage of households exposed to agroforestry training and extension by topic

In Eastern Africa, the largest increase for both men and women is seen in Rwanda, while in Somalia exposure increased from 14 to 36 percent and 10 to 27 percent for male and female household members, respectively.

We further observe changes in the specific training and extension topics that households reported being exposed to in both time periods (Figure 5). Overall, most households received training on tree planting, nursery establishment and management, as well as management and care of already established tree species. Exposure to tree planting training was very low in Senegal and Niger. Exposure to FMNR was provided to 34 percent of households overall, with the lowest percentage in Rwanda, while relatively fewer households were trained in grafting.

ESTIMATED NUMBERS OF HOUSEHOLDS, WOMEN, AND MEN SUPPORTED TO UPSCALE TREES ON THEIR FARMS AND IN THEIR COMMUNITIES

We estimate, using population data, the number of households, as well as women and men, supported to upscale trees on-farm and in the common land areas of Regreening Africa's direct intervention sites (Table 3). We estimate that over 160,000 households were supported across all the countries to take up or enhance regreening on their farms. Men and women were exposed to regreening activities in over 129,000 and 76,000 households, respectively.

Figure 6 shows the various actors that supported households in the direct intervention sites to upscale regreening practices. Across all countries, the main sources of information, training or support for farmers were non-governmental organisations (37 percent overall) and government affiliated institutions (16 percent overall). A lesser percentage of households were reached by peers and relatives, as well as farmer groups.

Table 3: *Estimated numbers of households exposed to regreening support intervention in Regreening Africa's direct intervention sites*[23]

COUNTRY	HOUSEHOLDS	HHS - WOMEN	HHS- MEN
Ethiopia	18,177	5,007	11,249
Ghana	46,391	28,757	39,209
Kenya	10,314	4,606	6,851
Mali	36,672	15,302	31,522
Niger	14,958	4,913	12,733
Rwanda	20,130	11,666	15,743
Senegal	12,427	4,823	9,830
Somalia	5,334	1,787	2,381
Total	**164,403**	**76,861**	**129,517**

23. The number of households in which male or female members were exposed is calculated by considering the gender sex of the persons in the household who received any training, advisory or support in any regreening practices. In some households, either men only or women only received such exposure, but in others, both men and women were exposed. Households in which both male/female members were exposed therefore fall in both columns 3 and 4. This means that the total number of households in column 3 and 4 are more than the overall number of households exposed.

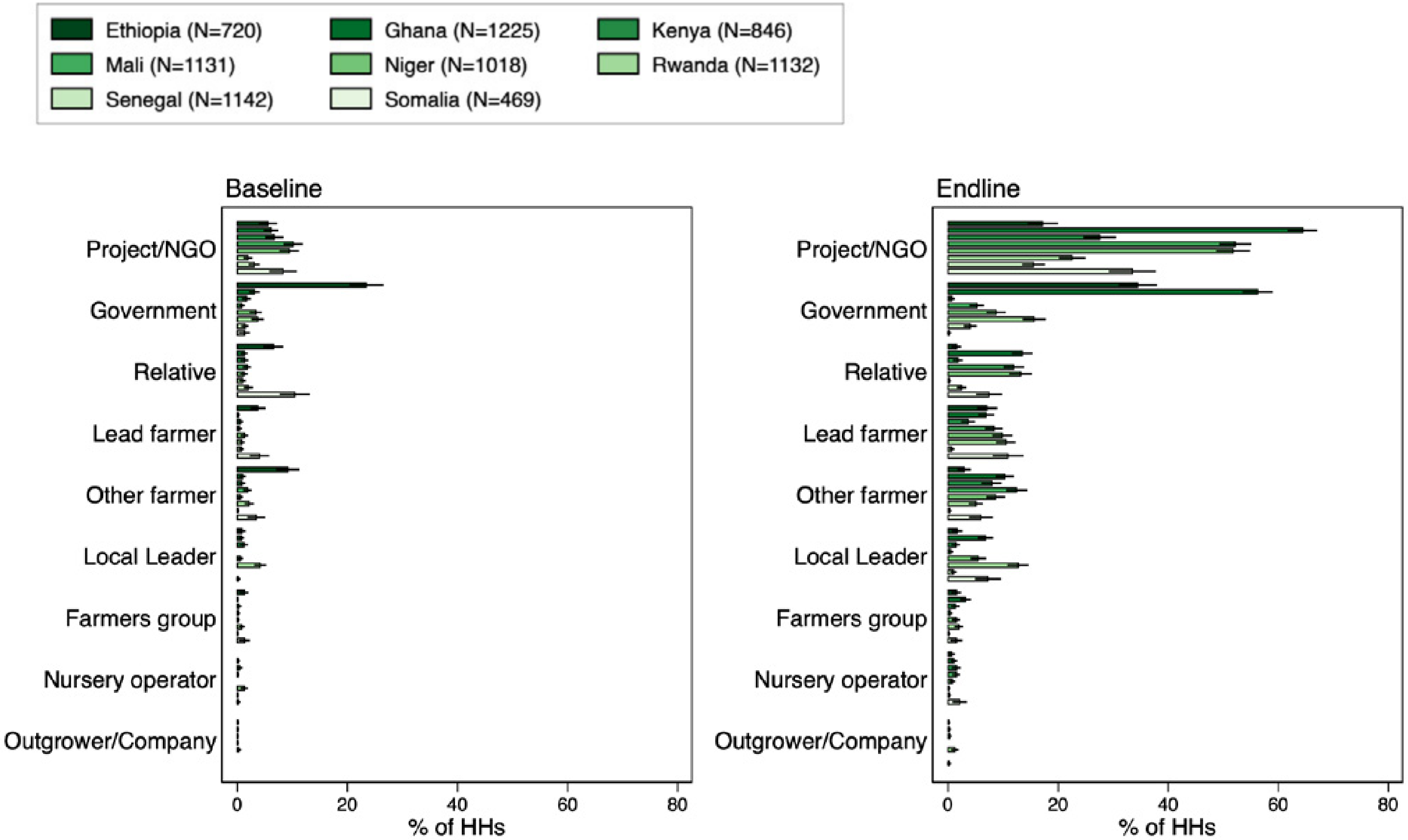
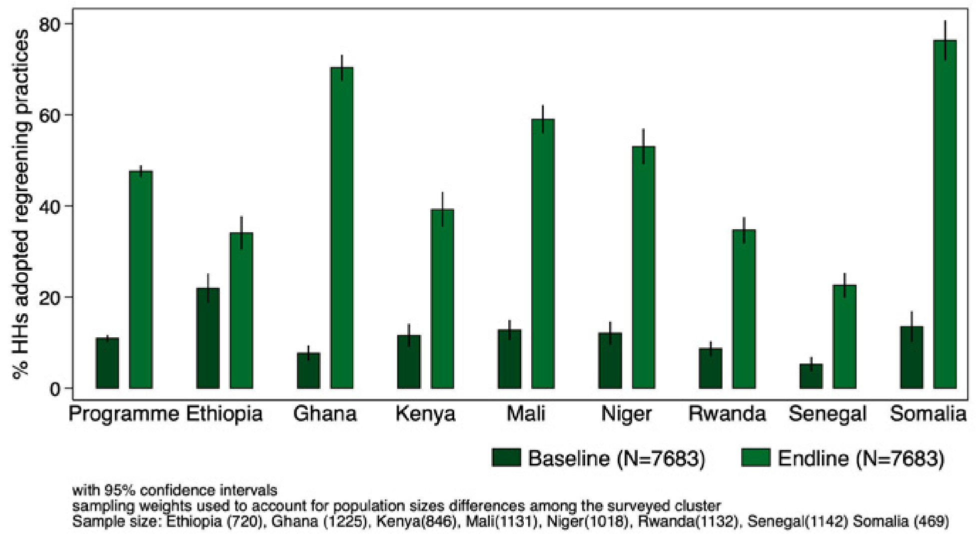


__Figure 6:__ Actors that provided regreening-related upscaling support

4 Regreening action

For Regreening Africa to have generated its expected biophysical and socioeconomic impacts, household and community-level upscaling of regreening related practices is a key prerequisite. Consequently, the baseline and endline surveys collected data on household's engagement in these practices. We first examine changes in household-level uptake of regreening-related practices in general (Figure 7). This includes undertaking several different practices, ranging from tree planting, tree grafting, nursery establishment or management of seedlings to practising FMNR and general tree management, e.g., pruning, coppicing, watering, mulching, manuring/fertilisation, weeding, and protecting trees through fencing. We observe that, overall, the undertaking of such practices increased from 11 to 48 percent over the life of the project, representing more than three-fold increase.

Figure 7: Percentage of households that undertook regreening actions in both baseline and endline periods



We observe considerable variation in regreening practice across the countries. While a significant increase was recorded in all countries, the extent of uptake varies. The highest increase in percentage of households up-taking at least one regreening practice was in Ghana, where it increased from 7 to 70 percent followed by Somalia. Ethiopia and Senegal experienced lowest increases, increasing from 23 to 34 percent and 5 to 22 percent, respectively.

Like the receipt of training and extension, we examine the sex of household members who engaged in regreening practice (Figure 8). We observe more male than female household members did so across all the eight countries in both the baseline and endline periods.

We further examine changes in specific regreening practices over the two time periods (Figure 9). We observe significant increases across most of the countries with respect to managing established trees on-farm (e.g., through pruning), tree planting, and FMNR. The percentage of households reporting planting trees on their farms significantly increased from less than 20 percent at baseline to more than 60 percent in Ghana, Rwanda, Ethiopia and Somalia. Relatively more households in West Africa – Ghana, Mali, Niger and Senegal – during the endline period reported engaging in FMNR compared to the baseline. In all eight countries, we observe tree nursery establishment and management and tree grafting had low levels of uptake.

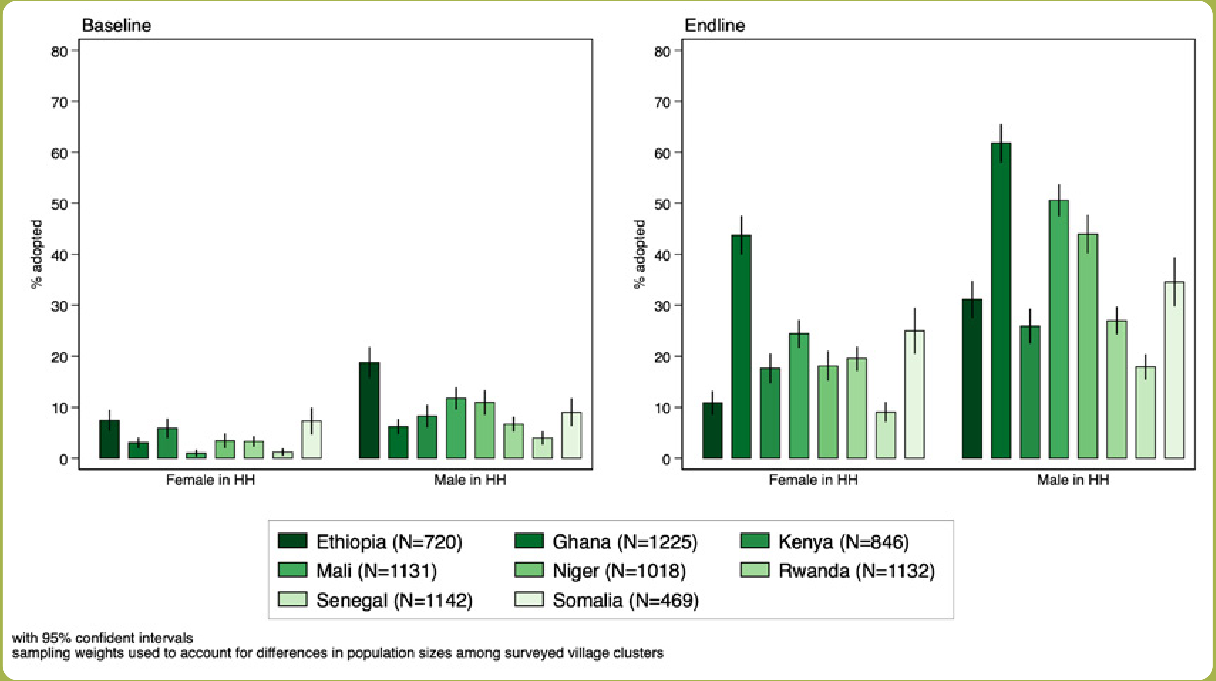


Figure 8: *Percentage of households that undertook regreening actions in both the baseline and endline periods by country and gender*

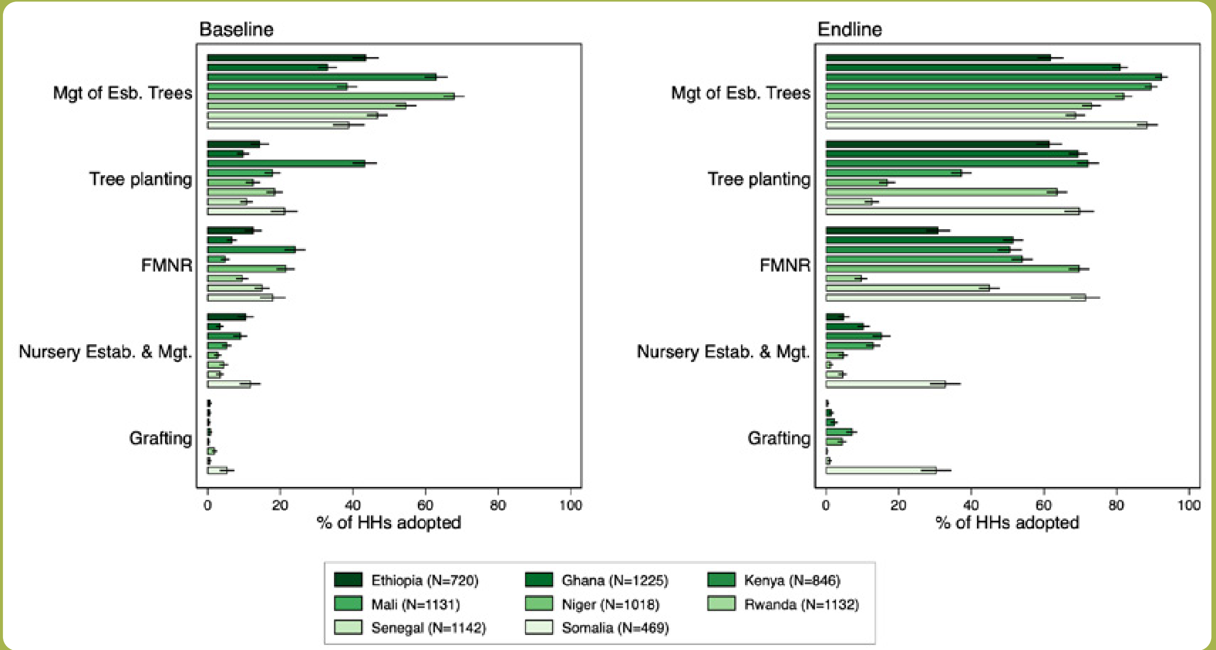


Figure 9: *Percentages of households that undertook specific regreening actions during the baseline and endline periods*

THE REGREENING ACTION INDEX

Restoration comprises several facets, which lends itself to multidimensional measurement.

As is clear from the above, the act of land restoration is multifaceted, and the combination of these elements will vary by context. To capture this richness, a multi-dimensional 'Regreening Action Index' was developed (Figure 10). This measurement approach is similar to those underpinning the Multidimensional Poverty Index (MPI)[24] and the Women's Empowerment in Agriculture Index (WEAI).[25]

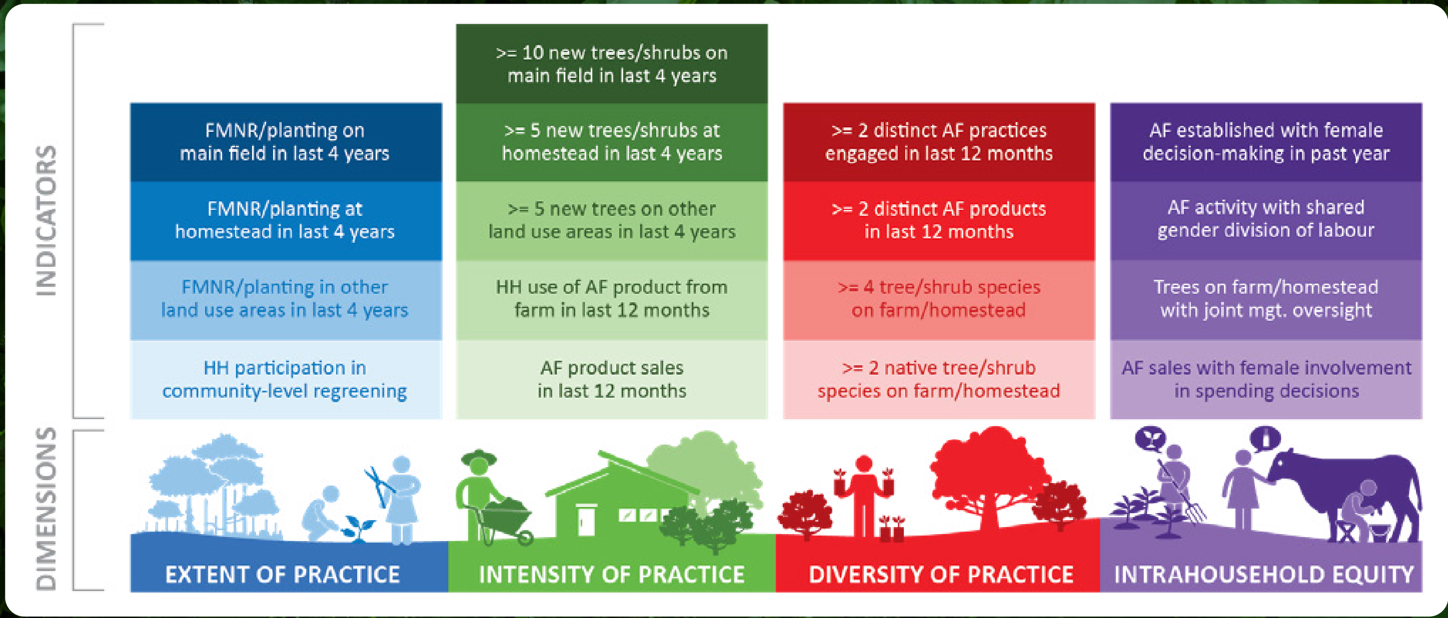


Figure 10: *Regreening Action Index (Dimensions and Indicators) to Measure the Breadth and Depth of Household-level Regreening Efforts*

The greater the depth and breadth of restoration practice, the higher the household's Restoration Index score on a 0 to 1 scale.

The Regreening Action Index (RAI) comprises four dimensions, with four to five binary (yes-no) indicators falling under each. The more a household engages in the various dimensions of regreening, the higher its score on the 0-to-1 index.

The first dimension **Extent of practice** pertains to the extensiveness of a household's regreening efforts over the past four years. Maximum points are awarded if it has engaged in FMNR and/or tree planting on

1. its main field;
2. at its homestead; and
3. on any other land use area (e.g., a secondary field) during this timeframe, as well as
4. participated in community-level regreening activities. Partial points, if any, are awarded otherwise.

The second dimension **Intensity of practice** relates to the intensity of the household's regreening practices. The more trees and/or shrubs established, the higher the score, with higher points still if agroforestry products produced on-farm were used by the household and/or if any of these products were sold.

The third dimension **Diversity of practice** measures the diversity of a household's regreening activities. The more distinct agroforestry practises a household has pursued and/or agroforestry products produced, the higher the number of points awarded. The same is true for the diversity of tree species on-farm or at the homestead, with higher points for having at least two native species.

The final dimension **Intrahousehold equity** gauges the extent a household's engagement in regreening is equitable along gender lines. If agroforestry activities were undertaken with female decision-making involvement and/or the associated work was undertaken by both women and men, the higher the household's score will be on this dimension. The same is true for the management of already established trees on-farm, as well as whether women were involved in spending decisions of agroforestry products sold by the household.

24. http://hdr.undp.org/en/content/what-multidimensional-poverty-index
25. http://www.ifpri.org/topic/weai-resource-center

CHANGES IN THE REGREENING ACTION INDEX

We observe statistically significant gains in the RAI across all countries, but with considerable variation (Figure 11). Ghana with 152 percent increase experienced the largest gains, whereas Ethiopia and Senegal experienced the least gain with 43 and 34 percent increases, respectively.

For the RAI's specific dimensions, overall, we observe the extent of practice dimension showed a significant increase (127 percent), driven mainly by more households reporting participation in communal land regreening initiatives and establishing trees on other land use areas apart from homesteads and cropping fields. The intensity of practice dimension also increased by 94 percent. Of the five binary indicators under this dimension, the increase in the percentage of households reporting selling at least one agroforestry product in the 12 months prior to the baseline and endline survey contributed the most, with a 156 percent increase. Additionally, there was a 113, 93 and 85 percent increase in the percentage of households establishing at least five trees in other land use areas, at least five trees around homesteads and at least ten trees on the main field, respectively.

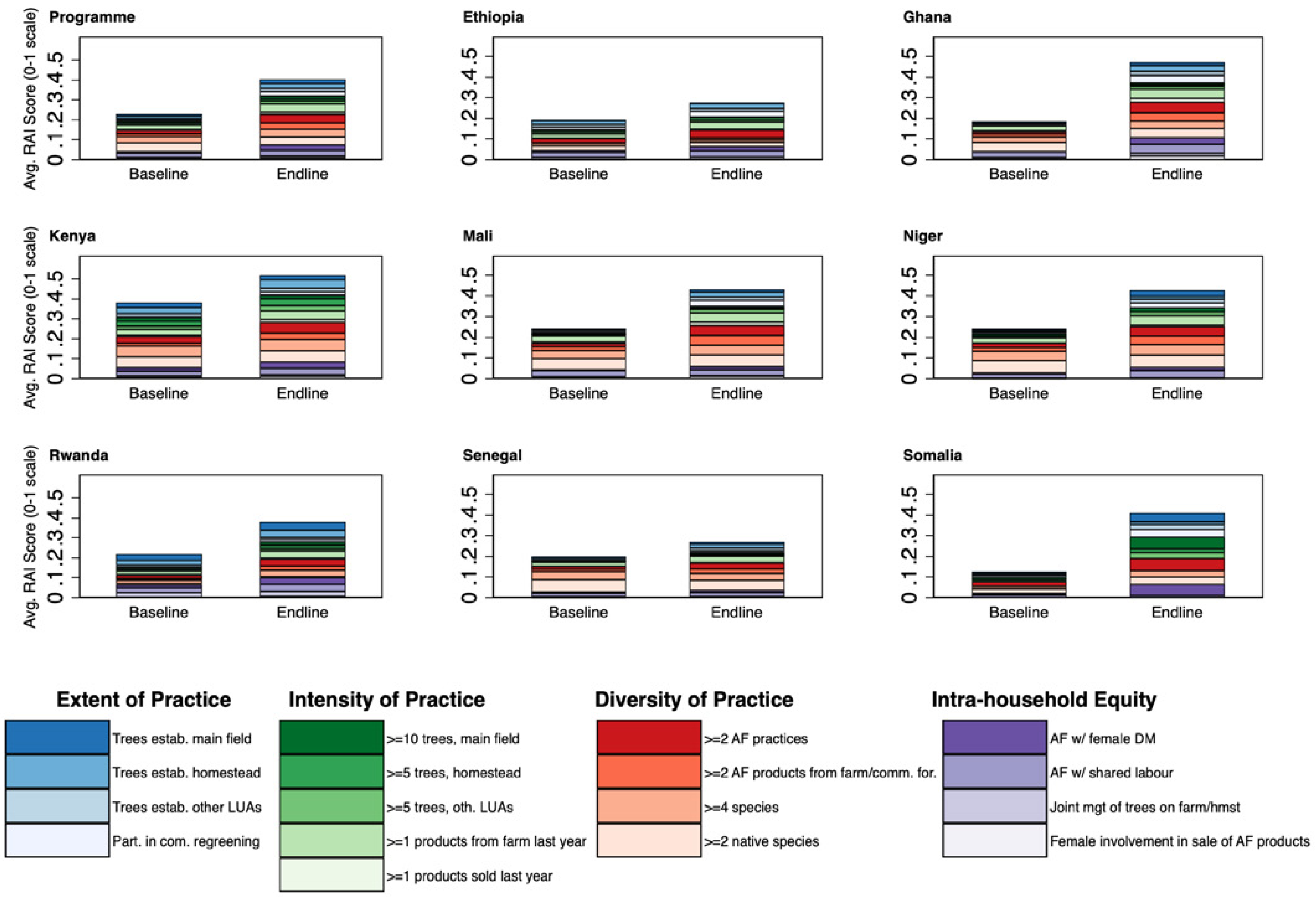


Figure 11: Regreening Action Index, with dimension and indicator contribution at baseline and endline

In general, the diversity dimension only showed a modest increase over the project period (44 percent). This is because the diversity of tree species that households established on their farms or homesteads did not change significantly compared to the baseline period. However, the percentage of households pursuing at least two distinct agroforestry practices and the use of at least two distinct agroforestry products increased by 134 percent.

The increase in intra-household equity dimension shows an improvement in women's involvement and agency in agroforestry practice. However, the change is not significant for all other countries, except Ghana where the gain is more than double. Specifically, in this country, the percentage of households reporting the involvement of female household members in decisions pertaining to both agroforestry establishment and the sale of agroforestry products increased by more than five and two folds, respectively.

Focusing only on averages can mask variation across sites within countries and even among households in specific geographies. We therefore graphically present the full distributions of household-level RAI scores, both overall and by country as density plots (Figure 12). We similarly observe that Ghana changed the most in terms of the distribution, with 50 percent of households being above 0.5 on the index at the endline, compared to 0.18 at baseline. The least gains were in Ethiopia and Senegal, where 50 percent of the households are below 0.3 on the RAI score at the endline.

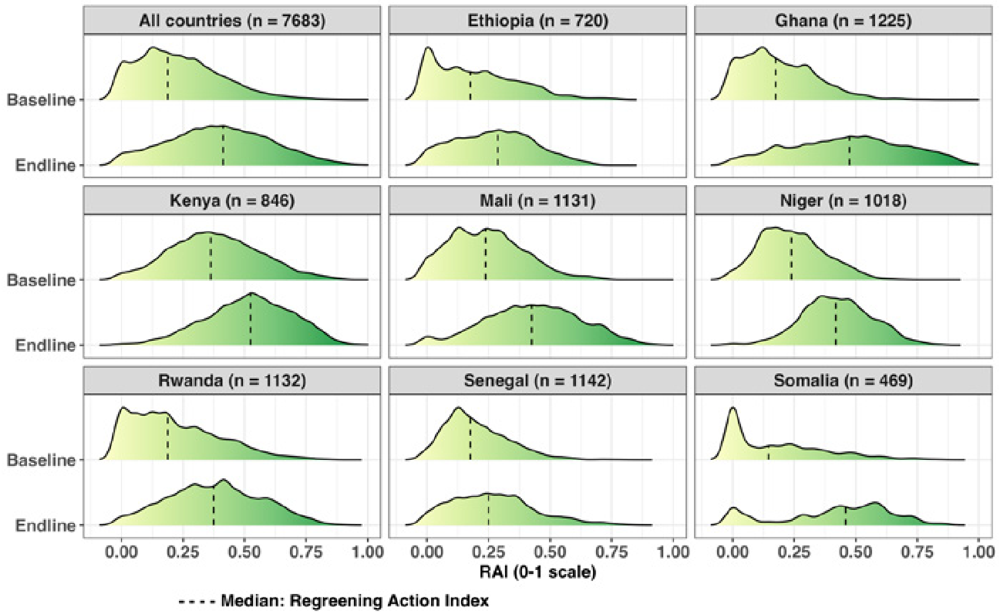


Figure 12: Density plot depicting changes in the statistical distribution of the RAI between the baseline (top plots) and endline (bottom plots) periods

The level and changes in RAI varied considerably across programme sites within each of the participating countries. As shown in the violin plots (Figure 13), for example, in Ghana the RAI score significantly increased at the endline across the three programme districts. However, in Ethiopia, where there were few serious agroforestry practitioners at the baseline in the woreda (district) of Sire, we see significant increase at the endline compared to Shashogo. We also observe similar trends in the districts of Gatsibo, Kayonza and Nyagatare in Rwanda.

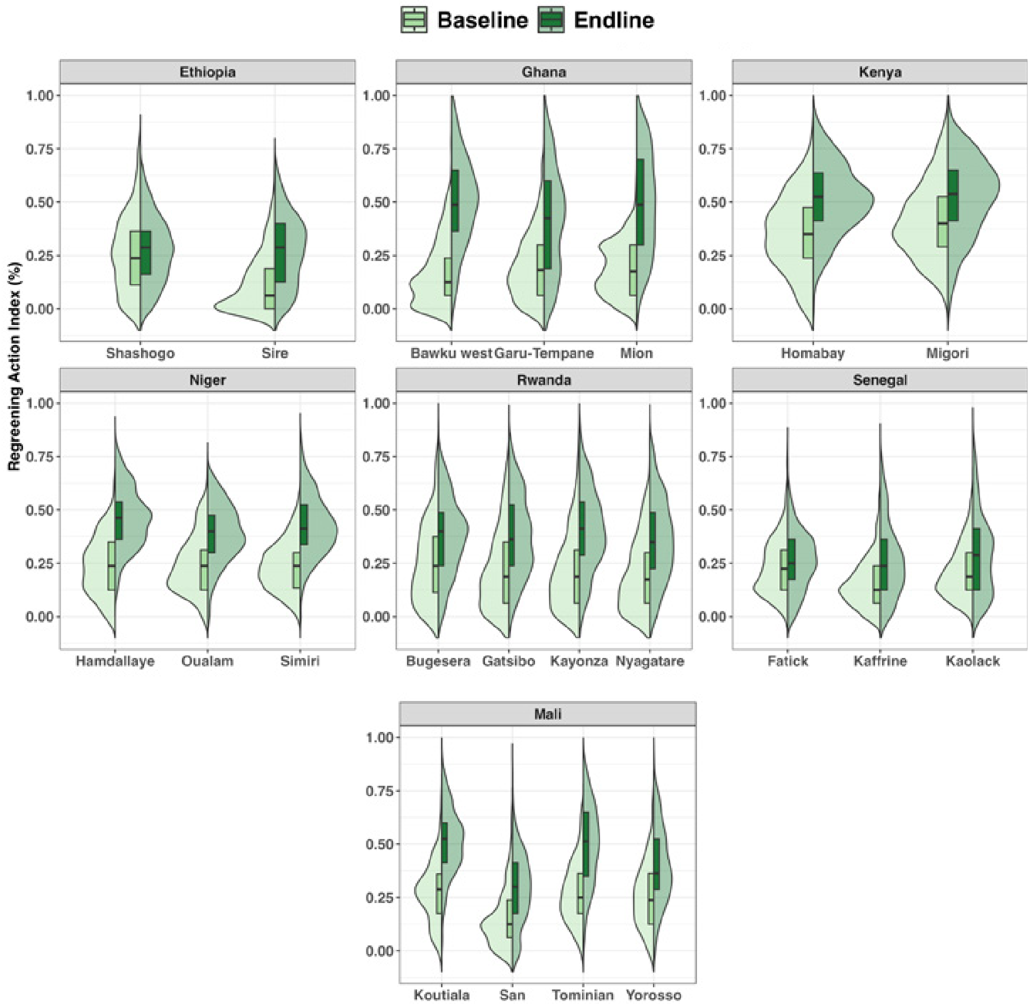


Figure 13: Violin plots showing the distribution of the RAI at the baseline and endline by programme site. The split violin plots with the box plots in the middle shows how the distribution moved comparing the two periods. The horizontal line in the box plot represents the median value of each period

CHANGES IN TREE PRODUCTS OBTAINED ON-FARM

We also observe the extent to which the collection of tree products changed over the life of Regreening Africa across all countries (Figure 14). In general, more households reported collecting tree products of various kinds at the endline compared to the baseline. Fuelwood was the most commonly collected tree product in both periods, and it was harvested by almost 60 percent of households by the endline period. Households also collected more fruits, timber and poles, fodder, and medicinal products from on-farm tree sources.

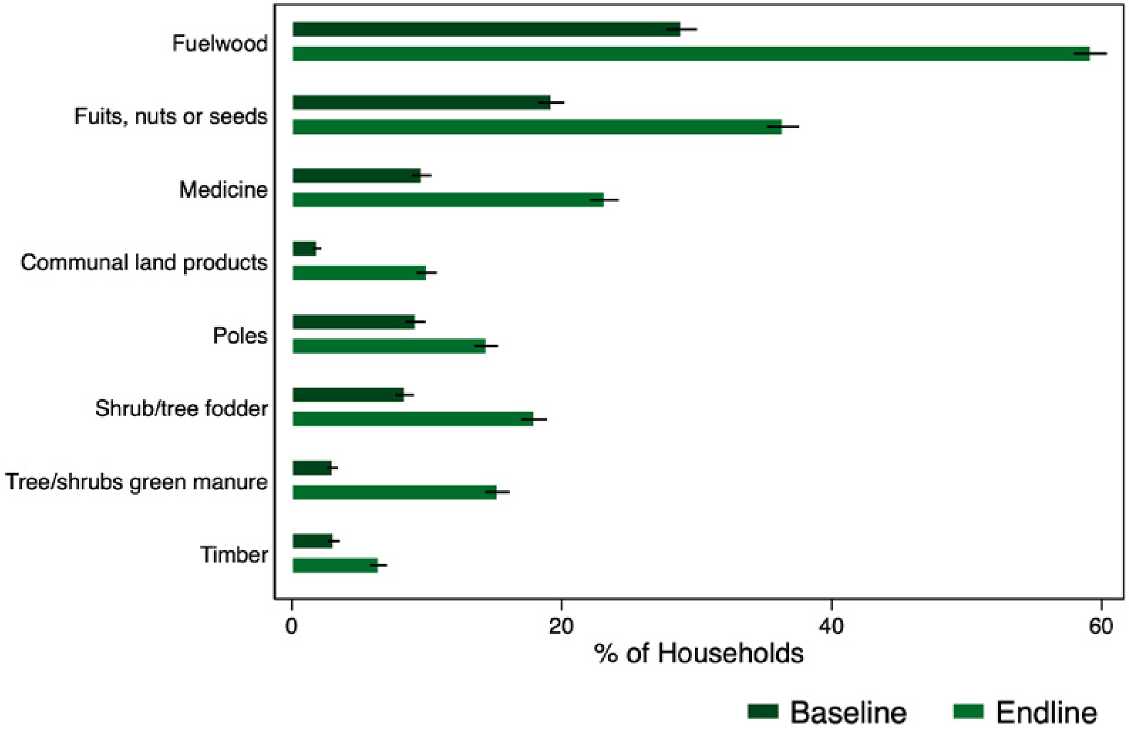


Figure 14: *Changes in tree products collected on-farm*

FUELWOOD ACCESS AND COLLECTION TIME

The vast majority of households in the programme sites rely on fuelwood for energy provision. One of Regreening Africa's expected benefits was to support households to increase the availability of fuelwood on-farm, with the intention of reducing the degradation of the community lands and protected areas while easing access especially for women. Respondents were asked several follow-up questions about fuelwood at baseline and endline. Figure 15 presents key results regarding the changes in fuelwood collected on-farm, purchased, and time spent collecting fuelwood for households that consider fuelwood as the primary energy source for cooking in the seven participating countries. Note that data pertaining fuelwood access was collected only during endline survey, so we cannot assess changes in such access between the two periods.

There is a significant increase in the percentage of households that obtained fuelwood from their farms since the baseline period, rising from 33 to 66 percent. The percentage of households reporting increased time spent on fuelwood collection in the last 30-day period prior to data collection decreased from 35 to 25 percent, which is consistent with increased availability of fuelwood on-farm. That said, there was little change observed in the percentage of households purchasing fuelwood between the baseline and endline periods.

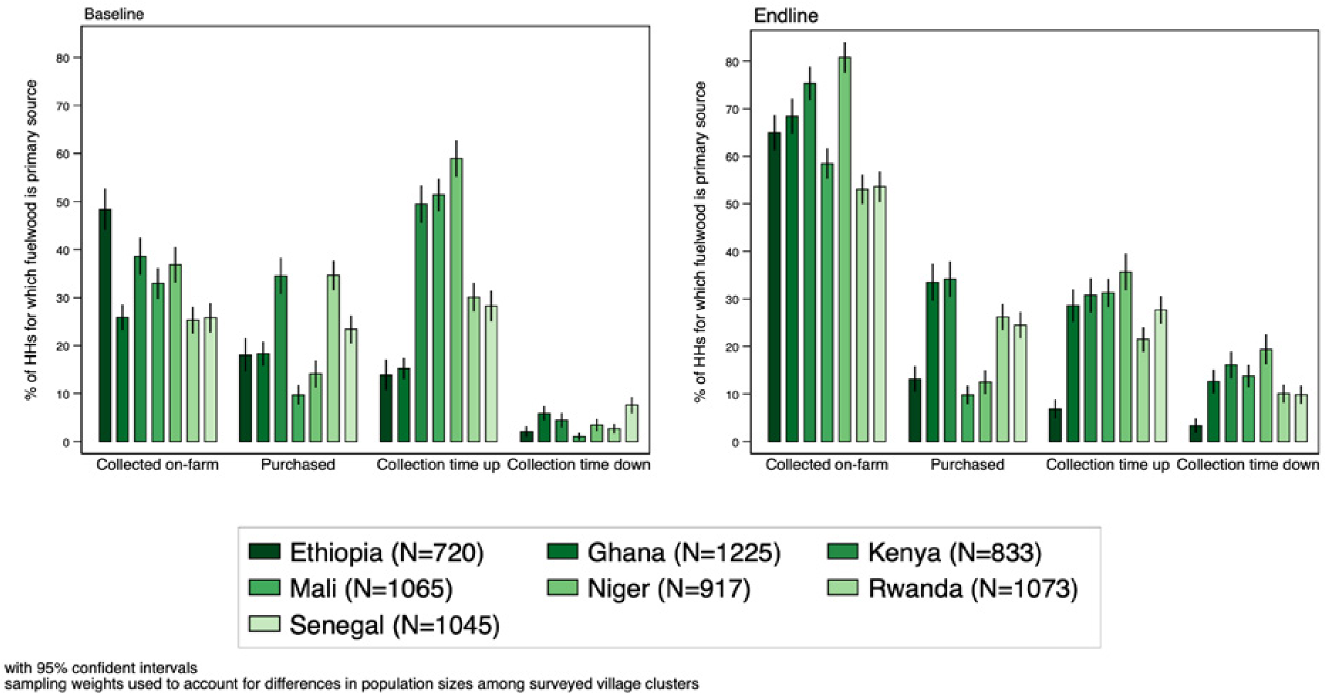


__Figure 15:__ Changes in fuelwood collected on-farm, purchased off-farm, and collection time

During the survey, respondents were asked the approximate amount of time (hours/month) they spent collecting fuelwood. As shown in Figure 16, on average, the time spent on fuelwood collection decreased from 16 to 12 hours per month. However, the result shows a big variation across the seven countries where households in Kenya, Niger and Rwanda experienced a big decrease. In Mali, households spent a little more time collecting fuelwood compared to the baseline.

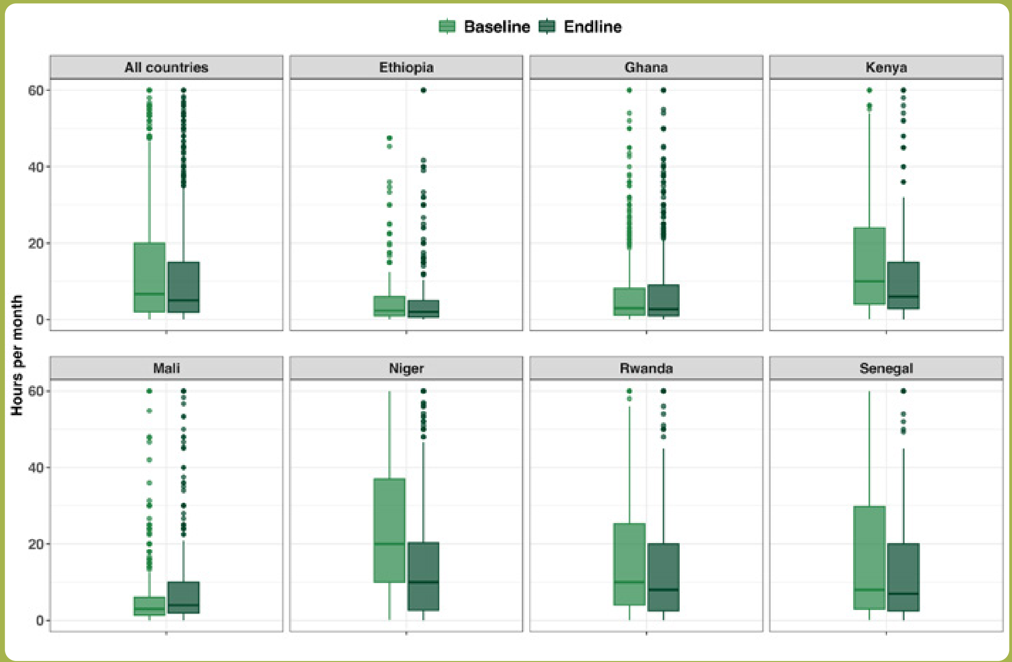


Figure 16: Distribution of hours spent collecting fuelwood per month comparing baseline and endline across the country. The horizontal line in the box plots represents the median hour

CHANGES IN GENDER ASPECTS IN LAND RESTORATION: DECISION-MAKING AND LABOUR

The other key indicator in assessing Regreening Africa programme's performance is the extent to which household involvement in regreening was equitable along gender lines. Therefore, respondents were asked who in the household contributed in terms of labour and made decisions for each of the regreening practices that the household engaged in. Figure 17 shows some changes in terms of women's agency in tree establishment and tree-related management decisions, as well as labour contribution. In Ghana, there is a significant increase in women's involvement in tree establishment and management decisions, as well as labour contribution. We also observe a slight increase in Kenya, Mali and Niger. Interestingly, women's involvement in decision-making and labour contribution declined in Ethiopia. The other interesting pattern our data reveals is that regreening related practices are male dominated across all eight participating countries and barely changed over the project period.

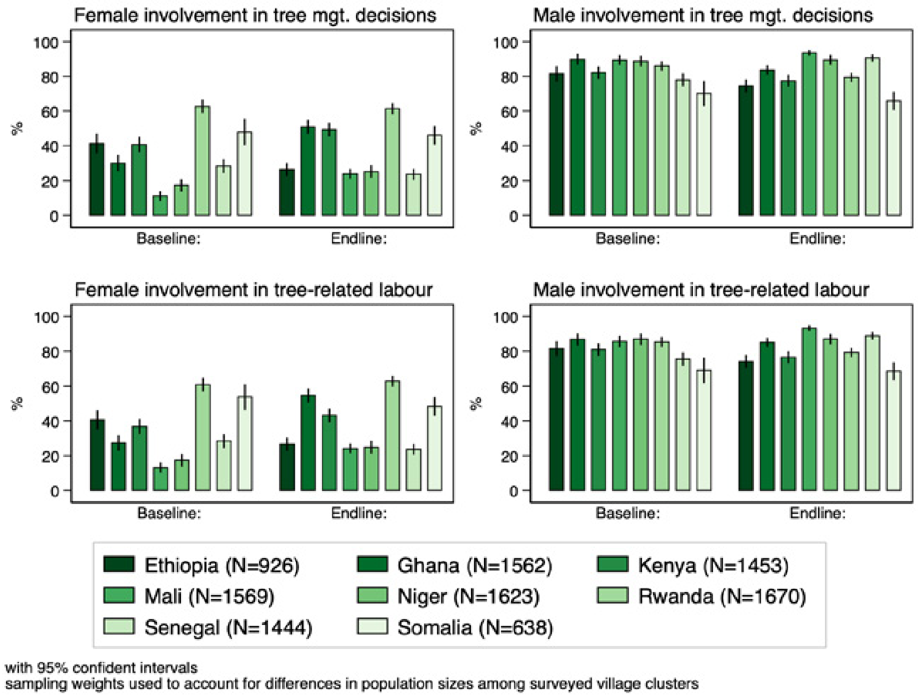


Figure 17: Changes in tree management decision-making and tree-related labour by sex

ESTIMATED NUMBERS OF HOUSEHOLDS, WOMEN, AND MEN UPSCALING TREES ON THEIR FARMS AND IN THEIR COMMUNITIES

As was the case for exposure to regreening related support, we estimate the number of households, as well as women and men, that upscaled trees on-farm and in communal land areas of Regreening Africa's direct intervention sites (Table 4). These are direct "adoption" estimates – representing households that were reached by different sources and took up new or intensified existing regreening practices. We estimate that over 150,000 households across the eight countries upscaled regreening practices in the direct intervention sites. And, as in the case for exposure, there were more households in which men upscaled regreening practices than households in which women upscaled regreening practices across all the countries.

Table 4: *Estimated numbers of households, that upscaled regreening related action on-farm and in their communities*[26]

COUNTRY	TOTAL HH DIRECT TARGET	HOUSEHOLDS REACHED AND PRACTISING	PERCENTAGE OF TARGET ACHIEVED	HHS- WOMEN	HHS- MEN
Ethiopia	45,005	12,168	27.0%	4343	10151
Ghana	20,000	44,542	222.7%	27766	37743
Kenya	10,000	10,201	102.0%	4606	6763
Mali	49,601	36,119	72.8%	15040	20923
Niger	28,750	14,493	50.4%	4713	12410
Rwanda	21,000	18,585	88.5%	10647	14747
Senegal	50,000	11,873	23.7%	4771	9427
Somalia	9,788	4,270	43.6%	1659	2297
Total	**234,144**	**152,251**	**65%**	**73,545**	**114,461**

26. The number of households in which male or female members practiced regreening is calculated by considering the sex of the persons in the household who engaged in any regreening practices. In some households, either men only or women only engaged in regreening practices. Households in which both male and female members practiced regreening therefore fall in both columns 5 and 6. This means that the total number of households in column 5 and 6 are more than the overall number of households practicing regreening.

5 Trees on-farm and homestead

A key intermediate step in Regreening Africa's Theory of Change is a more optimal integration of trees and shrubs in farming systems and landscapes. Significant efforts were therefore made in the baseline and endline surveys to capture data on tree numbers and tree species.[27] Figure 18 presents how the average numbers of trees and shrubs per household, both overall and by hectare, have changed over time.

Over the programme period, farmers established trees in different niches, either through planting or FMNR. The estimated total number of trees found on all household land use areas increased from an average of 67 to 129 trees. Figure 14 shows significant increases in most countries, with the highest increase in Kenya–rising from an average of 159 trees at baseline to an average of 325 at endline. The average number of trees in Ethiopia rose from 66 to 98, while in Ghana, the averages doubled between the baseline and endline periods, increasing from 29 to 58 trees. In Rwanda, the average increase was 39 to 66 trees. For the Sahelian countries, there were significant average increases in Mali and Niger, increasing from 75 to 139 and from 87 to 152, respectively. For Senegal, however, the average change was only marginal, increasing from 34 to 35 trees. This information is also presented as box plots in Figure 19.

27. Given the need to minimise the length of the survey, numbers of trees were captured in ranges for each land use area of the farm, e.g. 1 to 2; 2 to 5; 6 to 10; 11 to 20; 21 to 50; etc. The midpoint of the ranges was then taken for each land use area and added together. In short, precise tree and shrub counts were not undertaken, resulting in approximated numbers. Moreover, tree numbers in the above ranges by species were only captured in the household's main field. For other land use areas, the total number of trees in the above ranges were captured and the specific species separately.

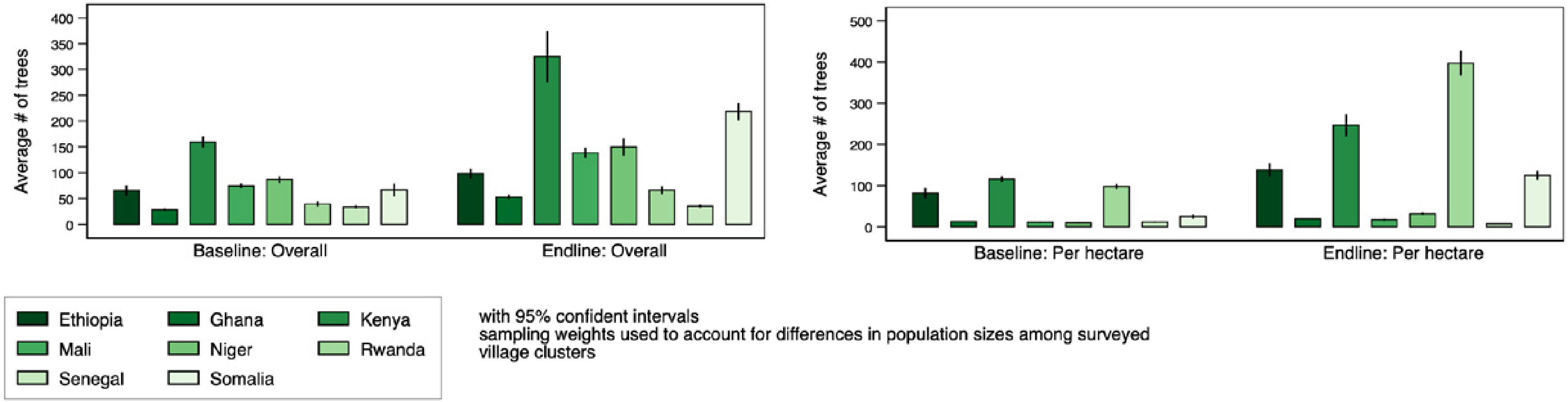


Figure 18: *Number of trees and shrubs on-farm and homesteads, baseline-endline comparison*

Figure 14 also shows changes in tree density. There was an overall increase from an average of 43 trees per hectare at baseline to 120 trees per hectare at endline. Like the number of trees found on-farm, there is also variation in densities across the countries. The highest density is in Rwanda, where we estimated an average of 397 trees per hectare at the endline, followed by Kenya with an average of 247 trees per hectare. For these two countries, this could be attributed to intensive tree establishment on relatively small parcels of land. Tree densities were found to be higher in East Africa compared to West Africa. In Ethiopia and Somalia, tree densities were found to be 138 and 125 trees per hectare, respectively. Tree density was lowest in Senegal, where it declined from 12 to eight trees per hectare. For the other West African countries, the number of trees per hectare increased marginally from 13 to 20 in Ghana, 12 to 18 in Mali, and 10 to 32 in Niger.

In East Africa, there was an increase in the number of exotic trees compared to native trees, especially in Rwanda where high value trees like *Eucalyptus spp*., *Grevillea robusta*, *Mangifera indica* and *Persea americana* were found to be the most prevalent. In West Africa, there was an increase in indigenous tree species, including *Combretum glutinosum*, *Faidherbia albida*, *Guiera senegalensis, Adansonia digitata*, *Piliostigma reticulatum* and *Ziziphus mauritiana*. In Ghana, the Shea butter tree, *Vitellaria paradoxa*, was among the most prevalent species in the programme sites.

The changes in the numbers of trees found on all household land use areas can also be presented differently as box plots as shown in Figure 19. The difference in the thick horizontal line in the middle, indicates changes in the median number of trees found across the programme and in individual countries, and corresponds to the changes seen in the average number of trees in Figure 18. Significant increase can be seen in all countries except Senegal.

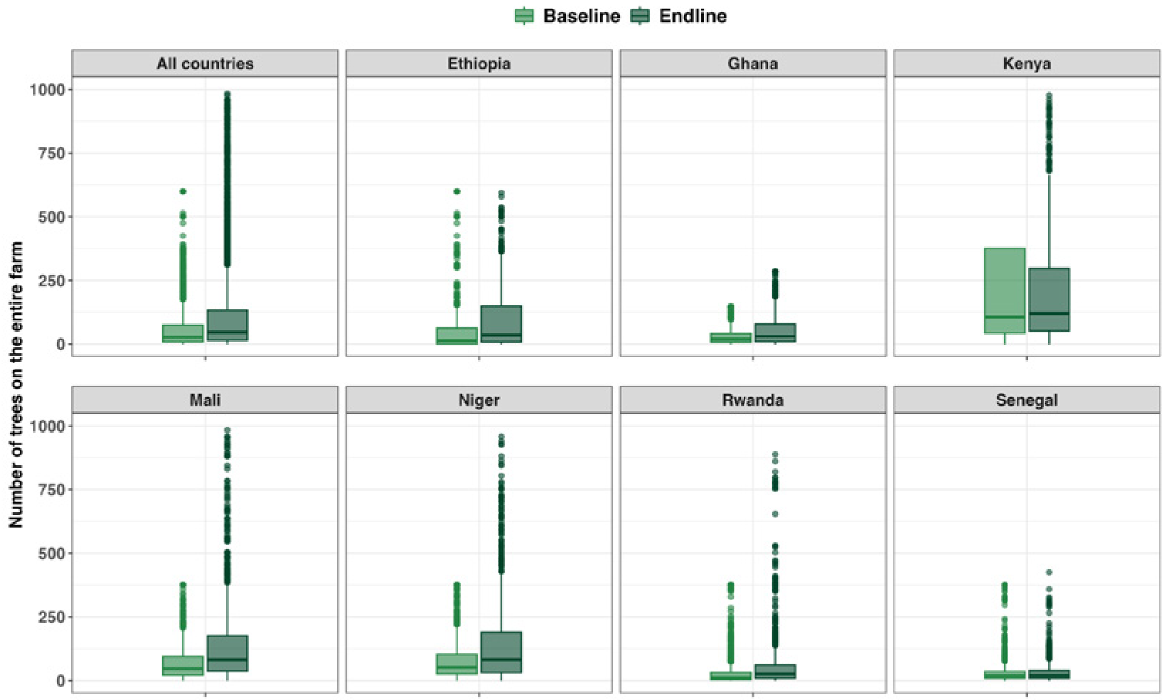


Figure 19: *Distribution of the average number of trees on the entire farm. The horizontal line of the box plots represents the median number of trees*

Figure 20 shows the distribution of the average number of trees on the main field only, with the median of this distribution as the thick horizontal line. There are significant variations across the countries, with the average for some countries, for example Mali and Niger increasing from 19 to 47 trees and from 44 to 85 trees, respectively, and others like Ghana and Kenya decreasing. The mean for Rwanda rose from 11 to 18 trees, and for Senegal the average remains relatively unchanged at 14.

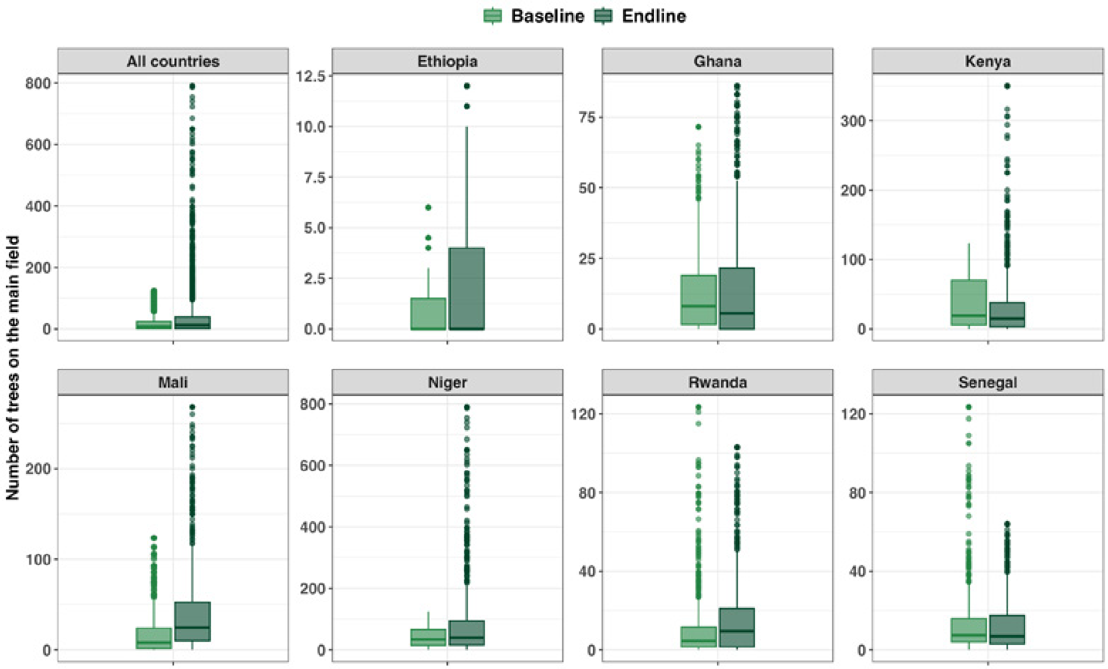


Figure 20: Distribution of the average number of trees on the main field. The horizontal line of the box plots represents the median number of trees

ESTIMATION OF HECTARES UNDER REGREENING

Table 5 shows the estimated number of hectares under regreening practices in the direct scaling sites in all the countries. The programme was able to reach 47% of the direct scaling target for the number of hectares under regreening, but with significant variation across countries. Some countries like Ghana, Somalia, and Mali either met or exceeded their targets, while Kenya, Niger, Rwanda and Senegal fell short. For some countries, for example Rwanda, the total amount of land owned by households in the targeted sites, was way below the overall target. This means even though the estimated proportion of land under regreening was relatively high, with the average land size being small (0.26Ha), the overall achievement was consequently low.

***Table 5:** Estimated number of hectares under regreening practices in the direct scaling sites in all the countries*

COUNTRY	TARGET HA (DIRECT)	REACHED TARGETS HA (DIRECT)	PERCENTAGE
Ethiopia	52,459	1,920	3.7
Ghana	45,000	50,656	112.6
Kenya	20,000	6,594	33.0
Mali	99,199	97,592	98.4
Niger	61,500	8,778	14.3
Rwanda	21,000	2,690	12.8
Senegal	100,000	11,078	11.1
Somalia	5,665	10,254	181.0
Total	**404,823**	**189,562**	**46.8**

6 Assessment of land and soil health

Baseline and endline assessments of **vegetation cover**, **SOC**, and **soil erosion prevalence** were conducted across all of the farmers' main cropping fields for households surveyed in both rounds. Maps of each indicator were produced using the global network of Land Degradation Surveillance Framework (LDSF)[28] sites, coupled with Earth Observation (EO) data (Figure 21). This includes the LDSF sites surveyed in Rwanda,[29] Senegal,[30] and Niger under this programme.

During the household surveys, the primary cropping fields of the sampled households were digitally mapped to generate geo-tagged field polygons. These farm polygons were overlaid onto the land health maps and values were extracted for both the baseline and endline time periods. Changes in these indicators are compared over time and against changes in trees established on the main cropping field or greening score. Improvements in the former coinciding with increases in the latter would provide some evidence of programme impact, i.e., the upscaling of trees on the main cropping field was strongly associated with improvements in soil health on this same field. It may be too early to detect these changes, however.

Implementing soil water conservation measures, including establishing trees along terrain contours and digging half-moons can, for example, curb soil erosion. Soil fertility can further be enhanced through decomposing leaf matter from aboveground vegetation, application of compost, and nodal nitrogen fixation.

28. http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/
29. https://www.regreeningafrica.org/project-updates/using-the-land-degradation-surveillance-framework-to-assess-land-health-in-rwanda/
30. http://blog.worldagroforestry.org/index.php/2019/03/13/land-degradation-surveillance-framework-deployed-in-senegal/

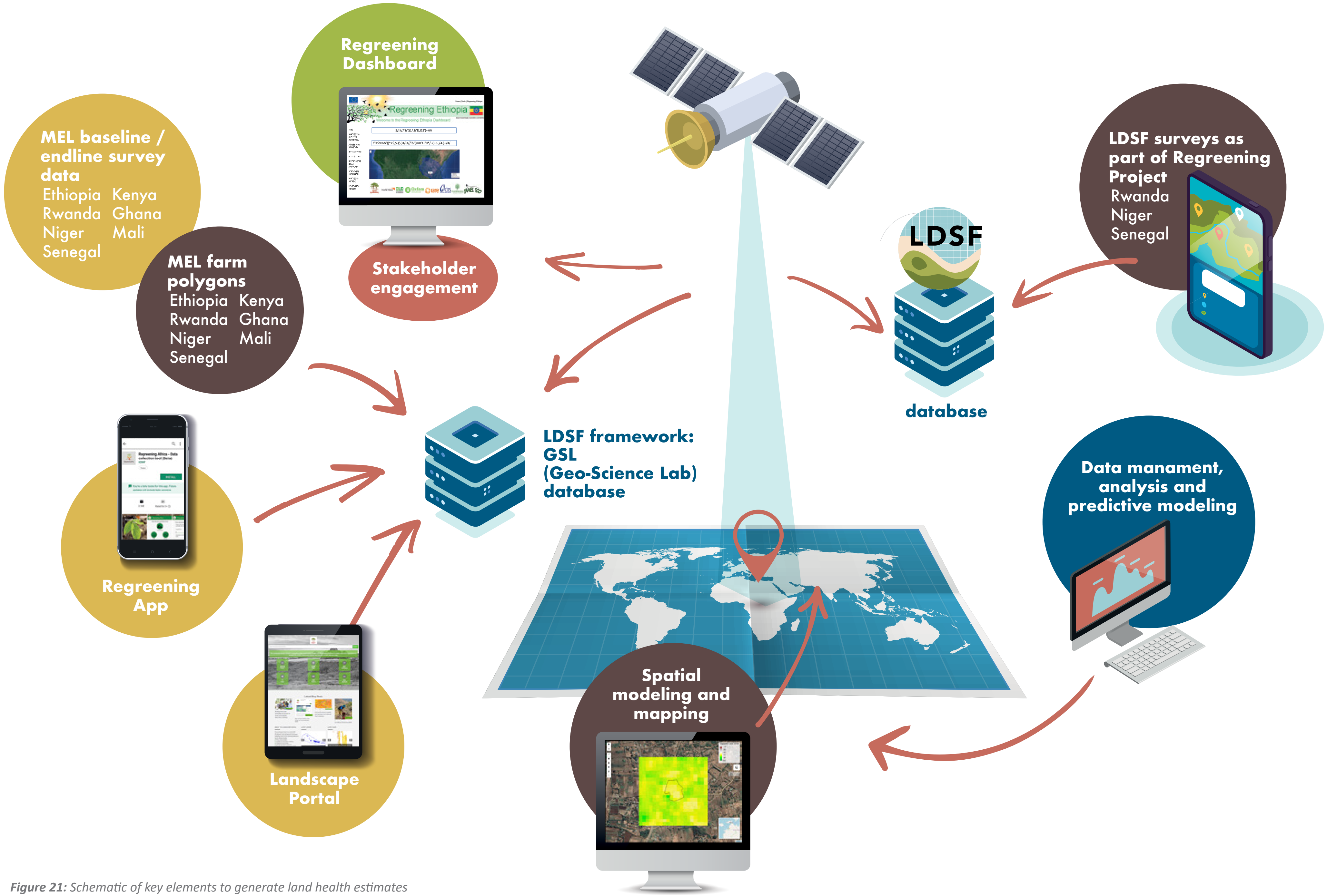


Figure 21: Schematic of key elements to generate land health estimates

FRACTIONAL VEGETATION COVER

When assessing the impact of land restoration efforts in increasing vegetation cover (greenness) in landscapes, various types of vegetation indices may be used as a proxy measurement. However, detecting a greening signal in the context of land restoration can be challenging, particularly in drylands where it can be relatively subtle. Also, such assessments need to consider the effects of variations in factors such as rainfall when determining whether the changes in vegetation cover are due to land restoration interventions or the result of natural dynamics. For example, in a wet year, an area may become greener regardless of any programme activities.

Fractional vegetation cover was calculated at baseline and endline using the Soil Adjusted Total Vegetation Index (SATVI),[31] integrating satellite data for 2016/2017 (baseline) and 2020/2021 (endline), respectively.

Figure 22 shows an example of a field polygon from a household survey in Homa Bay, Kenya, overlaid on the fractional vegetation cover map. The estimate for this field was derived by taking the weighted average of the pixels that fall within this field. The same approach was used for the other two indicators described below.

As shown in Figure 23, the overall fractional vegetation cover across the seven countries showed no significant improvement. It was higher in 2020/2021 than in 2016/2017 in the case of Kenya (Migori and Homa Bay) and Rwanda, while it was somewhat lower in Senegal, Ghana, and Niger. The apparent increase in Kenya is most likely due to there being two consecutive wet years in 2020 and 2021, which means we need to adjust for rainfall to assess whether these changes could be attributed to land restoration interventions.

For Regreening Africa, a novel approach was therefore developed that uses vegetation time series data from Landsat 8, an observation satellite and a Seasonal AutoRegressive Integrated Moving Average (SARIMA) model with rainfall as an external predictor. This model was trained to predict the vegetation signal in farmers' fields using Normalised Difference Vegetation Index (NDVI)[32] data over the period from 2013 to 2017 and then run over the period after 2017 to predict what that signal should look like based on variations in rainfall. Rainfall data were extracted from the Global Precipitation Mission (GPM). Greening was determined by assessing whether individual farmer fields had an actual vegetation signal over at least two consecutive years that exceeded that predicted by the model. Results were validated using both field data and visual interpretation of high-resolution satellite images where available. An example is shown in Figure 24, illustrating a case with very strong greening and no greening, respectively.

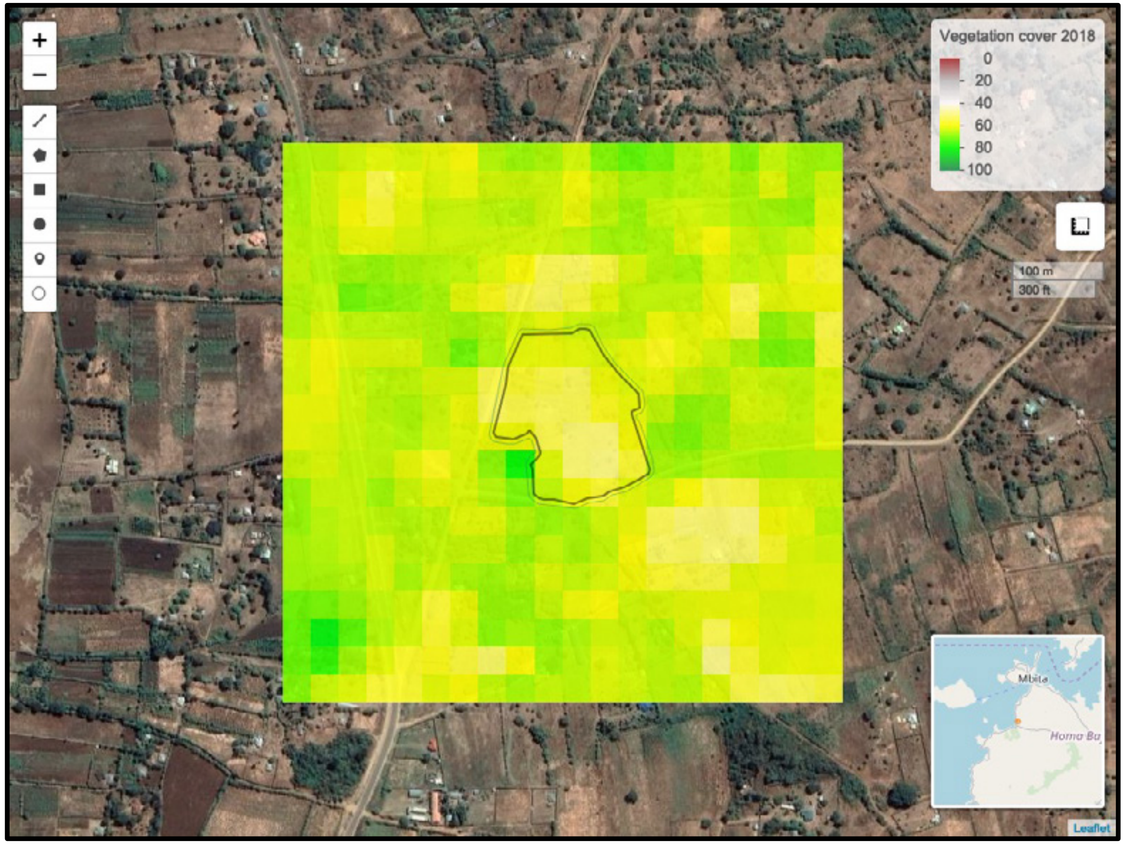
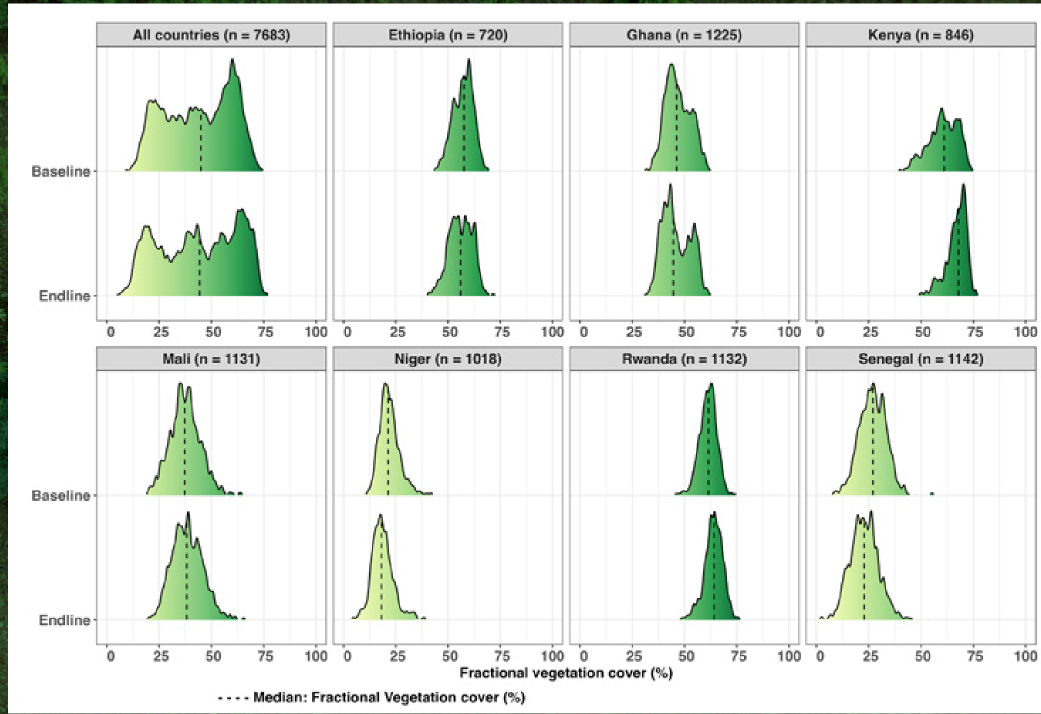


Figure 22: *Vegetation cover, using SATVI, for a farm polygon in Migori County, Kenya*

31. Qi, J., Marsett, R., Heilman, P., Bieden-bender, S., Moran, S., Goodrich, D., Weltz, M., 2002. RANGES improves satellite-based information and land cover assessments in southwest United States, Eos, Transactions American Geophysical Union. https://doi.org/10.1029/2002EO000411
32. NDVI is a method used in remote sensing where the difference between reflectance of near-infrared light which vegetation reflects and visible red light which it absorbs to quantify vegetation.

For Regreening Africa, a novel approach was developed that uses vegetation time series data from Landsat 8, an observation satellite and a Seasonal AutoRegressive Integrated Moving Average (SARIMA) model with rainfall as an external predictor. This model was trained to predict the vegetation signal in farmers' fields using Normalised Difference Vegetation Index (NDVI) data over the period from 2013 to 2017 and then run over the period after 2017 to predict what that signal should look like based on variations in rainfall.

__Figure 23:__ Density plots showing variations in fractional vegetation cover in 2016/2017 (baseline) and 2020/2021(endline) for each country



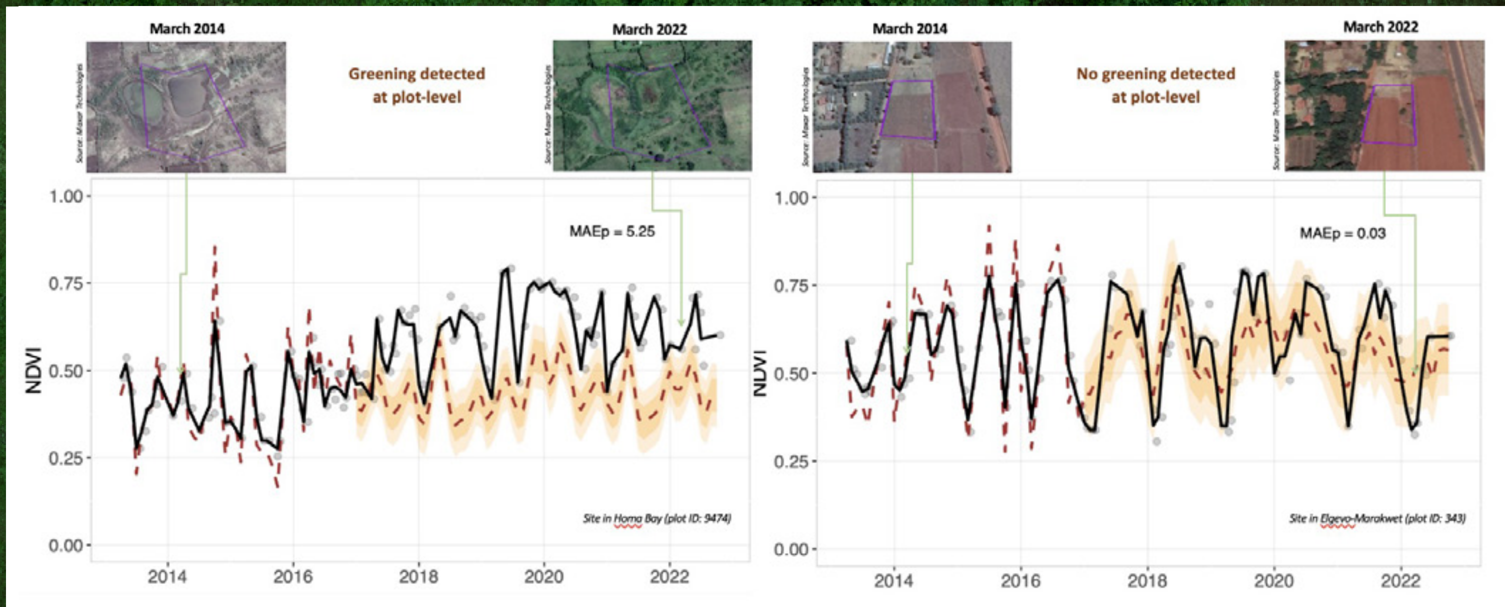


__Figure 24:__ Examples of greening (left) and no greening (right) and the associated Greening Score. The polygons shown are individual farmer fields from the project household surveys. The black line is the actual monthly normalised NDVI while the red line is the predicted NDVI with the 50 and 80 percent prediction intervals indicated with the yellow ribbons. On the left the black line goes above the red dashed line with yellow ribbon and on the right it does not

The model applied had an accuracy of 87 percent based on independent testing in Niger (arid), Ethiopia (semi-arid), and Rwanda (sub-humid). This analysis was conducted to assess a Greening Score by comparing NDVI time series over the project period to the period from 2013 to 2017 for the households surveyed in the project. Where this score (Figure 25) is higher than 0.5, we have an observable greening signal.

Overall, Ethiopia has the highest relative Greening Score at the country level (Figure 25), but with significant variations across districts, as indicated by the height of the box. Rwanda, Kenya, and Ghana also have a significant number of households where we are detecting a vegetation cover increase. Mean scores for Mali, Niger, and Senegal are all lower than 0.5, but we are detecting increases in some districts also in these countries. Overall, we are detecting greening (score > 0.5) in about 70 percent of the plots in Ethiopia, 49 percent in Ghana, 38 percent in both Rwanda and Kenya, and between 26 and 28 percent in the Sahel.

There may be many reasons for the weaker signal in the Sahel, but one explanation could be that these are predominantly FMNR systems where trees and shrubs are often pruned or lopped, so we may be underestimating the level of regreening to some extent. Also, trees in the Sahel are mostly deciduous.

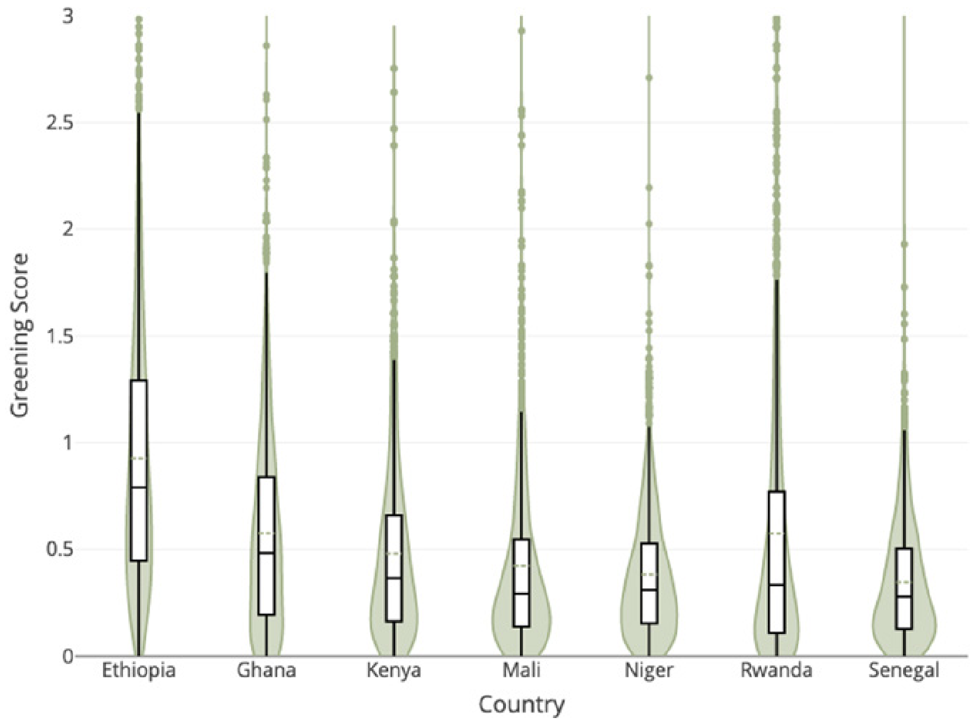


__Figure 25:__ Boxplots showing the distribution of the Greening Score for each country based on the monthly NDVI time series over the period from 2013 to 2022. The values indicate the relative amount of greening detected after 2017 (i.e., during the baseline year), relative to 2013 to 2017 (i.e., prior to the baseline year). The solid line within each box is the median value while the dashed line represents the mean

TREE COVER

To further assess changes in vegetation cover, we used the LDSF[33] database and remote sensing data to predict and map tree cover specifically, also based on Landsat 8. This approach uses satellite reflectance data to develop a predictive model based on LDSF field data on the presence/absence of trees and their density. The result is a map with tree cover (%) predicted for each pixel, which we can then extract values from each farmer's fields and compare baseline and endline conditions.

In Figure 26, results of this analysis are shown. Niger has very low tree cover in general and we observe no change between 2017 to 2022, while we see a decrease in tree cover in Senegal. Rwanda has the strongest increase in tree cover with a mean in 2017 and 2021 of 20 and 24 percent, respectively, and an increase in the number of plots with more than 50 percent tree cover over the project period. There may be multiple reasons for the increase in tree cover that we detected in Rwanda, one being that the tree species that are planted are predominantly exotic and fast-growing species, such as *Persea americana* (avocado), *Eucalyptus camaldulensis*, and *Solanum betaceum* (tree tomato). Also, many of these species are planted in woodlots or in fruit tree orchards where tree densities are relatively high.

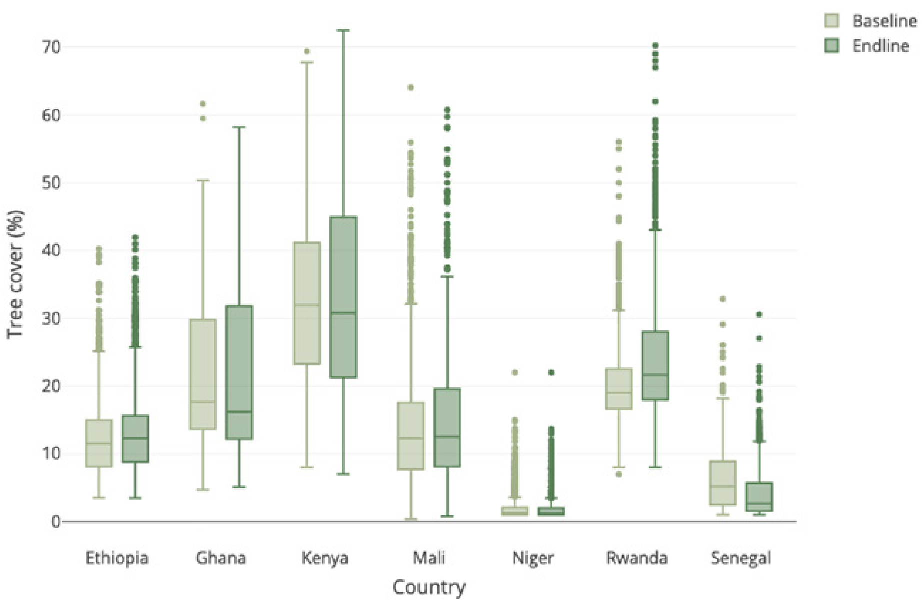


Figure 26: *Box plots showing changes of predicted tree cover (% of land area falling under such cover) on surveyed household's main cropping fields between the baseline and endline periods*

Disaggregating the results by programme sites within each country reveals more insightful variation (Figure 27). In Ethiopia, we see a significant increase in predicted tree cover for Sire woreda, consistent with the change in the RAI and predicted vegetation cover. Similarly, significant increase in predicted tree cover in the districts of Gatsibo and Kayonza in Rwanda aligns well with the change observed in the RAI and predicted fractional vegetation cover over the project period. Even if there is a significant increasve in predicted tree cover in Migori, we see a significant decrease in tree cover in Homabay County, thereby masking the overall picture for Kenya. The predicted tree cover also shows a strong increase in Yorosso region of Mali, which is consistent with the predicted fractional vegetation cover. In Ghana, we observe a decrease in tree cover across the three programme sites. This is also in line with the predicted decrease in fractional vegetation cover.

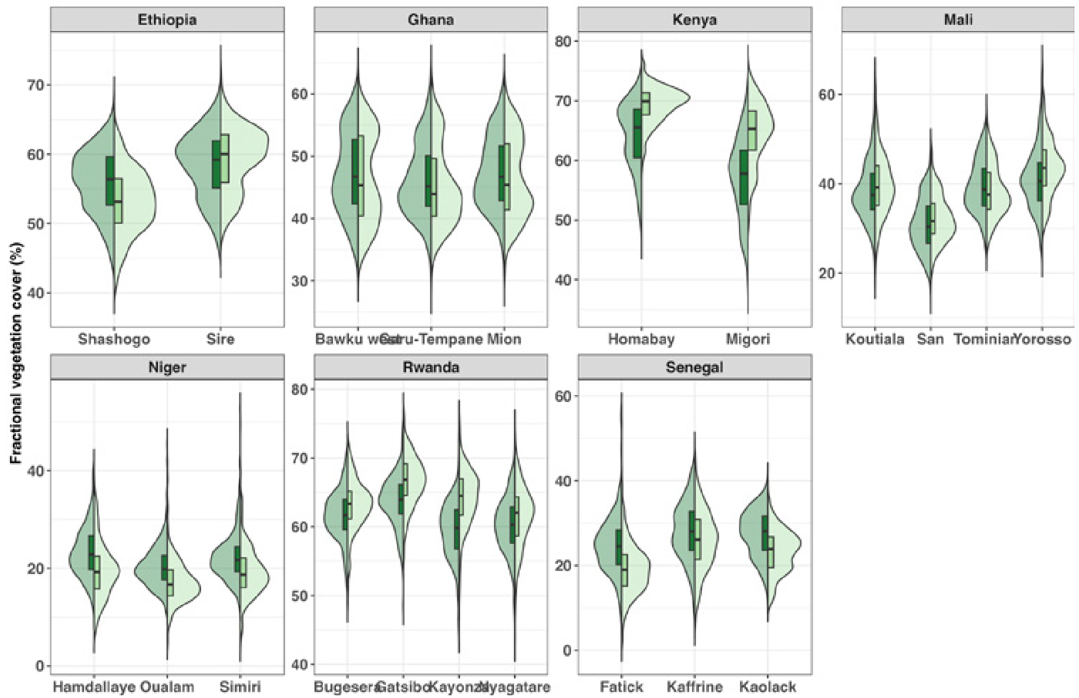


Figure 27: *Violin plots showing the distribution of the predicted tree cover (%) at the baseline and endline by programme site. The split violin plots with the box plots in the middle shows how the distribution moved comparing the two periods. The horizontal line in the box plot represents the median value of each period*

33. The LDSF was developed as a response to a lack of methods for systematic landscape-level assessment of soil and ecosystem health. The methodology is designed to provide a biophysical baseline at landscape level, and a monitoring and evaluation framework for assessing processes of land degradation and the effectiveness of rehabilitation measures (recovery) over time. http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/

SOIL ORGANIC CARBON: A KEY INDICATOR OF SOIL HEALTH

SOC, expressed as the grams of organic carbon per kilogram of soil (gC kg^{-1}), was estimated based on soil data from a global network of LDSF[34] sites and Landsat remote sensing data. Machine learning algorithms (models) were trained to predict SOC based on a satellite image reflectance value.[35] The accuracy of the SOC maps is greater than 80 percent, which is high. SOC is critical because it influences a range of ecosystem services provided by soil, and it provides an important opportunity for carbon sequestration. Increased SOC can play a critical role in enhancing land health and agricultural productivity given its influence on soil nutrients and their availability to plants, water regulation, and biodiversity.

There are large variations between project countries, as expected, given the wide range of climate zones, altitudes, and management systems represented. Ethiopia has the highest SOC overall, followed by Kenya and Rwanda, but with large variations (Figure 28). The higher SOC in Ethiopia can be explained by lower temperatures (higher elevation) in some of the project districts, higher rainfall, and also by soils with high clay content in some cases. In the Sahel, SOC is generally very low (Figure 28) due in part to a combination of lower rainfall and more sandy soils. Given the variations in climate, underlying soil properties, land cover and land use, impacts of interventions on SOC and other land health variables are likely to also vary strongly both between and within project countries.

The mean SOC increased by only 0.31 gC kg^{-1} overall, which represents a relative increase of 3 percent over the project period. While this increase may seem quite marginal on average, there is a significant variation across the programme sites. For example, in Sire woreda in Ethiopia, Gatsibo and Kayonza districts in Rwanda, and Yorosso District in Mali, we observe a strong increase in SOC compared to the baseline period. However, in Senegal (all districts), Simiri (Niger), Tominian and Koutiala (Mali), Enderta (Ethiopia), and in Ghana, we see no change or slight decreases in SOC. The lack of changes in SOC in the drier project areas in the Sahel is not surprising, given that it can take a number of years for the impacts of interventions to manifest in these regions. This highlights the need for long-term monitoring of soil and land health. Additionally, SOC is generally very low at baseline, indicating significant constraints at the onset of the project. Nevertheless, it is important to keep in mind that even small changes in these more marginal areas can have a large impact on productivity and their overall resilience.

When we model SOC relative to tree cover, we see a general increase in all of the project countries (Figure 29). However, the trajectories look different for each country (ecosystem) (Figure 29) due to variations in inherent properties of each system, including climate and soil properties. Taking site-specific factors into account is important in the design and implementation of land restoration interventions, as well as for monitoring change over time.

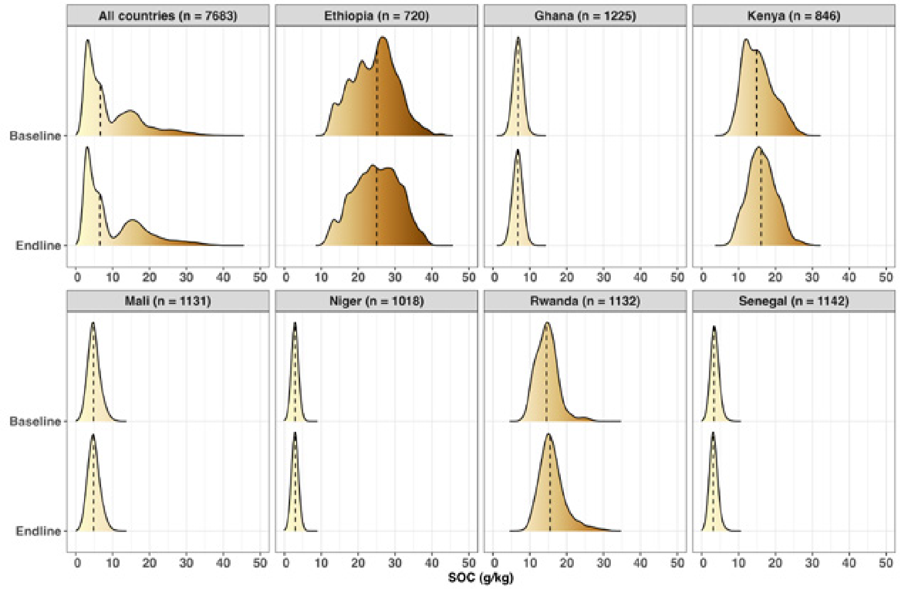


Figure 28: Distributions of SOC at baseline (top plot) and endline (bottom plot) across seven of the programme countries. The dashed line represents the median and the colour shows the level of SOC, with browner representing more SOC

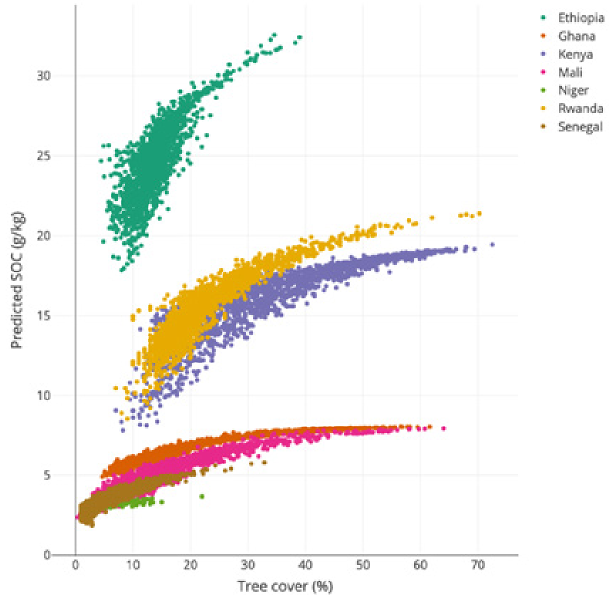


Figure 29: Changes in SOC in response to increasing tree cover for each country using a nonlinear regression model with random effects at country level. Countries in the Sahel generally have lower SOC and also a lower potential for storage of SOC due to for example higher sand content and less rainfall. However, there are significant variations. The points represent individual farmer fields delineated in the endline survey

34. http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/
35. Vågen, Tor-Gunnar T.-G., and Leigh A. Winowiecki. 2013. "Mapping of soil organic carbon stocks for spatially explicit assessments of climate change mitigation potential." Environmental Research Letters 8 (1): 015011. https://doi.org/10.1088/1748-9326/8/1/015011. Vågen, Tor-G., Leigh A. Winowiecki, Assefa Abegaz, and Kiros M. Hadgu. 2013. "Landsat-based approaches for mapping of land degradation prevalence and soil functional properties in Ethiopia." Remote Sensing of Environment 134 (July): 266–75. https://doi.org/10.1016/j.rse.2013.03.006. Vågen, Tor-G., Leigh A Winowiecki, Jerome E Tondoh, Lulseged T Desta, and Thomas Gumbricht. 2016. "Mapping of soil properties and land degradation risk in Africa using MODIS reflectance." Geoderma 263 (February): 216–25. https://doi.org/10.1016/j.geoderma.2015.06.023.

SOIL EROSION PREVALENCE: A KEY INDICATOR OF LAND DEGRADATION

Maps of erosion prevalence were developed using ICRAF's georeferenced database of ecosystem health indicators, coupled with remote sensing imagery[36] at the same spatial resolution as the maps of vegetation cover and SOC above.

Soil erosion prevalence (%), expressed as the weighted mean probability of severe erosion within each farmer field, was estimated using field data on different types of erosion from the global network of LDSF sites and Landsat remote sensing data. The accuracy of the soil erosion prevalence maps is greater than 86 percent.

Soil erosion is a relatively dynamic indicator of soil and land health that can vary quite significantly between years. It is strongly influenced by management practices such as soil and water conservation that help reduce runoff and keep the soil covered, but also by extreme weather events such as heavy rainfall. In drylands, soil erosion can be quite severe following prolonged droughts if these are followed by high intensity rainfall, making measures to increase permanent land cover critical.

We do not observe large changes in soil erosion across the project overall, except in Kenya, where there is a shift in lower erosion prevalence (Figure 30). The number of fields with higher levels of erosion prevalence relatively decreased in Rwanda as well. Erosion prevalence is significantly higher in Niger and showed some increase compared to the baseline. A similar pattern and trend is observed for Senegal and Ethiopia. In Ghana and Mali, we observe no significant change in soil erosion prevalence between the baseline and endline periods.

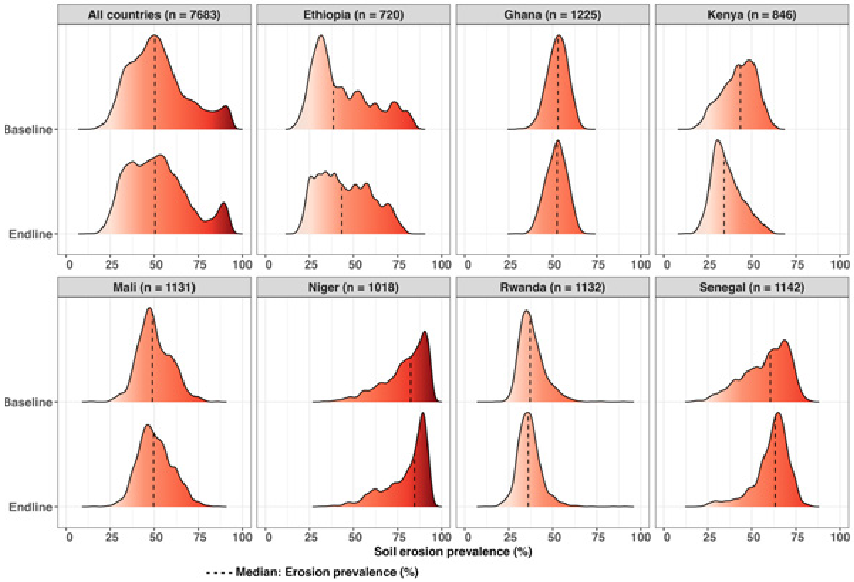


Figure 30: *Distribution of soil erosion prevalence (%) at the baseline (top plot) and endline (bottom plot) across seven of the programme countries. The dashed line shows the median and the colour shows the severity of erosion prevalence, with reddish representing serious erosion*

Similarly, we observe a decrease in erosion prevalence across two counties in Kenya and Gatsibo and Kayonza districts of Rwanda.

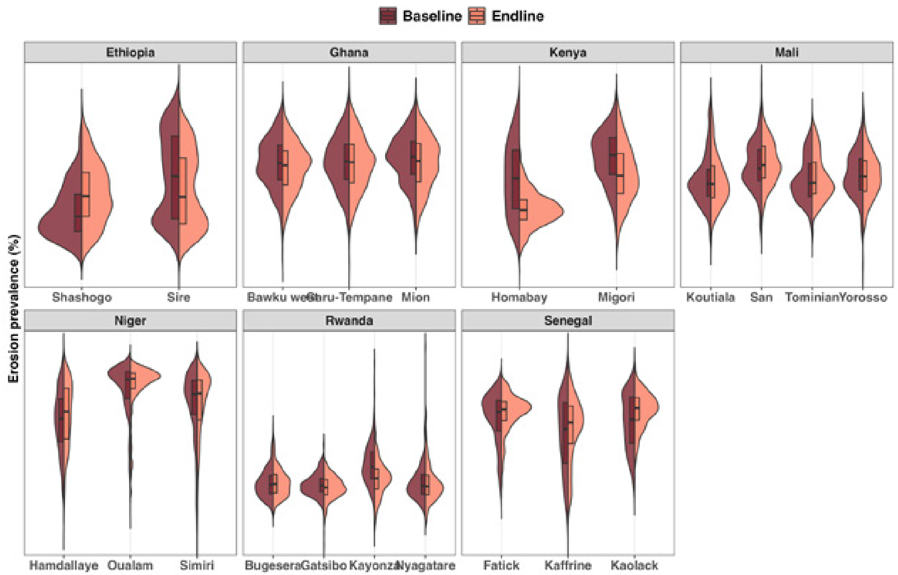


Figure 31: *Violin plots showing the distribution of the predicted soil erosion prevalence (%) at the baseline and endline by programme site. The split violin plots with the box plots in the middle shows how the distribution moved comparing the two periods. The horizontal line in the box plot represents the median value of each period*

36. Vågen, T.-G.; Winowiecki, L.A. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. Remote Sens. 2019, 11, 1800. https://www.mdpi.com/2072-4292/11/15/1800

CHANGES IN THE NUMBER OF TREES ESTABLISHED ON MAIN CROPPING FIELD AND SOIL HEALTH INDICATORS

A key hypothesis in Regreening Africa's ToC is that upscaling of trees on-farm in the right ways will lead to improvements in soil health. We now explore whether our data is consistent with this hypothesis, i.e., whether changes in our tree-and vegetation-related indicators are positively associated with changes in our soil health indicators, namely SOC and erosion prevalence. We do this using the first difference estimation approach, which is specified as follows:

$$\Delta Y_i = \Delta x_i \beta + \Phi_r + \Delta \varepsilon_i$$

where ΔY_i are changes in our two soil health indicators (SOC (g/kg) and erosion prevalence (%)) and Δx_i are changes in our tree and vegetation indicators. β is the resulting estimated linear coefficient, which Φ_r represent district dummy variables used to control for district specific influences and $\Delta \varepsilon_i$ is the change in idiosyncratic error term.

Overall, we observe positive and statistically significant association between changes in the numbers of trees scaled up on-farm and changes in soil organic carbon (Figure 32). This is to the greatest extent in Kenya, followed by Ethiopia and Rwanda. In Ghana and Senegal, the association is surprisingly negative, while there is no significant association in the cases of Mali and Niger. We found no statistically significant association between the numbers of trees upscaled on the main field and changes in predicted erosion prevalence.

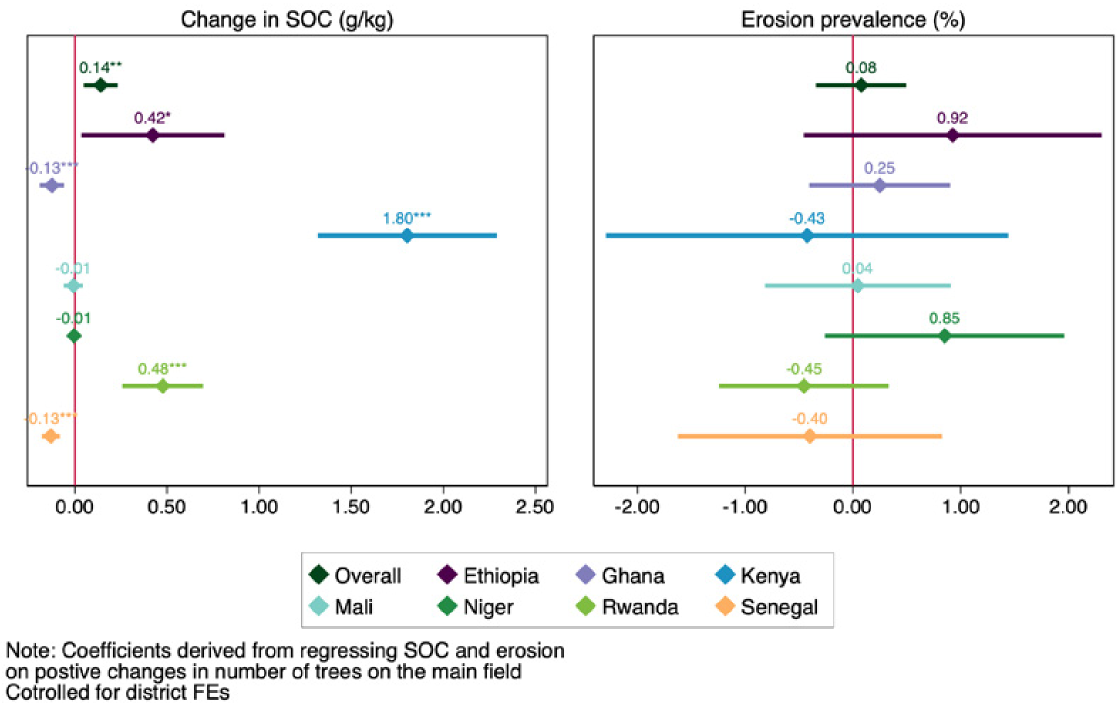


Figure 32: *Association between positive changes in number of trees reported on the main field and changes in soil health indicators*

We complement our analysis by examining the association between the greening score and changes in predicted tree cover, on the one hand, and changes in our two soil health indicators, on the other (Figure 33 and Figure 34). We now observe statistically significant associations. For changes in SOC and the greening score, the coefficients are generally small but statistically significant and in a positive direction overall, as well as for Kenya, Mali, and Rwanda, and Senegal. For Ghana the relationship is negative and statistically significant.

When analysing changes in tree cover (Figure 34), we find that its association with changes in SOC is statistically significant and positive overall for six out of the seven countries. The strength of the association between changes in SOC and both the greenness score and predicted changes in tree cover is generally statistically significant but small. This is to be expected since SOC typically takes time to build up in soil.

The results for erosion are less consistent but with more significant associations for several countries. We observe less erosion overall and for Ethiopia, Niger, Rwanda, and Senegal among those farming fields with higher greening scores (Figure 33). However, the association is insignificant for Ghana, Kenya, and Mali. We also find significant associations between changes in tree cover and predicted erosion prevalence, but with some noteworthy differences. We estimate that fields with gains in tree cover were slightly more likely to experience reductions in soil erosion overall and in Niger, Senegal, and, to a lesser extent, Ethiopia. However, the association is positive, contrary to what we would expect, but weak in the cases of Ghana, Kenya, Mali, and Rwanda.

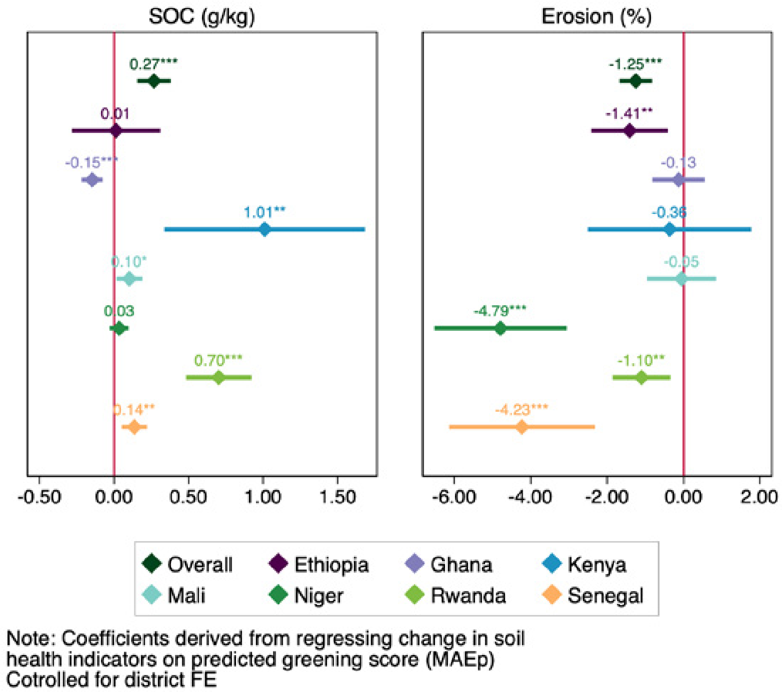


Figure 33: *Association between changes in greening score vis-a-vis farmer's field and changes in soil health indicators between the baseline and endline periods*

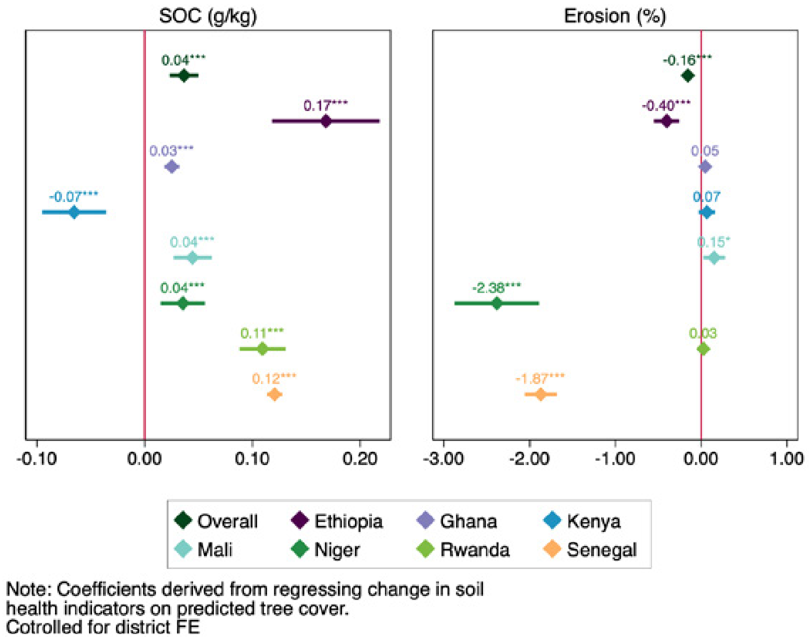


Figure 34: *Association between changes in predicted tree cover on farmer's field and changes in soil health indicators between the baseline and endline periods*

7 Tree product use and income

CHANGES IN TREE PRODUCT USE

During the baseline and endline surveys, data were also captured on household use, rather than simply collection, of tree-related products obtained from on-farm and communal land. Respondents were asked if they sold any of these products over the last 12 months. We observe that, overall, the percentage of households reporting the use of tree products doubled during the project period (Figure 35).

However, we also observe significant variation across countries and product types. The percentage of households using fuelwood from both on-farm and communal land increased from 30 percent at baseline to 60 percent at endline across seven countries. The change was more significant in Ethiopia, Ghana, Kenya, and Niger. Across all seven countries, the percentage of households reporting the consumption of fruit and nuts increased from 20 to 37 percent, with significant increases observed only in Ghana, Mali, Niger, and Rwanda. In Kenya and Mali, the percentage of households reporting the use of poles slightly increased, as well as the use of timber in Kenya and Mali. Interestingly, the percentage of households reporting the use of fodder shrubs increased considerably for countries in the Sahel region, namely Mali, Niger, and Senegal. Similarly, many households in Ghana, Mali, and Niger upscaled the use of medicinal plants.

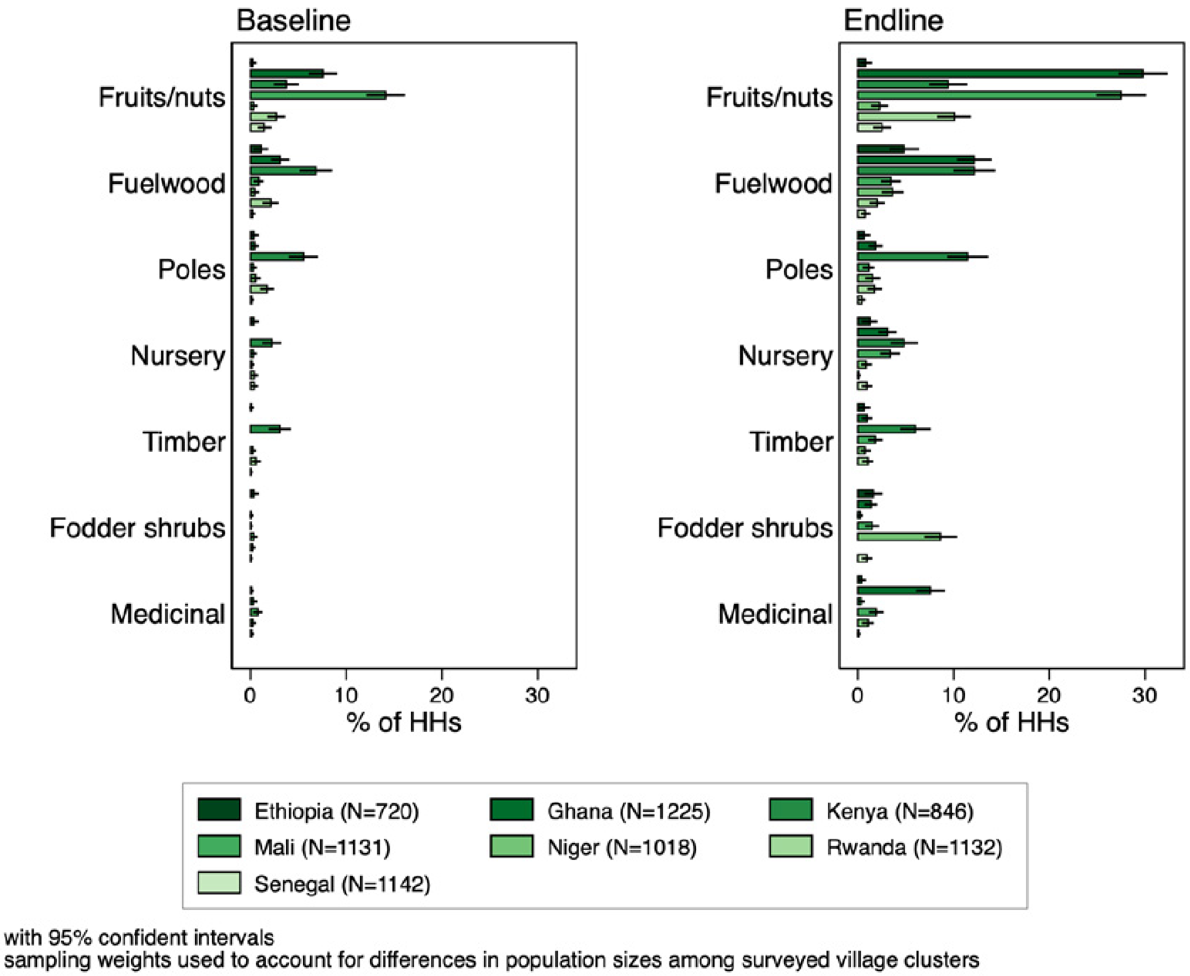


Figure 35: *Percentage of households that reported use of tree-related products from on-farm and communal lands at the baseline and endline*

CHANGES IN THE SELLING OF TREE PRODUCTS

In general, the percentage of households reporting the sale of tree products sourced from on-farm and communal lands was low across seven countries but increased by the endline period for some (Figure 36). In Ghana and Mali, there was a noticeable increase in the percentage of households that reported selling fruits and nuts, for example, rising from 8 to 30 percent and 14 to 28 percent, respectively. Similarly, the percentage of households that reported selling fuelwood increased from 3 to 12 percent in Ghana and from less than 1 to 3 percent in Mali.

Respondents were asked the income they generated from selling tree products in the local currency of the respective countries. We converted the nominal values to USD PPP values using conversion rates from the 2022 International Comparison Program of the World Bank.[37] Further, to enable the comparison across the period, we report real values adjusted using the consumer price index data obtained from the World Bank for each country, with the base year being 2011.

The overall average income per household did not show any significant change over the project period, at USD 82 PPP in real values, with considerable variations across countries (Figure 37). Notably, households in Senegal earned higher income at USD 242 PPP, but this did not change over the project period. In Mali, it increased from USD 116 at baseline to USD 150 at the endline. In Ethiopia and Ghana, the average income from trees increased from USD 25 to USD 30 over the project period. However, it is worth noting that the number of households earning additional income from trees significantly increased from less than 600 to over 1500 over the project period.

37. International Comparison Program , World Bank|World Development Indicators database, World Bank|Eurostata-OECED PPP Programme.

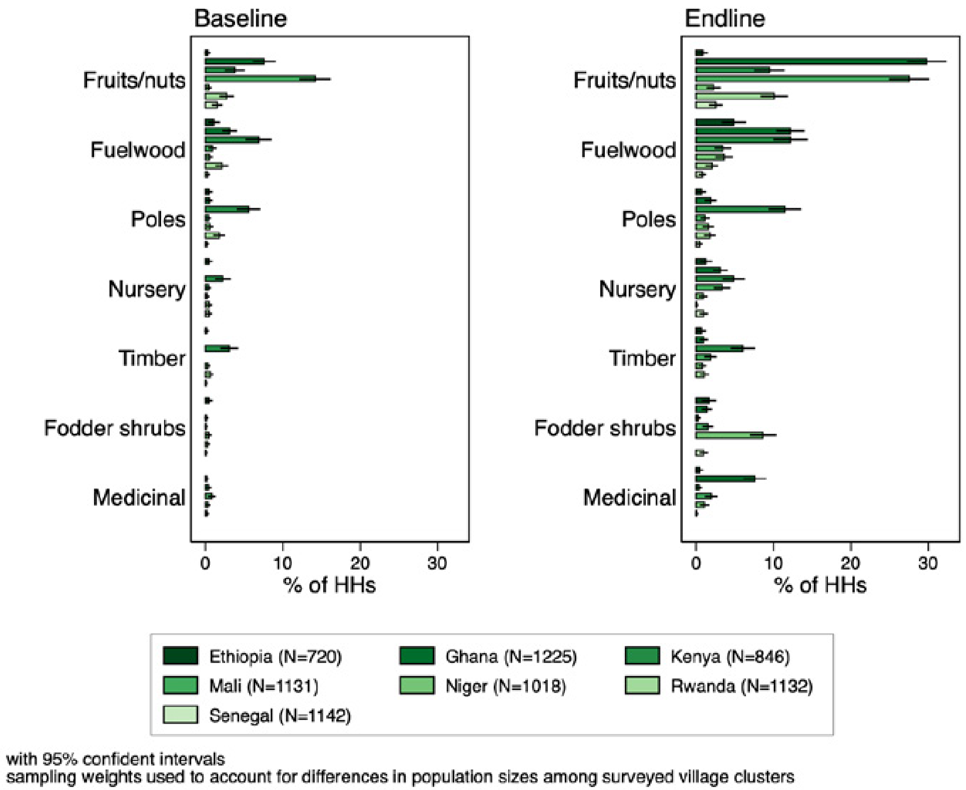


Figure 36: Percentage of households that reported selling tree-related products collected on-farm and from communal lands at the baseline and endline

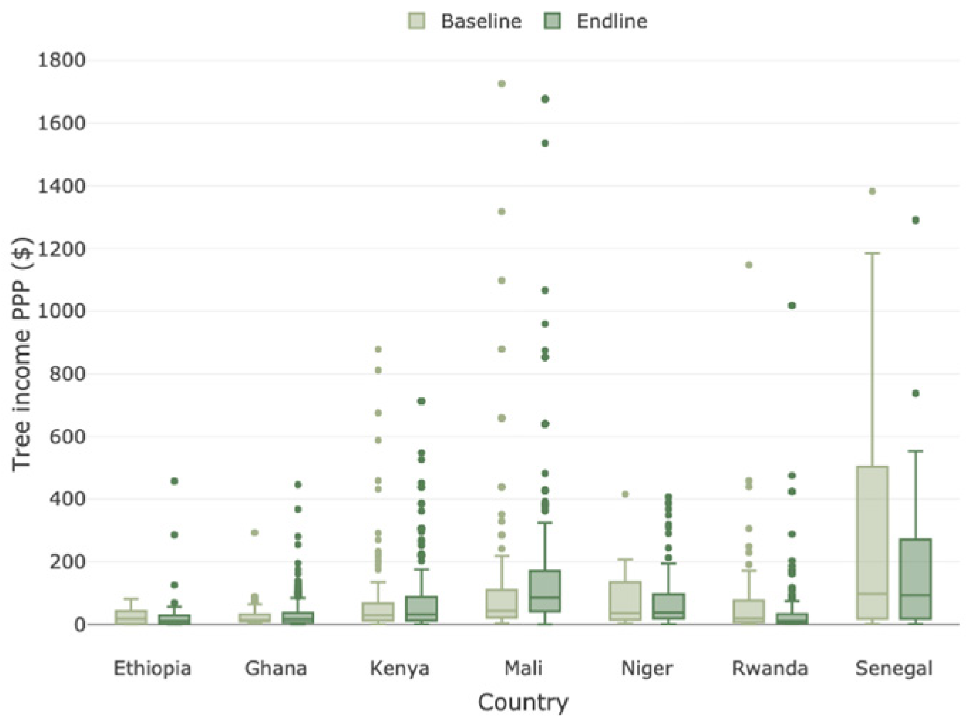


Figure 37: The distribution of income (PPP $) from selling tree products by period and country. The horizontal line in the box plot represents the median value of each period

Respondents were asked the income they generated from selling tree products in the local currency of the respective countries. We converted the nominal values to USD PPP values using conversion rates from the 2022 International Comparison Program of the World Bank. Further, to enable the comparison across the period, we report real values adjusted using the consumer price index data obtained from the World Bank for each country, with the base year being 2011.

The overall average income per household did not show any significant change over the project period, at USD 82 PPP in real values, with considerable variations across countries (Figure 37). Notably, households in Senegal earned higher income at USD 242 PPP, but this did not change over the project period. In Mali, it increased from USD 116 at baseline to USD 150 at the endline. In Ethiopia and Ghana, the average income from trees increased from USD 25 to USD 30 over the project period. However, it is worth noting that the number of households earning additional income from trees significantly increased from less than 600 to over 1500 over the project period.

8 Food security and household wealth status

CHANGES IN THE TREE FOOD USE/INCOME AND FOOD SECURITY

We examine the associations between tree product use and household food and nutrition security, focusing on the consumption of tree products that directly or indirectly contribute to food and nutritional gain through consumption and income. To facilitate our analysis, we created a binary indicator for households that reported the use of fruits and nuts, fodder shrubs, and/or sold any tree products.
For the food and nutrition security indicators, respondents were asked, both at the baseline and endline, questions pertaining to two individual-level measures of food and nutritional security: the Minimum Dietary Diversity-Women (MDD-W) and the Food Insecurity Experience Scale (FIES). The FIES is used to measure Sustainable Development Goal (SDG) Indicator 2.1.1 (Severity of Food Insecurity). The MDD-W is a proxy for measuring micronutrient adequacy. Capturing the data on this measurement involved asking respondents if they had consumed various food items during the previous day from a list of 17 items. These were subsequently grouped into MDD-W's 10 food group categories.

Data to inform the FIES was obtained by asking the following eight questions that refer to self-reported behaviours and experiences associated with difficulties in accessing food due to resource constraint:

Over the last 12 months:

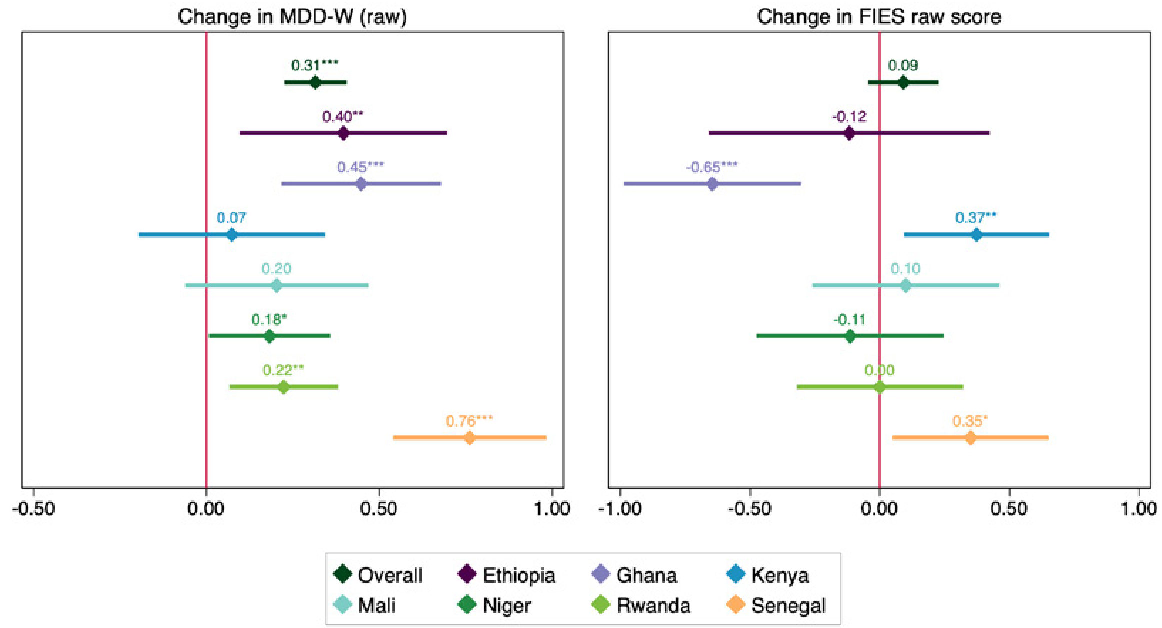
1. *Were you worried you would run out of food?*
2. *Were you unable to eat healthy and nutritious foods because you did not have enough money or resources?*
3. *Did you only eat a few kinds of foods because you did not have enough money or resources?*
4. *Did you skip a meal because you did not have enough money or resources?*
5. *Did you eat less than you thought you should because you did not have enough money or resources?*
6. *Did your household run out of food?*
7. *Were you hungry but did not eat because of a lack of money and resources?*
8. *Did you not eat for a whole day because you did not have enough money or resources?*

The overall average MDD-W raw score increased from 3 at baseline to 3.2 at endline, which is a marginal improvement. The percentage of respondents that reported consuming at least five of the ten food items (MDD-W cut-off point) increased from 16 to 21, a 31 percent increase compared to the baseline. However, it is important to note that there is a large variation across the seven countries. For example, in Mali, the percentage of respondents who reached the MDD-W cut-off increased from 17 to 37 percent, while in Ghana, it increased from 26 to 33 percent. In the case of Ethiopia, it dropped from 6 to 3 percent.

The FIES score showed no substantial change over the project period. The overall score dropped from 4.9 to 4.8 out of the 8 possible points, indicating moderate food insecurity.

We fit the model for each country using the raw scores, the number of food items consumed out of the ten for MDD-W, and the raw score out of eight points for FIES. We present the results of the estimation between changes in the scores and our binary indicator for the use of food-related tree products and/or selling. In all models, we control for district fixed effects.

All our estimates point in a positive direction for dietary diversity, indicating that those households that intensified their consumption and general use of tree products also experienced improvements in dietary diversity (Figure 38). The relationship is statistically significant overall and for Ethiopia, Ghana, Niger, Rwanda, and Senegal. The association is less clear for the FIES, except for Ghana, where households that intensified the use of tree products also experienced less food insecurity. The association is also negative in Ethiopia and Niger, but not statistically significant. Contrary to our expectation the association is positive and statistically significant in the case of Kenya and Niger.



Note: Coefficients derived from regressing change in food security indicators on change in reported edibale tree product use and sell.

Figure 38: *Association between changes in tree-related product use and changes dietary diversity and food security outcomes*

CHANGES IN THE RAI AND TREE-RELATED INCOME AND ASSET WEALTH

In this subsection, we investigate whether households that a) upscaled regreening practices (as measured by the RAI) in general; and b) experienced gains in tree-related income, in particular, also accumulated more assets between the baseline and endline periods.

The asset gain index was constructed using Principal Component Analysis (PCA) based on information captured on households' livestock ownership, non-durable farm assets, other durable assets, and housing characteristics during the baseline and endline survey (see Annex 2). Our results show a positive and statistically significant association between changes in RAI and asset gain overall and for all countries except Niger (Figure 39). The results highlight that households that upscaled various regreening practices on their farms were also more likely to experience an increase in assets. However, further investigation may be needed to understand the underlying mechanisms better and to rule out potential confounding factors.

Similarly, we observe a positive and statistically significant relationship between asset gain and income from trees (Figure 40). The result is consistent for all countries except Niger, where the relationship is negative, even though statistically insignificant. Even though the effect size is small, ranging from 0.01 to 0.08 gain on asset index for a 1 percent increase in tree income, it highlights the importance of additional income from asset accumulation for household resilience and tree-based income.

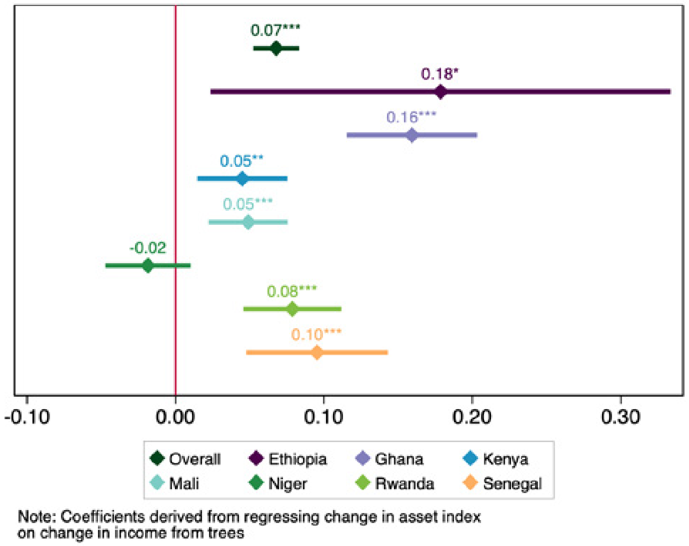


Figure 40: Association between household's asset gain index and changes in tree product income[38]

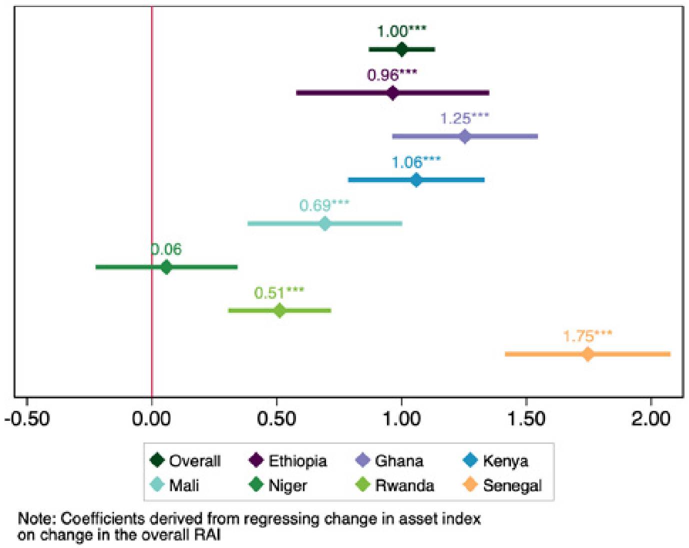


Figure 39: Association between household asset gain index and changes in the overall regreening action index

38. The income measure is inverse hyperbolic sine (IHS) transformed because it is highly skewed with zero values for several households.

9 Leverage-based out-scaling

Given the ambitious targets set for each country, implementing partners devised different strategies to attain these targets by the end of the programme period. Leveraging other projects within their organisations or in other organisations was considered one of the ways through which partners could reach more farming households. To be considered a case of leveraged adoption, there needed to be a clear link to Regreening Africa (i.e., project 'signature'). For example, these other projects/organisations had to have been directly influenced to either incorporate regreening practices in their activities or to take up the scaling approaches that Regreening Africa was using to promote tree establishment within the countries, which they were not originally doing.

Table 6 shows the leverage targets for each country, as well as the extent to which these were achieved. Since different countries employed different strategies to achieve the indirect targets, a single estimation method was not workable. We, therefore, employed different strategies to estimate the numbers presented. One approach was to carry out surveys in leverage sites. This was done in Ethiopia, Mali, and Rwanda. Through the resulting data, we estimated the numbers of households reached and those that upscaled regreening practices, as well as the hectares where trees were established within the project period (Table 6). For Rwanda, leveraging was done through a World Vision Rwanda livelihood project operating in two districts, but in administrative units different from where the Regreening Africa programme was implemented. In Ethiopia, due to security issues in direct intervention sites in Tigray, partners were forced to identify other sites in which they could work. While not exactly classified as leverage, the assessment for these replacement sites was done in a similar way to Rwanda, as they did not have baseline data. In Kenya, leverage sites were spread across a wide geographical region, covering sites in most semi-arid districts in the country. World Vision Kenya worked through other sister livelihood/ natural resource management projects in the targeted areas. Because of this, it was impossible to carry out a survey in all sites. The Regreening Africa app has been used to estimate hectares under regreening in Kenya.

Leveraging activities, however, did not take place to any measurable level in Ghana and Senegal, and in Niger, it was mostly achieved though community level projects targeting communal lands. For this latter country, administering a household survey was not possible because interventions were done by groups of people. In Mali, World Vision Mali and CRS Mali exited from the project earlier than other partners, and OXFAM Mali did not leverage on other projects or activities apart from leading a caravan to sensitise the communes on the conservation of forest resources. However, Sahel-Eco influenced a sister project operating in three communes outside the Regreening Africa intervention area, by promoting regreening activities among households. A survey, similar to the uptake surveys that were done to monitor programme implementation, was carried out to estimate uptake in the leverage sites in Mali.

Table 6: *Leverage targets for each country, as well as the extent these were achieved*

Country	Indirectly facilitated country targets - HHs	# of HHs reached and taken up	Target achieved (%)	Country Target - Hectarage	Actual targets reached to date	Target achieved (%)
Mali	30,000	3,339	11%	60,000	25,913	43.2%
Rwanda	49,000	5,392	11%	79,000	613	0.8%
Total	**79,000**	**8,731**	**11%**	**139,000**	**26,526**	**19%**

10 Policy and practice influence

Each country team identified policy or institutional challenges they wanted to address at the national, sub-national or local level through the programme. Engagement activities targeted a change in behaviour or actions of individuals in institutions. Outcome mapping[39] was used to track changes and are presented in Table 7. Outcome mapping acknowledges that the actions of any programme contribute to but are not solely responsible for behavioural shifts. Shifts in policy, awareness, and institutional arrangements were seen over the programme period.

Table 7: Policy influences targeted by country, actions and change recorded

COUNTRY	POLICY OR INSTITUTIONAL SHIFT TARGETED	ACTIONS	CHANGE
Ethiopia	Woreda officials, experts and District Assemblies (DAs) actively support programme implementation.	Joint visits to the field, workshops, training, regular meetings, and sustainability planning.	Integration of FMNR in the district government annual plan, user groups in exclosures are allowed to practise FMNR and utilise the resource from pruning, thinning, and cut and carry grass.
Ghana	District and community by-laws against land degradation enacted.	Dialogue with the district assembly and departments, drafting of bylaws or review of existing.	Environmental committees have been formed in the Bawku West District and the Management Plans for their operation established as well as committees in Mion District that are operational.
	Coordination and planning for the northern regions.	Workshops, dialogue, advocacy with stakeholders, review of evidence.	Northern Restoration Initiative developed as a multi-stakeholder approach to the northern regions with a shared vision.

39. Earl, S., Carden, F., Smutylo, T. 2001. Outcome Mapping: Building Learning and Reflection into Development Programs. International Development Research Centre, Ottawa, Canada.

COUNTRY	POLICY OR INSTITUTIONAL SHIFT TARGETED	ACTIONS	CHANGE
Kenya	Regreening included in government strategies and policy documents for increased tree cover and enhanced funding for implementation.	Input to Forest and Landscape restoration Implementation plan, agroforestry strategy, and county policies.	Draft restoration plan and agroforestry strategy awaiting launch.
	Enhance coordination of restoration stakeholders in the country.	Kenya Landscape Restoration Scaling movement supported through action groups and conferences.	Seven action groups representing around 100 organisations formed and at least two continuing. Two conferences were held.
Mali	Women having access to land.	Advocacy conducted with traditional authorities, customary land right holders and elected officials, in charge of land right formalisation.	Twenty women groups operating in non-timber agroforest product processing, obtaining land ownership certificates, over 60 hectares of agroforestry parks of shea, néré, cashew, and moringa.
Niger	Enhanced land and tree tenure through the FMNR decree.	Field visits, dialogue and decree preparation followed by decree translation and distribution.	Presidential decree on FMNR giving greater tree use rights to land managers and more awareness of the decree through local language.
Rwanda	Agroforestry task force established.	Discussion with government and stakeholders and meetings to identify scope and role of the task force.	Task force established and members appointed.
Senegal	Communes /municipalities to join the association of green communes to support FMNR.	Sharing of training materials and sensitisation caravans as well as dialogue with communes led by the mayor leading the green communes.	Three new communes joined and others showed interest to join.
	Grazing areas for transhumant cattle herders in communes established in collaboration with the community.	Discussions with key stakeholders, particularly traditional, religious, and local elected authorities to understand their opinions regarding pastoralism management in the area, and the solutions. A formal multi-stakeholder platform was formed and committees established to receive and orient pastoralists and resolve conflict.	Seven committees for the orientation and installation of pastoralists entering the area of Touba Mbella.
Somalia - Puntland	Government ministries include FMNR and enabling conditions in state policy and strategy documents.	Consultative meeting held for line ministries and relevant stakeholders to mainstream FMNR into existing policies.	FMNR incorporated into the policy document.
Somalia - Somaliland	Government incorporates FMNR into their strategic, development and budget plans and resource FMNR and agroforestry work.	Series of consultative meetings with the Ministry of Environment took place to discuss how to mainstream FMNR in the ministry strategy and national policies.	The Minister of Environment and the Director General of the Ministry of Environment mainstreamed FMNR in their strategic plan.

11 Conclusion

The Regreening Africa programme was designed with the ambitious goal of improving smallholder livelihoods, food security, and resilience to climate change in Africa and restore ecosystem services through tree incorporation into different land use areas at household and communal levels. The programme aimed to directly reverse land degradation on one million hectares of agricultural land in eight Sub-Saharan African countries, benefitting 500,000 households, and also influence other organisations and programmes across the continent to increase trees on different landscapes.

To evaluate the programme's impact, data were collected from participating countries in 2018, prior to programme implementation, and near the end of the programme in 2022. This report examines changes that occurred in the programme's direct implementation sites between baseline and endline. Due to non-adherence to the initially designed implementation plan, the impact assessment strategy and analysis methods had to be modified. First difference analysis was used to assess whether changes in the uptake of practices or other intermediary outcomes were associated with changes in downstream outcomes and impacts. Despite this, it was not possible to fully demonstrate a causal link attributing changes in indicators to the Regreening Africa programme.

Over the four-year period measured by the survey, various gains were recorded in the number of households exposed to regreening activities, the number of households scaling up regreening practices after exposure, and the hectares under regreening.

Progress according to the simplified Theory of Change (ToC)

The programme's Theory of Change initially assumed that farming households and community groups would be provided with contextually appropriate regreening support.

- The overall reach, **where regreening support was acknowledged, increased from 14 percent at baseline to 50 percent in direct intervention sites**. Exposure was mainly provided by NGOs and government affiliated personnel in all countries.

Next in the ToC, it was expected that households and communities reached with regreening support would scale up both ecologically and socioeconomically impactful regreening action, leading to a more optimal integration of trees into farming systems and wider landscapes.

- Over 152,000 households were exposed and scaled up regreening practices, **representing 65 percent of the direct intensification adoption target**. Our analysis further estimates that regreening practices were scaled up on over 189,000 hectares, **representing 47 percent of the direct hectarage target**.

The programme also aimed to achieve its ambitious targets through leveraging on other projects and initiatives, but the varied approaches used across the countries made it challenging to estimate the number of households that upscaled regreening practices in a uniform way. A household survey in Rwanda and Mali revealed **an additional 8,700 households were exposed and practising regreening**, and **over 26,500 hectares were under regreening** in the leverage sites.

- Most notably, households engaged in tree care, management, and tree establishment, either through planting or FMNR, across various land use areas. There was a **near doubling of the overall average numbers of newly established trees, rising from 67 to 129 trees**.
- Households also embraced regreening on different niches, including communal lands, especially in Sahelian countries. **There was a significant increase in average tree density, with the overall average across the programme countries increasing from 43 trees per hectare to 120 trees per hectare** over the programme period.
- While the number of tree species per household was also scaled up, **in Eastern Africa, there was an increase in the number of exotic trees compared to native trees**. This was particularly visible in Rwanda, and future efforts should be made towards increasing uptake of native tree species in that country. In contrast, **households in West Africa showed a greater inclination towards upscaling indigenous tree species**.
- There was also **significant improvement in our Regreening Action Index (RAI)** across all countries.

The engagement of stakeholders and policy makers, as envisaged in the ToC, was instrumental in driving reach and adoption. A key component of Regreening Africa was the active involvement of policy makers in each country to create an enabling policy environment that fostered regreening efforts at different levels. Each country identified policy or institutional challenges that the programme could address.

- In each of the eight countries, local, sub-national or national **institutional or policy engagement took place** in addition to wider stakeholder engagement and was tracked with outcome mapping.
- **Key achievements were observed across all countries.** The programme's collaborative approach succeeded in forming environmental committees in Ghana, integrating FMNR into district development plans in Ethiopia, devising restoration plans and agroforestry strategies in Kenya, and securing land access for women in Mali. Niger experienced a pivotal milestone with a presidential decree granting greater tree user rights to communities. In Rwanda, an agroforestry task force was established, and in Senegal, different communes joined the association of green communes to support FMNR and grazing areas for transhumant cattle herders were established. In Somalia, FMNR was mainstreamed into state government policy documents.

Achieving more optimal tree integration to improve soil and land health, and other ecosystems including vegetation and tree cover was a central focus of the ToC.

- **Fractional vegetation cover showed limited change in seven countries**, it improved in Kenya and Rwanda while declining in Senegal. However, this measure does not account for the effects of natural variations such as rainfall.
- The introduction of **a greening score**, an alternative indicator accounting for such natural dynamics, was used to assess changes in vegetation cover. **Overall, greening was detected in about 70 percent of the sample plots in Ethiopia, 49 percent in Ghana, 38 percent in both Rwanda and Kenya, and 26 and 28 percent in the Sahel**.
- The utilisation of the LDSF database and remote sensing data enabled us to predict and **map tree cover for sampled household fields. Results demonstrated an increase in the number of plots with over 50 percent tree cover in all programme countries except Senegal**. Interestingly, the changes and variation predicted in tree cover across the programme sites aligned well with the change observed in the RAI.
- **SOC increased marginally by 0.31 g of carbon/kg of soil and was generally lower in the Sahel compared to East African countries**, primarily due to landscape and management differences. These results are expected, given that SOC requires time to accumulate, and significant changes may not be attainable within the programme period.
- While **no substantial changes in soil erosion were observed across the programme overall**, there was variation across and within countries. Countries such as Rwanda and Kenya, with increased tree cover, exhibited lower soil erosion prevalence, underscoring the vital role of trees and other measures in promoting permanent land cover and erosion control.
- The **positive and statistically significant associations** found between changes in **the number of trees upscaled on-farm and SOC**, as well as between changes in vegetation-related indicators (greening score and tree cover) and changes in soil organic carbon, are noteworthy. Conversely, **a negative and statistically significant association between changes in erosion prevalence and changes in tree cover and the greening score was observed**, with variations across programme countries.

We assumed in the ToC that optimal tree integration, improved land health and vegetation combined with tree-based value chains and strengthening, and stakeholder policy engagement would result in increased productivity and farm income.

- Overall and across individual countries, the consumption of tree products was higher at endline compared to baseline, with **more households reporting the use of at least one tree product**.
- The **utilisation of fuelwood increased significantly**, with 60 percent of households across countries consuming it at endline. Additionally, more households accessed fuelwood on their farms, and more reported a reduction in time taken to collect fuelwood.
- Access to and use of tree products at household level increased. **Harvesting and consumption of fruits, nuts and seeds, fodder, timber and poles, and medicinal herbs by households saw an upward trajectory between baseline and endline.**
- The **sale of tree-related products remained low** at the endline, possibly due to trees not reaching maturity to yield marketable products by the programme's conclusion. However, **the percentage of respondents selling tree products considerably increased compared to the baseline**.
- The **overall average income per household** earned from selling tree products remained relatively constant at around 82 in PPP USD throughout the programme period.

Sustainably increased productivity and farm income was to improve household food security, overall income and resilience in the ToC. Our hypothesis is that improved access to a wide range of edible tree products and the additional income derived from trees, thereby improving purchasing power and access, would lead to an enhancement in households' dietary diversity.

- We assessed whether households that up-scaled their use of tree products and earned some income from trees also experienced improvements in food security and the accumulation of wealth.
- Overall, **household dietary diversity**, as measured by the MDD-W indicator, showed a slight increase over the programme period. The percentage of respondents who reported consuming at least five out of the ten food items **increased from 16 to 21 percent**.
- Self-reported **food insecurity experience**, measured with the FIES score, **showed minimal change**, both overall and across countries.
- The results of the first difference estimation revealed **a positive and statistically significant association between changes in use of food-related tree products and income from trees, and the subsequent changes in household dietary diversity score**.
- **We did not detect any discernible association between changes in the FIES score and changes in the use of food-related tree products and income**.
- A **positive and statistically significant association between asset gain and changes in tree product use and income from trees, as well as changes in the overall regreening action index**. This finding indicates households that intensified their regreening practices both on-farm and at the community level are more likely to experience improvements in dietary diversity and accumulate assets.

In summary, our Theory of Change and associated assumptions have been largely validated, although notable variations emerged across different countries and sites. Initial findings indicated that only around half of the targeted households acknowledged support, indicating that our scaling models were not saturating the target area as originally planned. Over the span of four years, more than 65 percent of the direct intervention target was achieved in terms of households adopting regreening practices, showcasing a positive outcome when compared to other projects and considering the time frame. However, a lower percentage of the hectare target was achieved, suggesting that our projections did not adequately align with the rate of uptake and the land available for households to regreen. Within East Africa, the limited diversity of tree species revealed a preference for exotic species, raising concerns regarding biodiversity preservation. Vegetation and land health indicators demonstrate a slow but overall positive trajectory. Significant variation highlights the need for differentiated targets by landscape.

The Sahel region showed a slower response in terms of land health indicators, with some indicators such as erosion not shifting significantly in any country. While average income derived from selling tree products did not change, increased collection, utilisation, and sale of these products signals a positive shift. However, the extent to which this regreening effort will significantly impact future incomes remains uncertain. Household dietary diversity and assets shifted in a small but positive direction, whereas food security did not change. Further evaluation over the next five years, revisiting these indicators, will provide insight into whether additional time is necessary for more pronounced shifts in certain indicators and to monitor if progress sustains. Future monitoring will need to ensure the phase-in design approach is followed during implementation to enable the use of more appropriate impact evaluation methods that enable us to identify the causal links.

Annex 1
Logframe matrix (Regreening Africa)

Table 8: *Logframe matrix*

	RESULTS CHAIN	INDICATORS	BASELINES	TARGETS	SOURCES AND MEANS OF VERIFICATION	ASSUMPTIONS
Overall objective: Impact	*Improve livelihoods, food security and resilience to climate change by smallholder farmers in Africa and restore ecosystem services particularly through evergreen agriculture.*	**II 1.** Projected changes in total farm income	Balanced	10% average increase over comparison households	• Farm system financial modelling based on analysis of baseline and endline survey data. • Remote sensing estimates derived from field geo coordinates of sampled HHs, based on established LDSF field data	While full financial returns of regreening will not fully manifest by end of the project, they can be credibly estimated with appropriate modelling.
		II 2. Soil erosion prevalence	Balanced	5% decrease over comparison fields		
		II 3. % of tree cover within & along the boundaries of farmer fields (changed to fractional vegetative cover)	Small difference (0.7%; p<0.05)	10% increase over fields in non-scaling comparison sites		
Specific Objectives: Outcomes[40]	*Equip 8 countries with surveillance and analytic tools on land degradation dynamics, including the social and economic dimensions, to support strategic decision-making and monitoring for the scaling-up of evergreen agriculture.*	**SOI 2.1.** # of country intervention areas where tools to monitor changes in land degradation are developed in coordination with LDN country focal people, piloted, used by country teams, and promoted for further upscaling	0	8 country intervention areas	• Country progress reports • Semi-annual and annual consolidated reports prepared by ICRAF.	Political environments in participating countries is sufficiently stable and secure, and country-level partners and stakeholders fully support and participate in the piloting processes.

40. Objective 1 applies specifically to the work of the Economics of Land Degradation (ELD). Its work contributes to the project's overarching Theory of Change, but is under a separate, albeit complementary, contract with the European Commission

	RESULTS CHAIN	INDICATORS	BASELINES	TARGETS	SOURCES AND MEANS OF VERIFICATION	ASSUMPTIONS
Specific Objectives: Outcomes Continued	*Support 8 countries in the accelerated scaling-up of evergreen agriculture by smallholder farmers, along with the development of agroforestry value chains.*	**SOI 3.1.** # of households up taking new regreening practices	0	500,000 households (281,650 direct; 218,350 leveraged[41])	• HH baseline and endline surveys, as well as annual uptake surveys and Outcome Mapping • Country progress reports • Semi-annual and annual consolidated reports prepared by ICRAF.	High level of motivation among farming households to engage in evergeening.
		SOI 3.2. # of hectares where new regreening practices are being applied	0	1,000,000 hectares (527,083 direct; 472,917 leveraged)		Existence and motivation of value chain actors to engage.
		SOI 3.3. # of country implementation areas with demonstrably strengthened agroforestry value chains	0	6 country intervention areas		Political and security situations of participating countries sufficiently conducive.
Outputs	Viable & promising evergreening options identified for targeted scaling sites. **R2.2**	**OI 1.1**. # of country intervention areas with promising and inclusive regreening options participatorily identified and refined for scaling	0	8 country intervention areas	• Country activity reports and ICRAF quality assessments	High partner & community interest in prioritising evergreening options, with open questions to be answered through project M&E and learning.
	Project stakeholders equipped with new knowledge, skills, tools & resources to effectively promote prioritized regreening options. **R3.2**	**OI 2.1.** # of stakeholders appropriately equipped with relevant regreening knowledge, skills and tools	0	320 external stakeholders (40 per country). *Examples include* lead farmers, local leaders, government extension agents and officials, and local organisaiton staff and volunteers.	• NGOs country activity reports • Annual project reports	Sub contracted CBOs, government departments and other collaborators possess the requisite 'base' capacity and interest necessary for the capacity development inputs to bear fruit.
	500,000 households supported with viable & inclusive regreening options. **R3.2**	**OI 3.1.** # of farmers supported (disaggregated by gender, age group, and type of support provided, e.g., training, extension, tree germplasm, etc.)	0	500,000 farmers disaggregated by gender and age group	• Country activity reports & uptake surveys	High community participation and interest in the project's various training, extension & capacity development activities.

41. The project has defined two types of adoption: (1) 'directly facilitated adoption' expected through the project's own community-level programming work; and (2) 'leveraged adoption'—an evidenced-based projection of such adoption that is expected (or known to have occurred) following the dissemination of evergreening approaches among non-project related initiatives and investments. 'Leveraged adoption' could be a result of a complementary project implemented by one of the iNGOs members of the consortium and embracing the same approaches as those promoted by this project. However, it could also be less direct, for example, another organisation or government institution pursuing the same scaling approaches as developed under the project. Note that if any of the project consortium partners are able to leverage and bring in additional resources to the project, the 'additional' adoption targets reached as a consequence would be counted under 'directly facilitated adoption.' The project has adopted the Outcome Mapping approach to track and evidence the extent the scaling approaches developed under the project have been taken up and successfully implemented. We will combine this evidence with the evergreening adoption rates associated with the project's direct scaling work to estimate its leveraged adoption achievements. Where possible, this will be triangulated by relevant M&E data generated by these leveraged initiatives.

	RESULTS CHAIN	INDICATORS	BASELINES	TARGETS	SOURCES AND MEANS OF VERIFICATION	ASSUMPTIONS
Output Continued	Targeted agroforestry value chains assessed and provided with relevant regreening support. **R3.3**	**OI 4.1.** # of value chains identified and assessed per country	0	2 value chains per country	• Country activity reports	Market conditions for the identified value chains remain the same throughout the project.
		OI4.2. # of targeted value chain actors (e.g., traders, processers, and farmer associations) reached by interventions to strengthen targeted value chains	0	At least 3 types of actors supported per country		Risks associated with value chains investment/ participation will be minimal or well-managed.
	Implementation and uptake monitoring data for adaptive management **R3.2**	**OI 5.1.** # of Joint Quality Monitoring missions per country per year	0	2	• Country activity reports • Uptake survey reports	Partners & ICRAF staff will have the time, capacity and resources to carry out the field monitoring and rapid uptake surveys.
		OI 5.2. # of rounds of uptake surveys over life of the project per country	0	3		Security issues do not prevent the carrying out of these surveys.
	New evidence on the effectiveness of regreening is generated to inform wider policy and practice. **R 3.1**	**OI 6.1.** # of countries where policy or regulatory gaps for evergreen agriculture are assessed, identified and communicated	0	8	• Consolidated report on policy gaps	Sourcing of appropriate enumerators in each country will be possible, as well as capturing of biophysical data, given budgetary resources available
		OI 6.2. # of learning events in which cost-effective ways to promote regreening have been disseminated	0	4	• Scaling option comparison reports	
		OI 6.3. # of country-level project impact policy briefs developed and disseminated	0	6	• Impact assessment reports	Security issues do not prevent the carrying out of impact assessments.
	Land degradation dynamics, dimensions in all countries assessed. **R2.1**	**OI 7.1.** # of land health baseline datasets compiled, including LDN indicators	0	8 (at least one per targeted country)	• Databases of land degradation indicators developed.	Data, including remote sensing and local project data, are accessible and suitably meta-tagged.
		OI 7.2. # of intervention areas where land degradation dynamics have been assessed in coordination with in-country LDN assessments	0	8	• Maps of land degradation hotspots and dynamics/ changes	

	RESULTS CHAIN	INDICATORS	BASELINES	TARGETS	SOURCES AND MEANS OF VERIFICATION	ASSUMPTIONS
Output Continued	Countries equipped with surveillance and analytic tools (i.e. dashboards) **R2.1**	**OI 8.1.** # of dashboards co-designed and available	0	4	• Dashboard beta versions online	Data, including remote sensing and local project data, are accessible and suitably meta-tagged.
		OI8.2. # of stakeholders engaged and using dashboards and other tools	0	60	• Online monitoring of dashboard access/use via google analytics	All stakeholders are willing to participate in innovative modes of land use planning.
	Regreening successes are compiled and communicated to policy makers, government and project stakeholders. **R2.3; R 3.1**	**OI 9.1.** # of structured evidence sharing events	0	8	• Workshop reports	Suitable evidence exists or can be created on existing re-greening successes and, if so, policy makers and other actors with find such evidence credible and relevant.
		OI 9.2. % of targeted policy makers and other actors reached by re-greening success messages	0	80%	• Country and overall progress reports	
		OI 9.3. # of media pieces disseminated/ generated on regreening successes (i.e., via online videos, media coverage)	0	80 online or offline media pieces	• Online video viewing data	

II=Impact Indicator; SOI=Strategic Objective Indicator; OI=Output Indicator

Annex 2
Asset measures used for constructing asset gain index

We constructed the asset measures for each country via PCA and what is dubbed the 'arbitrary' or 'naïve' approach[42]. The latter involves simply adding the asset binary measures together without differentially weighting them. We implemented the latter as a robustness check.

To construct the PCA measures, we first took the binary asset for the baseline and endline periods for each country and assessed their inter-item correlation and removed those negatively correlated with the other assets. The resulting inter-item correlation (alpha) for each country was quite high for the baseline 2018 and endline 2022 binary asset measures. We then constructed tetrachoric matrices with them, and principal component factor analysis (PCA) was then run on these matrixes. Variables based on the first principal component were subsequently constructed. We did this for each period for the overall dataset using a set of 100 asset measures, which includes livestock ownership, farm asset, other non-farm assets and house characteristics (Table 9)

Table 9: *Comprehensive list of assets and other wealth indicators used to construct asset gain indices*

LIVESTOCK	FARM ASSET	NON-FARM ASSET	HOUSE CHARACTERISTICS
1. Cow 2. Improved cow 3. 3+ Cow 4. Cow for commercial milk 5. Bull 6. 2+ Bull 7. Goat 8. 4+ Goat 9. Improved goat Sheep 10. 4+ Sheep 11. Poultry 12. 6+ Poultry 13. Donkey 14. Horse 15. Camel 16. Pig 17. Rodent	1. Bullock plough 2. Tractor 3. Ox/horse/donkey cart 4. Sickle 5. Shovel/spade 6. Axe 7. Pickaxe 8. Rake 9. Watering can 10. Milking can 11. Wellington boots 12. Modern beehives 13. Wheelbarrow 14. Manual water pump 15. Motorised water pump 16. Carpentry tools 17. Knapsack sprayer 18. Milling machine 19. Private Pond or dam 20. Zero grazing unit (cattle shade) 21. Modern poultry house 22. Livestock/ poultry feed mixer 23. Feeding & watering trough 24. Granary/maize crib	1. Electricity (grid) 2. Electricity through Solar 3. Protected shallow well or spring (private) 4. Sofa/couch 5. Dining table. 6. Coffee table 7. Bed 8. Mattress 9. Refrigerator 10. Charcoal stove 11. Electric or gas stove 12. Fan 13. Charcoal iron 14. Electric iron 15. Wristwatch 15. Clock on the wall 16. Kerosene Lamp 17. Electric lamp 18. Torch 19. Mirror in the wall 20. Floor mat/rug 21. Sewing machine 22. One simple mobile phone 23. 1+ simple mobile phone 24. One or more smartphone 25. Radio 26. Tape or CD player 27. Television 28. Tv cabinet 29. Satellite dish 30. DVD player 31. Solar panel for house 32. Hot water flask 33. Cupboard 34. Suitcase 35. Suit 36. Formal traditional dress 37. Gold Jewellery 38. Generator 39. Bicycle 40. Motorcycle/tricycle 41. Car/truck 42. Small shop/grocery 43. Building for business 44. Coffee /tearoom 45. Water tank 46. Record keeping book 47. Active Bank account	1. External kitchen 2. 3+ rooms 3. Pit latrine with concrete slab 4. Cemented or tiled floor 5. cemented walls 6. Iron sheet or roof tiles 7. 1 + glass windows 8. Wooden front door 9. Fence around the compound 10. Gate to compound

Given that implementing PCA for each period separately would generate different time-specific sets of asset weights, we avoided simply differencing the two indices to obtain a differenced measure. Rather, we first identified whether there had been gains over the two periods for each asset indicator. Then we checked the inter-item correlation again for the resulting set, while iteratively removing negative values. We did this until we arrived at a low but still reasonable inter-item correlation coefficient (alpha) of 0.7343 for the overall dataset. After that, we constructed a tetrachoric matrix and ran PCA on it again, thereby creating an 'asset gain index'.

42. O'Donnell et al., 2008: Analyzing health equity using household survey data: A guide to techniques and their implementation. World Bank, Washington, DC (2008). Retrieved from https://openknowledge.worldbank.org/handle/10986/6896

Funded by European Union
CIFOR
World Agroforestry
World Vision
CRS CATHOLIC RELIEF SERVICES
care
Oxfam International
SAHEL ECO
ELD THE ECONOMICS OF LAND DEGRADATION