REGREENING AFRICA: CONSOLIDATED BASELINE SURVEY REPORT

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Regreening Africa

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CONTENTS

Forward 1

Acronyms and Abbreviations 2

Executive Summary 3

01 Introduction and Purpose 7

02 Impact Assessment Strategy and Methods 11

03 Agroforestry Training and Extension Support 14

04 Regreening Action 16

05 Trees on Farm and Homestead 26

06 Assessment of Land and Soil Health 30

07 Projected Baseline Farm Income 39

08 Food Security and Household Wealth Status 45

09 Tree-based Value Chains 51

10 Baseline Statuse of Policy and Institutions 55

ANNEX 01 Logframe matrix (Regreening Africa) 60

ANNEX 02 Generating tree and crop production estimates 63

FOREWORD

Reversing, or at least reducing, the challenges that threaten our life on this small planet has never been more important. Headlines in news media remind us of this every day, in addition to numerous scientific reports and journals. One of the biggest of these challenges is environmental degradation in all its manifold ways.

If we can find ways to successfully and sustainably reverse the effects of land degradation in Africa, we would be reducing the most important existential threat to people on the fastest growing continent in the world. Restoration makes eminent economic sense, as the Bonn Challenge has reminded us – the net benefits of restoring 350 million hectares by 2030 would exceed USD 170 billion. The challenge is to get this done in a way so as to satisfy multiple goals simultaneously because otherwise, as history shows us, early successes lead to failures as soon as funding spigots are turned off. And funds for restoration remain scarce.

Making the invested Euro stretch farther and with multiple benefits, while restoring – or 'regreening' – one million hectares of farm and pastureland across eight sub-Saharan African countries is the challenge set by the European Union to the Regreening Africa partnership. It's a partnership of organizations that approach development from three different perspectives – policy, implementation and research. This project is about catalyzing meaningful, transformative change by moving people to 'regreen' or restore their landscapes so that they benefit now and their children continue to reap benefits in the future. It's a unique attempt to use processes of structured learning, underpinned by scientific research, to inform an adaptive, iterative system of delivering better development outcomes.

In this project the research partner, World Agroforestry (ICRAF), also plays the lead role in programme implementation in partnership with five international non-governmental organizations (NGOs): World Vision, Oxfam, Care International, Catholic Relief Services, and Sahel Eco. The countries where this bold and innovative effort is taking place, thanks to the support of the governments concerned, are Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal, and Somalia.

The report presented here takes to heart the adage, 'you cannot manage what you cannot measure', because it stipulates the need to measure holistically so as to manage holistically. The result is unique, innovative, and informative: a rounded picture of how things stand at the starting point of the project, as can be expected from any baseline study. But it goes further, because it is also an expression of soaring ambition – to deliver on multiple, meaningful objectives simultaneously. In this it is unique.

The report draws on recent advances in geospatial and agroecological sciences, the world's best repository of knowledge on the keystone role of trees in agricultural systems, as well as fields such as behavioural economics and social sciences. From remote sensing, through smartphone-based apps, to 'boots-on-the-ground' truth-seeking, this report represents our best understanding of how to establish a launch pad for restoring landscapes by mobilizing people – 'moving' their social capital – into a regreening movement that works to better their livelihoods and restore their ecosystems. The report would be worth studying just for its articulate and precise explanation of regreening, and to see how far we have to go to restore these landscapes. But it offers much more: a glimpse of what could be a changed world for people in these landscapes when the project completes its work programme in 2022, and the bold vision of the European Union in establishing this project pays off.

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

ACRONYMS AND ABBREVIATIONS

AFR100	African Forest Landscape Restoration Initiative
BAU	Business As Usual
CBD	Convention on Biological Diversity
CBI	Centre for the Promotion of Imports from developing countries
CBO	Community Based Organization
CIFOR	Centre for International Forestry Research
ELD	Economics of Land Degradation
EO	Earth Observation
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FGD	Focus Group Discussion
FIES	Food Insecurity Experience Scale
FLR	Forest Landscape Restoration
FMNR	Farmer-Managed Natural Regeneration
GHG	Greenhouse Gas
HHs	Households
ICRAF	International Centre for Research in Agroforestry
II	Impact Indicator
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
LDN	Land Degradation Neutrality
LDSF	Land Degradation Surveillance Framework
MDD-W	Minimum Dietary Diversity-Women
MPI	Multidimensional Poverty Index
NDVI	Normalized Difference Vegetation Index
NFTP	Non-Timber Forest Products
NGO	Non-Governmental Organization
NIR	Near-infrared
NOCC	National Oversight and Coordination Committee
NPK	Nitrogen (N) Phosphorus (P) and Potassium (K)
NPV	Net Present Value
OI	Output Indicator
PCA	Principal Component Analysis
PPP	Purchasing Power Parity
SATVI	Soil Adjusted Total Vegetation Index
SDGs	Sustainable Development Goals
SHARED	Stakeholder Approach to Risk-informed and Evidence-based Decision-making
SOC	Soil Organic Carbon
SOI	Strategic Objective Indicator
SWIR	Shortwave Infrared
ToC	Theory of Change
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WEAI	Women's Empowerment in Agriculture Index

EXECUTIVE SUMMARY

Background

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. Restoring degraded lands is critical to regain lost ecological functionality that underpins life-sustaining ecosystem services, such as the provision of food, fresh water, and 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.

Regreening Africa (2017 to 2022) is part of a larger global and regional effort to reverse and halt land degradation, which is being implemented in eight African countries: Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal, and Somalia. It is funded by the European Union and implemented by World Agroforestry (ICRAF), in partnership with five international non-governmental organizations (NGOs): World Vision, Oxfam, Care International, Catholic Relief Services, and Sahel Eco. It seeks to (a) directly reverse land degradation among 500,000 households across one million hectares of agricultural land in the eight sub-Saharan African countries; and (b) catalyze a much larger scaling effort to restore tens of millions of hectares of degraded land across the continent.

Purpose

This report presents findings from Regreening Africa's baseline survey. The purpose for undertaking the baseline survey was threefold:

1. To generate baseline data required to later assess the programme's local-level socio-economic and biophysical impacts, as well as the extent of household and community-level engagement in land restoration.
2. To identify critical factors in the policy and institutional environment (including those relevant to targeted tree-based value chains) that need to be addressed to unlock the scaling-up of cost-effective and impactful land restoration practices.
3. To generate evidence to inform the design and scaling up of land restoration efforts.

Summary of methods

The baseline survey is a key element of Regreening Africa's impact assessment strategy, which aims to evidence the extent to which the project is likely to benefit the communities and households it is directly targeting. This strategy is informed by the phase-in impact evaluation design. Here, country implementing partners identified a pool of village clusters that they had not yet started working in and for which there was flexibility on when they would be engaged in project activities. These village clusters were then assigned (at random) for targeting in Year 1 and Year 4, and baseline data were collected from 9,377 randomly selected households residing within these clusters. Household surveys were administered to randomly selected male and female farmers to collect socio-economic data. In addition, their main cropping fields of these households were digitally mapped. The resulting geo-tagged field polygons were then overlaid onto the land health maps to generate field-specific indicators of land and soil health. Baseline assessments of vegetation cover, soil organic carbon (SOC), and soil erosion prevalence were produced across all surveyed farms. Maps of each indicator were produced using the global network of Land Degradation Surveillance Framework (LDSF) sites, coupled with Earth Observation (EO) data. LDSF surveys were conducted in Rwanda, Senegal, and Niger to complement ICRAF's GeoSpatial Lab's pre-existing datasets.

Given that many of the project's expected impacts – on smallholder income, for example, are unlikely to fully manifest within Regreening Africa's implementation window, efforts will be made to model what these impacts are likely to be several years after project closure. The baseline data collection effort was complemented by qualitative data of 192 gender disaggregated Focus Group Discussions (FGDs) with a total of 974 men and 975 women participants to prioritize tree-based value chains that the project will seek to strengthen. A key aim of Regreening Africa is to create an enabling economic and policy environment that will facilitate regreening and broader land restoration that benefits smallholder farmers. In addition, a country-level policy desk review, complemented by stakeholder network analysis and online surveys were conducted and the findings validated through national workshops. Finally, implementing partners were supported to identify relevant behavioural and structural barriers to land restoration in their respective contexts, as well as strategies to overcome them.

Key findings

The table summarizes Regreening Africa's baseline survey results, following the main steps of a simplified Theory of Change (ToC) for its direct community engagement work.

ToC step	Baseline survey highlights
Provision of contextually appropriate restoration support	• Farmer receipt of agroforestry-related training or extension in the 12-month period leading to baseline data collection was low at 15% overall (11% women and 18% men) but with statistically significant variation across countries. • The most popular types of support reported were related to tree planting (8.6% of households) and nursery establishment (7.5% of households).
Households and communities scale up both ecologically and socioeconomically impactful restoration activities	• Overall, 59% of households undertook at least one restoration activity 12 months prior to being surveyed, but again with statistically significant variation across the seven countries. Kenyan households exhibited the greatest breadth and depth of restoration, followed by Ethiopia. • The most popular action undertaken was pruning existing trees on farms (36% of households), a common practise under Farmer Managed Natural Regeneration (FMNR); followed by tree planting (20% of households). • While 34% of respondents across the seven countries reported awareness of community-level restoration activities in their local area, only 16% reported their households were involved. The exception is Ethiopia, where 50% of respondents reported such engagement.
More optimal integration of trees into farming systems and wider landscapes	• Across the seven countries, 94% of households reported the presence of at least one tree on their farm or homestead, with the bulk of trees for most households located in niches other than their main cropping field. • Overall, the estimated average number of trees per hectare was 150, but with a huge range both across and within the seven countries e.g. 195 trees per hectare on average in the East African countries with much smaller land holdings, and 12 trees per hectare on average for the Sahelian countries with much larger land holdings. • In general, households tended to have more native tree species on-farm (2.9 on average) compared with exotic species (1.79 on average). This trend is the case for all countries, except for Rwanda, where the average number of native tree species is only 0.44, against 2.2 for exotic species.

ToC step	Baseline survey highlights
Improved soil, land health and other ecosystem services	• Using the **Land Degradation Surveillance Framework (LDSF**) database, predictive models were applied to satellite imagery of the main cropping fields of sampled households to derive three key indicators of land health: fractional vegetation cover, soil organic carbon (SOC), and erosion prevalence. • **Fractional vegetation cover***, the percentage of land with green vegetative cover, was lowest in Niger and Mali (3% and 6% on average, respectively) and highest in Ethiopia and Kenya (54% and 63% on average, respectively). Given that the trees targeted for establishment will be young by the end of the project, this method of measuring changes in vegetative cover was deemed appropriate. • **SOC follows a similar trend:** it is very low for the Sahelian countries, and higher for those of East Africa, but with considerable variation within the latter. • Overall, **soil erosion prevalence*** – the weighted mean probability of severe erosion within each farmer field – was found to be high across all seven countries, but highest in Niger (most fields were > 75%), and with the highest variation in Kenya (with approximately 50% of fields both above and below 50% erosion prevalence).
Sustainable increases in productivity and farm income	• An agroecological economic model was used to generate farm cash flow projections over a 25-year period for each surveyed farm's baseline tree crop portfolio, representing the 'business as usual' situation. • The projections were analyzed both annually and over an initial 10-year period* on a per capita basis adjusted for purchase power parity (PPP). The 'without-project' projections are generally low but with considerable variation across countries and households. For example, average Year 1 projections ranged from €590 for Niger to €2,683 for Mali. • The 10-year projected returns for tree products was found to be highest for Rwanda at €4,140 on average, followed by Kenya (€1,385) and Mali (€1,234) at distance second and third places. Rwanda was the only country where tree products make up a significant share of projected farm returns. Therefore, there is significant room to bolster the economic contribution of trees in the farming systems that Regreening Africa is targeting.
Improvements in household food security, overall income and resilience	• Dietary diversity is low across the seven countries, with only 13% of male and female respondents on average estimated to have adequate micronutrient intake. However, this varied considerably, e.g. 2.2% for Niger compared with 31% for Senegal. • Reported food insecurity experience is also a cause for concern, but again, with significant variation across countries. Half of respondents in Kenya, Rwanda, and Niger indicated severe food insecurity experience, with fewer problems reported among both male and female respondents in Ethiopia, Mali, and Senegal. • As would be expected, fooad insecurity experience correlated negatively with household wealth status. Interestingly, the reverse is true for the breadth and depth of regreening action, which correlated positively with household wealth across all countries.

ToC step	Baseline survey highlights
Improved soil, land health and other ecosystem services	• Fuelwood, timber, fruits, and edible leaves were identified as top value chain priorities by men and women in the direct intervention sites, with variations across sites and countries. Common constraints affecting the development and successful farmer integration into the prioritized value chains include: poor market linkages and access, including involvement of private sector; mismatch between skills and needs; low access to quality germplasm; unsustainable exploitation and extraction of seeds which undermines natural regeneration of trees; access to finance; and low empowerment of women and youth.
Sustainable increases in productivity and farm income	• A desk review of relevant policy documents in all seven countries found that almost all countries explicitly reference agroforestry, with four having specific agroforestry policies or strategies at least in draft form. Key issues identified include no or sub-optimal policies pertaining to tree tenure and poor coordination among relevant government sectors. • Poor coordination among actors working on land restoration was further evidenced through social network analysis on information provided by stakeholders at national level workshops. Network density scores were found to be particularly low (0.1 to 0.2), demonstrating that while there are many organizations working on restoration (between 29 and 77 in each network), they are not well coordinated or connected. Poor access to quality, accessible and relevant evidence to inform decision-making was highlighted as an additional issue. • Implementing partners also identified a plurality of structural and behavioural barriers hindering successful land restoration at the local level, including: poor access to quality germplasm and water; poor infrastructure, low market access and economic incentives; poor policy and heavy handedness in law enforcement in tree protection by governments; land and tree tenure insecurity; women's disempowerment; and beliefs that trees will compete with crops and attract unwanted wildlife.

Photo: Dicko Mohammed, Oxfam Mali / Tree seedling protected against livestock invasion.

INTRODUCTION AND PURPOSE

Why land restoration?

The United Nations General Assembly declared 2021 to 2030 as the decade of 'ecosystem restoration', signalling a global consensus on the urgency of restoring degraded lands. Environmental degradation appeared for the first time among the top five global risks prioritized by world leaders under the Global Risk Report by the World Economic Forum in 2020.[1] This urgency is driven by multiple interrelated factors. First, land degradation is putting the health, livelihoods and wellbeing of an estimated 3.2 billion people on the planet at risk, while generating an estimated USD 490 billion per year in global losses.[2] Left unchecked, it will lead to a vicious cycle of forest, tree and biodiversity loss, poverty, hunger, unemployment, instability and conflict. Second, we are facing an unprecedented and accelerating rate of biodiversity loss and species extinction, which is threating the health and livelihoods of present and future generations.[3] Third, approximately 24% of greenhouse gas (GHG) emissions come from agriculture, forestry, and other land uses.[4] Deforestation, land degradation and unsustainable land use practices are therefore exacerbating climate change and its associated impacts.

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

Restoring degraded lands is critical to regain lost ecological functionality that underpins life-sustaining ecosystem services, such as the provision of food, fresh water and 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, as envisaged in the Paris Agreement,[5] the Aichi Biodiversity Targets,[6] and the Sustainable Development Goals (SDGs).

In Africa, land is the foundation for food and nutritional security, human well-being, economic growth and development in most countries. An estimated 83% of people in sub-Saharan Africa depend directly on land for their livelihoods. However, two-thirds of the land (approximately 700 million hectares) is already degraded to some degree.[7] According to the FAO Global Forest Resource Assessment, Africa is the only continent where deforestation and forest conversion to agricultural land is on the rise.[8] It is therefore the continent with the largest challenge of degradation, but also with high potential for restoration.

Regional and global commitments

There is considerable commitment globally to both halt and reverse land degradation. The Bonn Challenge, for instance, is a global effort to restore 150 million hectares of degraded land by 2020, and a further 200 million hectares by 2030.[9] The New York Declaration on Forests is seeking to halve deforestation by 2020, and to end it by 2030.[10] There are also several important regional initiatives, such as the African Forest Landscape Restoration Initiative (AFR100)[11] which aims to restore 100 million hectares by 2030, and a similar initiative in Latin America and the Caribbean, the 20X20,[12] targeting 20 million hectares. Under the United Nations Convention to Combat Desertification (UNCCD)[13] at least 122 countries have committed to ensuring that human activities aim for Land Degradation Neutrality (LDN), which includes the setting of specific LDN targets.[14] Finally, SDG target 15.3 aims to 'combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods'.

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[1] World Economic Forum. (2020) The Global Risks Report 2020. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf
[2] World Economic Forum. (2020) The Global Risks Report 2020. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf
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[4] UNFCCC. (2007) Impacts, Vulnerabilities and Adaptation in Developing Countries. https://unfccc.int/resource/docs/publications/impacts.pdf
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[6] CBD (2010). Strategic Plan for Biodiversity 2011–2020 and the Aichi Targets. https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf
[7] Economic Commission for Africa (2007), Africa Review Report on Drought and Desertification in Africa, http://www.un.org/esa/sustdev/csd/csd16/rim/eca_bg3.pdf
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[10] United Nations. (2014) New York Declaration on Forests: Declaration and Action Agenda. https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Forests/New%20York%20Declaration%20on%20Forests_DAA.pdf
[11] https://afr100.org/
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[13] https://www.unccd.int/convention/about-convention
[14] https://www.unccd.int/actions/achieving-land-degradation-neutrality
[15] https://www.unccd.int/actions/great-green-wall-initiative

Introducing Regreening Africa

Regreening Africa is part of this larger global and regional effort to halt and reverse land degradation. It is contributing to the achievement of the AFR100 targets, and catalyzes local and national actions in a way that complements similar efforts, such as the Great Green Wall Initiative.[15] Regreening Africa runs for five years (2017 to 2022), and is being implemented in eight African countries: Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal and Somalia. It is funded by the European Union and implemented by World Agroforestry (ICRAF), in partnership with five international NGOs: World Vision, Oxfam, Care International, Catholic Relief Services and Sahel Eco. **It seeks to:**

a. Directly reverse land degradation among 500,000 households across one million hectares of agricultural land in eight countries in sub-Saharan Africa; and

b. Catalyze a much larger scaling effort to restore tens of millions of hectares of degraded land across the continent.

Regreening Africa is one of the few multi-country, multi-stakeholder large-scale restoration projects being implemented prior to the onset of the abovementioned restoration decade. It therefore offers a unique opportunity to generate lessons for enhancing the cost-effectiveness of the restoration efforts that are to be intensified and scaled-up going forward.

Regreening Africa is part of a larger global and regional effort to reverse and halt through both direct community engagement and influencing policy and practice.

Regreening Africa's goal is to improve smallholder livelihoods, food security and resilience to climate change in Africa and restore ecosystem services. Its specific objectives are:

1. To strengthen national ability to assess the costs of land degradation and the economic benefits of investment in sustainable land management in eight African countries.

2. To equip eight 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 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.

Purpose of the baseline survey

This report presents highlights from Regreening Africa's baseline survey, focusing on the last two objectives above. Work associated with the first objective is being spearheaded by the Economics of Land Degradation (ELD) Initiative, and relevant findings can be accessed through the ELD website.

This report is a high-level synthesis of the detailed baseline studies undertaken in the seven of the eight implementing countries. Data on Somalia was collected much later and will be presented in a separate country report.

The purpose for undertaking the baseline survey was threefold:

1. To generate baseline data required to assess the programme's household-level socio-economic and biophysical impacts at a later stage, as well as the extent of household and community-level engagement in regreening.

2. To identify critical factors in the policy and institutional environment (including those relevant to targeted value chains) that need to be addressed to unlock the scaling-up of cost-effective and impactful land restoration practices.

3. To generate evidence and insights to inform the design of Regreening Africa's local-level interventions, including:

   i. Identifying practices and the potential for scaling up involving stakeholder engagement and addressing policy and practice barriers;

   ii. Strengthening of green value chains and developing integrated tools and methods for monitoring land restoration.

Report structure

This report begins by briefly describing Regreening Africa's impact assessment strategy and the associated data collection methods and processes. Its remaining sections are structured around a simplified version of Regreening Africa's Theory of Change for its direct intervention work (Figure 1).

Section 3 starts with data reviews on recent levels of exposure to agroforestry-related training and extension, thereby identifying key gaps to be addressed. Section 4 builds on this by presenting the extent to which targeted farming families undertook regreening action prior to project implementation, using an innovative 'Regreening Action Index' as a primary analytical tool. This also includes regreening efforts undertaken on communal land, and access to fuelwood. Section 5 describes the prevalence of tree species found on-farm.

The next half of the report focuses on indicators pertaining to both the ecological and socio-economic benefits expected from Regreening Africa's implementation. Section 6 focuses on the former, where baseline data derived through innovative remote sensing and field data collection techniques are presented on three key land health indicators: fractional vegetation cover, soil erosion prevalence and soil organic carbon (SOC). Given that trees take time to grow and, in turn, for their potential impacts to manifest, Section 7 presents the results of modelling work that will be used to project what Regreening Africa's impacts on farm income are likely to be several years following the project closure. The baseline status of these future-oriented indicators is presented, given that the project's value chain development component is working to shift them in a more

Photo: Joseph Bidiar / A farmer from Kawitiane village explaining the steps of FMNR during the projects' joint reflection and learning mission.

positive direction. Section 8 then presents the baseline status of high-level impact indicators focusing on dietary diversity, food insecurity experience and household asset wealth.

The final sections of the report, Section 9 and 10, document the baseline status of the tree-based value chains that Regreening Africa is targeting and relevant characteristics of the policy and institutional environments in the seven participating countries, respectively. A central premise in Regreening Africa's Theory of Change is that strategic action is required in both of these areas in order for farming families to scale up tree-based and other complementary land restoration practices dramatically, and with impact. Incentives need to be maximized and disincentives minimized, while opening opportunities and removing barriers.

The structure of this report follows a simplified version of Regreening Africa's Theory of Change.

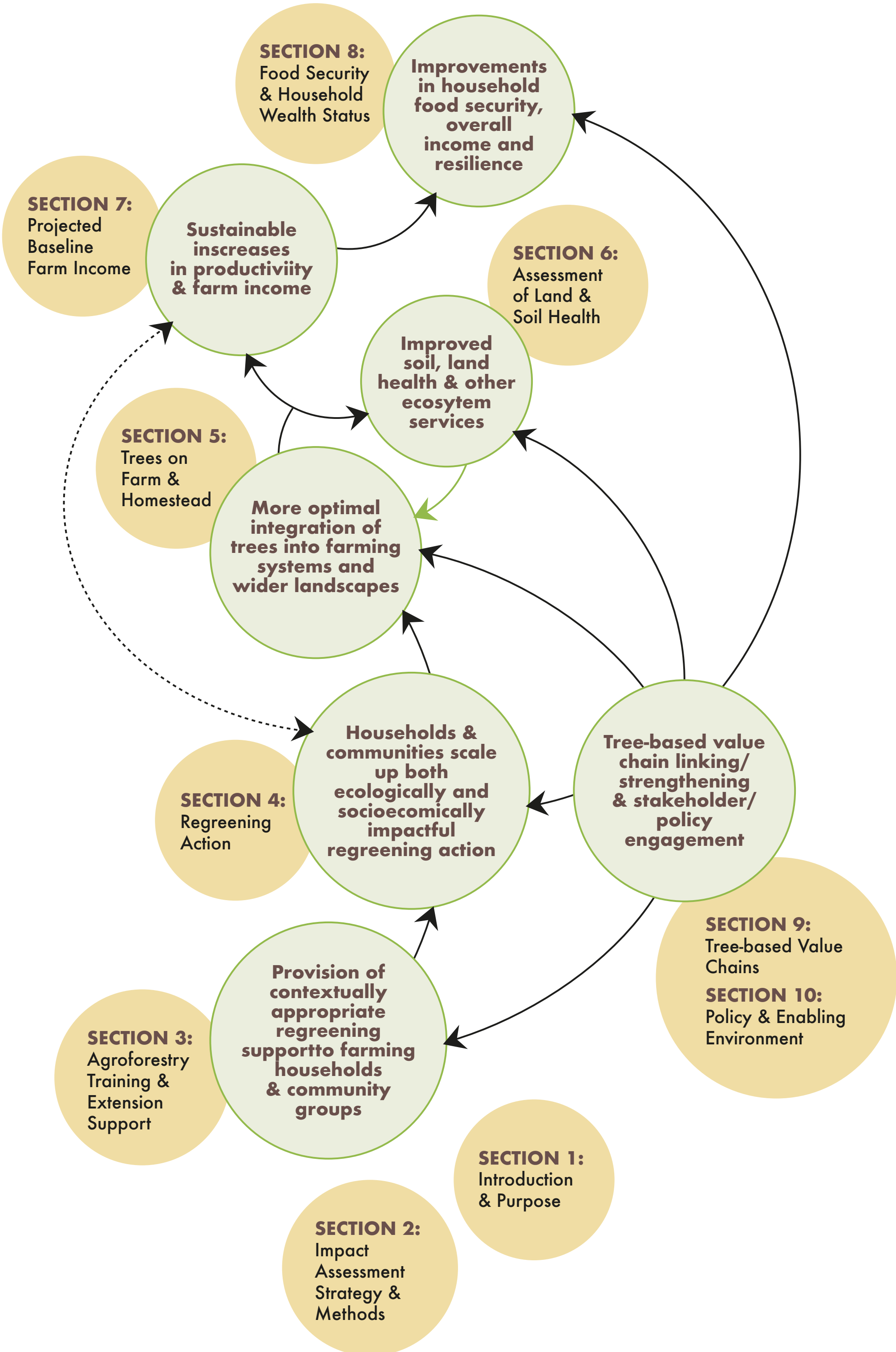
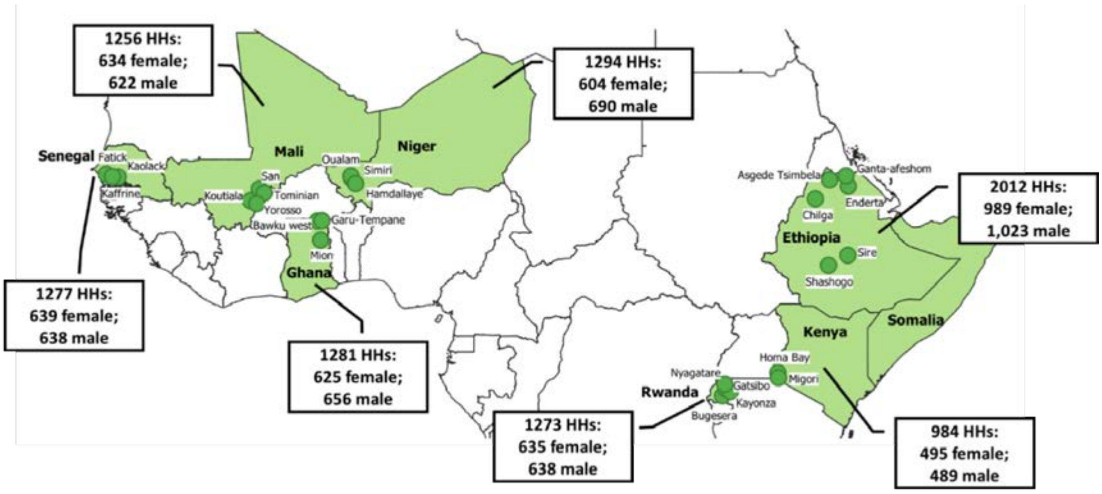


FIGURE 1: Simplified Theory of Change with baseline report sections

IMPACT ASSESSMENT STRATEGY AND METHODS

The key focus of Regreening Africa's impact assessment strategy is to evidence the extent to which it is likely to benefit the communities and households it is directly targeting. Tracking its influence on policy, wider practice, and investment decisions – another key component of the project – will be done primarily using the Outcome Mapping approach.

To capture data on the outcome and impact indicators associated with the project's direct implementation work, including those of the Logical Framework Matrix (Annex 1), baseline surveys were administered in its seven initial participating countries (Figure 2).[16] In addition to the administration of a household survey directed to randomly selected male and female farmers, the main cropping fields of these households were digitally mapped. The resulting geo-tagged field polygons were then overlaid onto the land health maps to generate field-specific indicators of land and soil health. Baseline assessments of vegetation cover, soil organic carbon (SOC), and soil erosion prevalence were produced across all surveyed farms. Maps of each indicator were produced using the global network of Land Degradation Surveillance Framework (LDSF) sites, coupled with Earth Observation (EO) data. LDSF surveys were conducted in Rwanda, Senegal and Niger to complement ICRAF's pre-existing datasets.



- Data collected on multiple socioeconomic and biophysical indicators from 9,377 households and farm fields across 7 countries and 25 districts and communes;
- 4,621 female and 4,756 male farmers interviewed

FIGURE 2: Locations of Regreening Africa's baseline survey

In general, assessing impact involves more than tracking changes in the status of a project's impact indicators over time. This is because there are likely to be other non-project-related factors, e.g. seasonal rainfall patterns, government policies, or other development projects, that will simultaneously influence their evolution. To assess the impact of interventions that target large numbers of communities, groups, households, and/or individuals, it is good practice to use a suitable control or non-intervention group.

Regreening Africa is part of a larger global and regional effort to reverse and halt through both direct community engagement and influencing policy and practice.

Consequently, and given that it would be challenging for Regreening Africa to directly implement project activities everywhere at the same time, we are following a phase-in impact evaluation design. Here, country implementing partners each identified a pool of village clusters that they had not yet started working in and for which there was some flexibility as to when they could be engaged in project activities. Baseline surveys were carried out in either all or a subset of these village clusters, and then each cluster was assigned (at random) for targeting in either Year 1 or Year 4 of project implementation. This approach was preferable, as opposed to having a pure control group, because it avoids the necessity of collecting data from households that would never be reached by Regreening Africa's direct interventions.

[16] Activities started in Somalia in 2019 and streamlined baseline surveys were undertaken.

The project's endline survey is planned to take place in the final year of the project, i.e. when the Year 4 village clusters have either not been engaged or where such work will have just started. While it is unlikely that the Year 4 clusters will have been completely uninfluenced by the project, the phase-in impact assessment design will involve comparing a set of communities, households and individual farmers exposed to the project's community-level interventions in a relatively intensive way for a period of three years with those that have not. If such interventions have been effective in moving the project's impact indicators in a significant way, we should see a difference.

However, many of the project's expected impacts – for example, on smallholder income or soil organic carbon – are unlikely to fully manifest within Regreening Africa's implementation window. Trees, for example, take time to grow. Regreening Africa's impact assessment strategy, therefore, also includes a component to model what these impacts are likely to be on farm income based on the extent of regreening that transpires at the household and community levels by the end of the project.

This report, however, does not focus on comparing households residing in the Year 1 and Year 4 village clusters, as would be typical for a technical baseline impact evaluation report. Rather, it is a synthesis of results from more detailed country-level baseline reports, highlighting what conditions were like prior to Regreening Africa's implementation vis-à-vis key components of its Theory of Change. Hence, the data from the Year 1 and Year 4 households were pooled together, and the results are primarily presented at the country level.

Regreening Africa's impact assessment strategy takes advantage of the fact that the implementation of community level activities cannot take place everywhere at the same time. Areas targeted in the first year will be compared with those targeted in the last.

In several countries, it was not desirable to subject some village clusters to the Year 1 and Year 4 random assignment exercise, because, for example, implementation had already started in these clusters. Moreover, in Ethiopia, it was only practically and financially possible to administer surveys in six out of the 14 woredas (districts) that are being targeted. In addition, in both this country and Niger, security challenges required the redirection of project activities from some geographic locations to others.

The results presented in this report, therefore, only pertain to the original village clusters assigned to the Year 1 and Year 4 groups. That said, sampling weights were used to adjust for differences in their respective population sizes, thereby ensuring statistical representativity. Bearing in mind these caveats, the results presented in the following sections depict the general situation at baseline in the seven initial countries participating in Regreening Africa.

Photo: Joseph Bidiar, World Vision Senegal / Staff from World Vision Senegal indulge farmers in discussions during the joint reflection and learning missions.

Photo: Brian Wambua, World Vision Kenya / A farmer demonstrating FMNR techniques on his farm in Kenya.

AGROFORESTRY TRAINING AND EXTENSION SUPPORT

The baseline survey ascertained the extent to which households, as well as female and male farmers, in Regreening Africa's direct intervention sites had already been exposed to interventions promoting agroforestry.

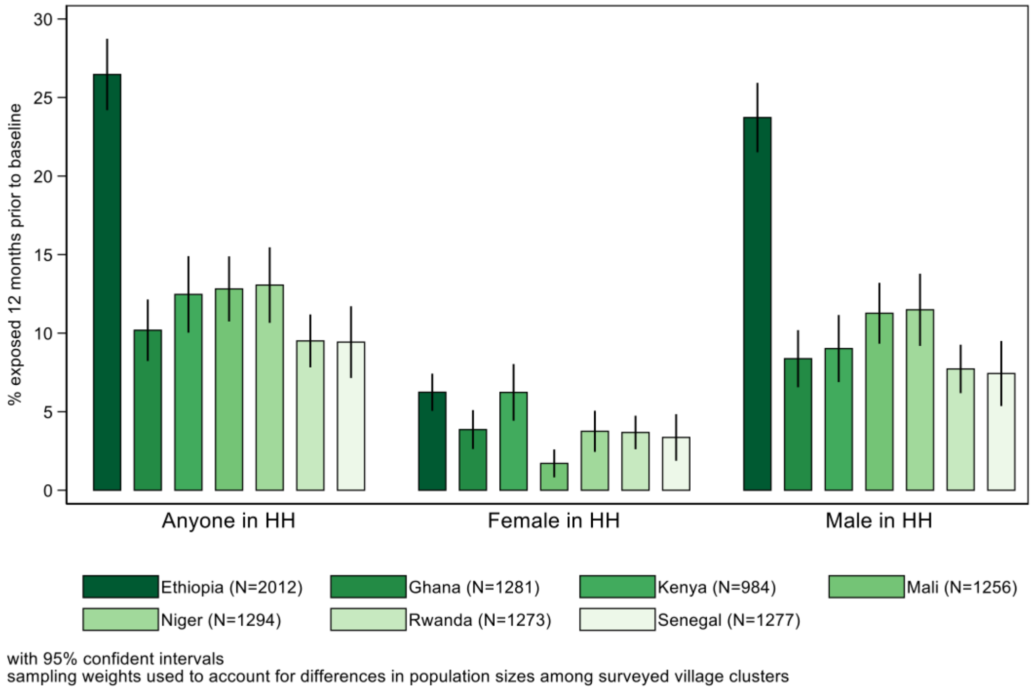


FIGURE 3: Receipt of agroforestry training or extension by country

While there is variation across countries, the levels were low, ranging from a high of 27% in Ethiopia to 9% in Rwanda and Senegal (Figure 3). Moreover, in all seven countries, men were much more likely to have been exposed to agroforestry-related training and extension.

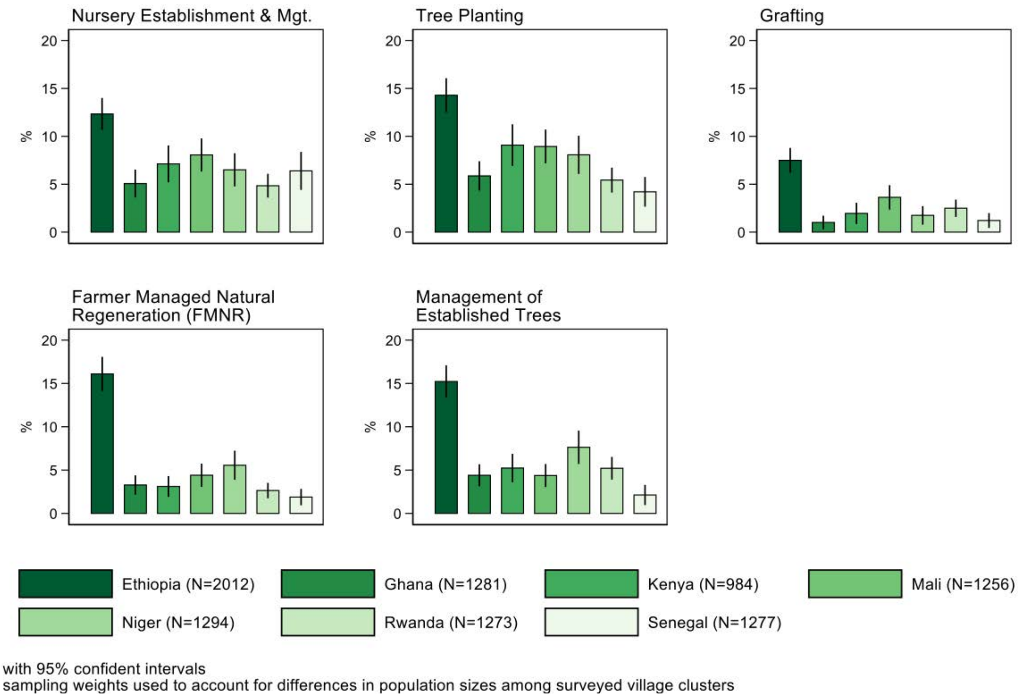


FIGURE 4: Percentage of HHs exposed to AF training/ extension by topic

Among those that were exposed to training and extension, tree planting and nursery establishment were the most commonly reported for most countries (Figure 4). Relatively few respondents reported that their households had been supported to undertake grafting.

Relatively households reported receipt of agroforestry training and extension services with a strong bias agains female farmers in all countries.

In Regreening Africa's early days, FMNR was the primary restoration method to be promoted, with 14% of households having had applied this innovative technique in the year preceding baseline data collection. While still key, the diversity of land restoration options has since expanded in consideration of the different biophysical conditions and in response to farmers' needs.

Farmer Managed Natural Regeneration (FMNR)

FMNR is a set of techniques for assisting the natural regeneration of trees and shrubs on farm and communal land relying on either already existing rootstock or seed stock. Where rootstock is the source of regeneration, stumps of desirable tree species with new shoots or stems are identified and managed using different methods. One method is through coppicing, which seeks to reduce competition for water and nutrients. Because the stump already has an established root system, coupled with reduced competition, growth rates (all else being equal) are generally significantly faster as compared with planted seeds or seedlings. Survival rates are usually higher too. The disadvantage is that tree species selection and spacing options are limited to what regenerating stumps happen to exist on the farm.

Photo: Abena Agyei-Boateng, World Vision Ghana / FMNR farmer David tending to his crops.

REGREENING ACTION

As implied by its name, Regreening Africa's mission is to restore Africa's degraded farmlands, as well as the wider landscapes of which they are a part. One key entry point is to promote the scaling up FMNR and tree planting, as well as the protection and management of already established trees and shrubs. The baseline survey, therefore, collected data on households' engagement in these practices, given that the aim of the project is to strengthen and broaden to a greater diversity of restoration practices. Figure 5 shows the percentages of households that undertook at least one regreening action 12 months prior to the baseline survey. Overall, most households did (59%).

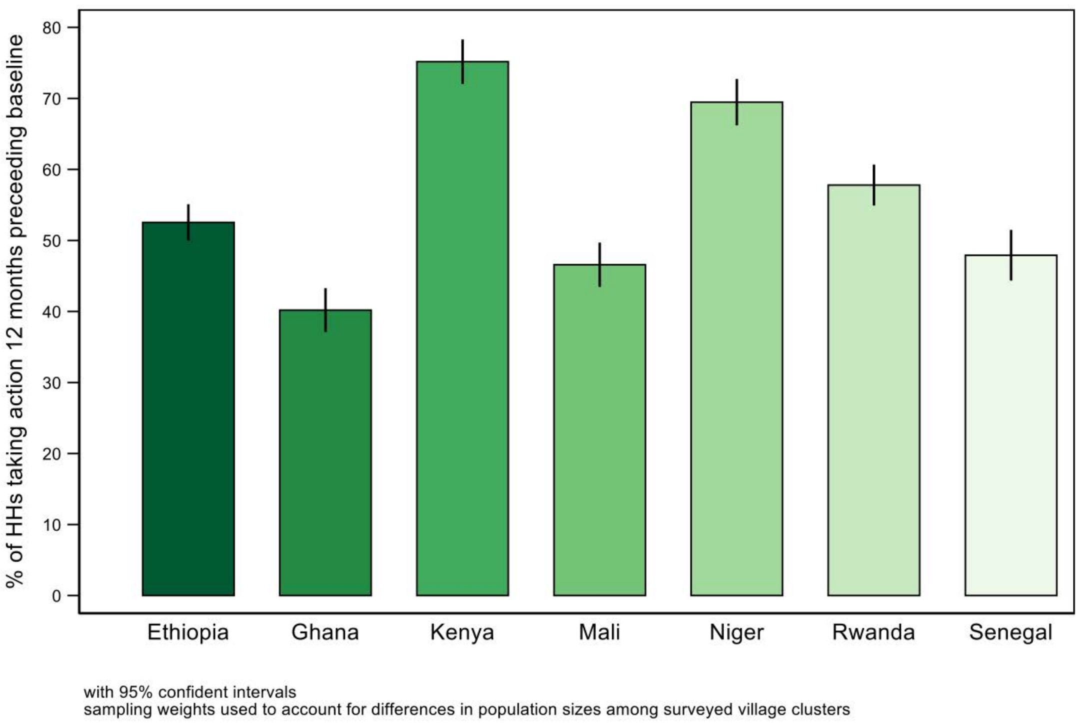


FIGURE 5: Percentage of HHs that undertook regreening action in previous year

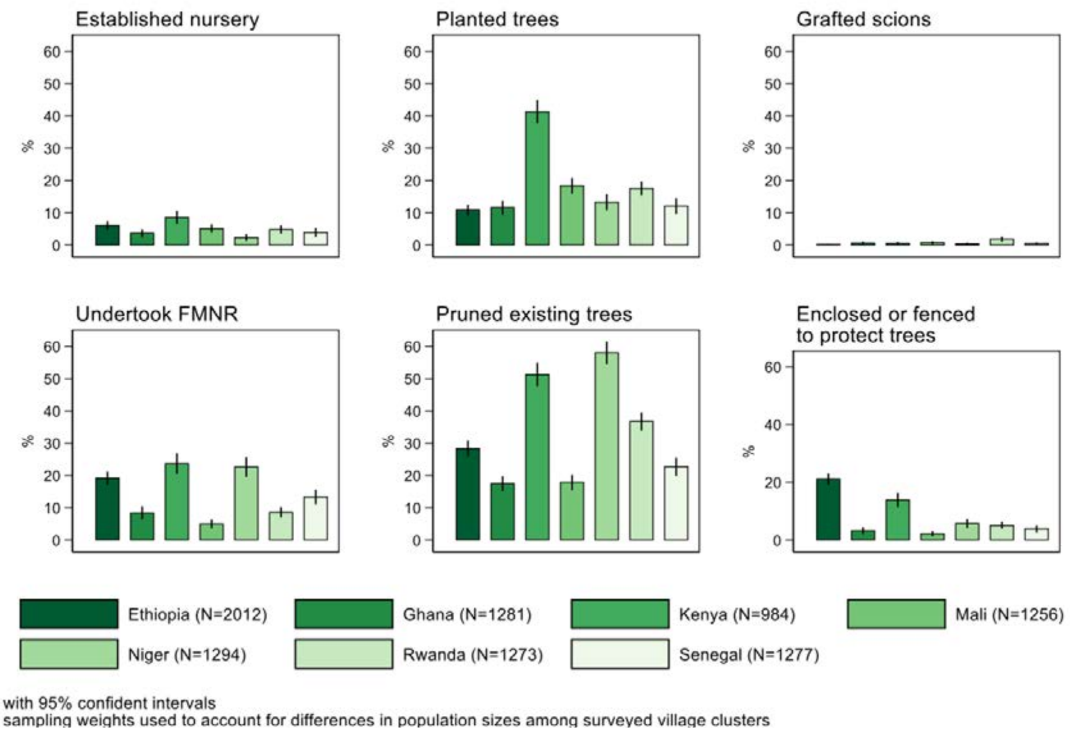


FIGURE 6: Percentage of HHs that undertook specific regreening actions

The specific regreening actions undertaken on-farm varied by country (Figure 6). Nevertheless, many households reported that they practised FMNR through selecting and pruning of trees and shrubs on their farms. While 40% of respondents in the Kenyan sites reported that they had planted trees, this was less than 20% for the other countries.

Participation in community-level land restoration

Most of the sites being directly targeted by Regreening Africa comprise considerable tracks of communal land. Supporting community-led efforts to restore such land is therefore a key project priority. Respondents in the baseline survey were asked whether they are aware of any of such initiatives and, if so, the extent of their respective household's participation and receipt of benefits (Figure 7).

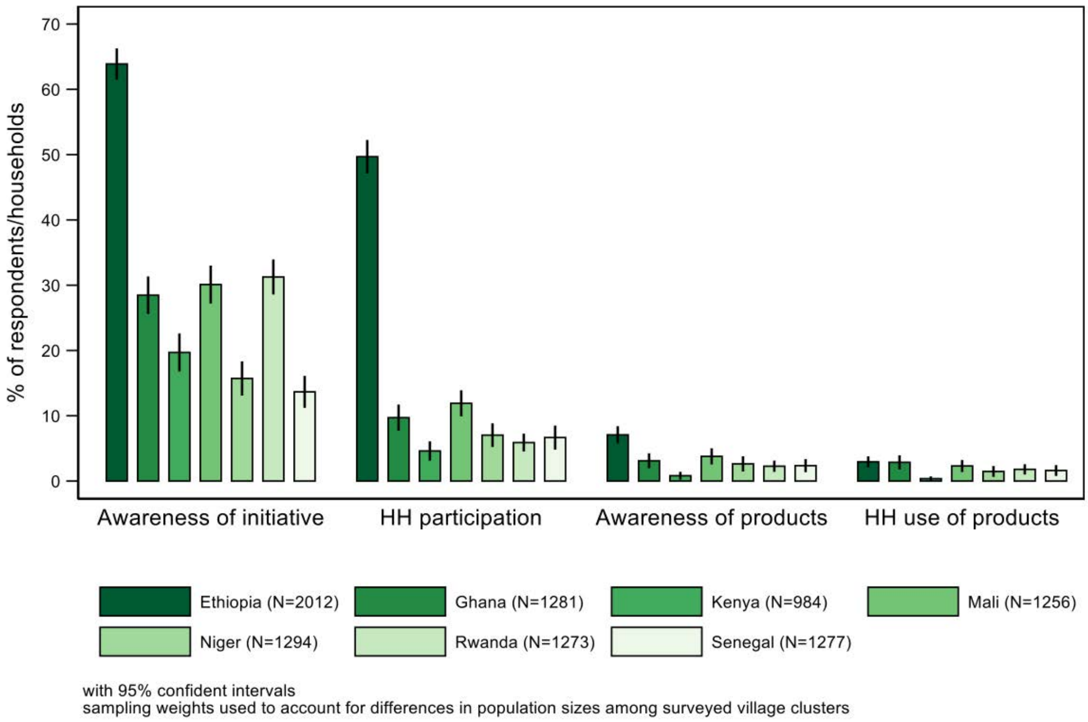


FIGURE 7: Community-level regreening participation and product

Photo: Felix Mulindagabo, World Vision Rwanda / Tree seedling sprouting.

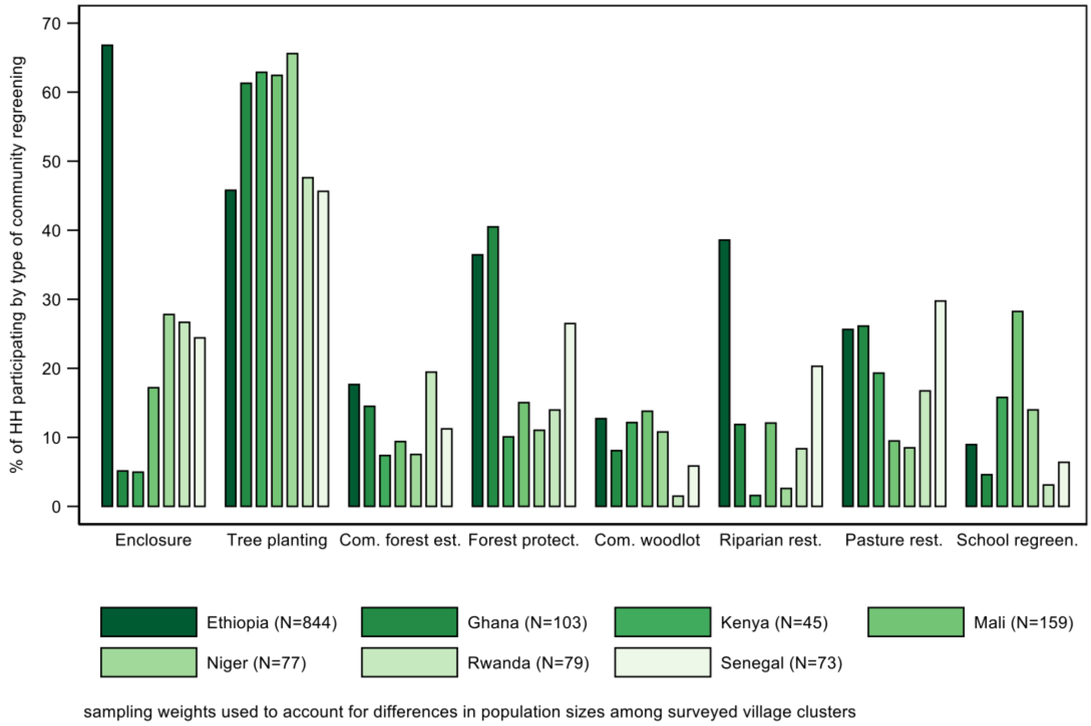


FIGURE 8: Community-level regreening participation by initiative type

Overall, very few respondents reported that their households are participating in and accessing products from community-level land restoration activities.

Overall, 34% and 16% of baseline survey respondents reported awareness of and participation in community-level restoration initiatives, respectively. However, there is considerable variation across the countries, with Ethiopia standing out far ahead. In all countries, household use of products emanating from such efforts is low.

Respondents who reported that their households had participated in community-level regreening initiatives were then asked about the type of interventions undertaken (Figure 8). Tree planting was the most commonly reported, with high variability across countries vis-à-vis the other interventions. Enclosing land, so it can naturally regenerate, was a popular regreening option cited for Ethiopia.

Restoration is not a 'yes or no' affair. It comprises several facets, which lends itself to multidimen-sional measurement.

The Regreening Action Index

As is clear from the above, the act of land restoration is not just one thing; there are multiple elements, and the combination of these elements will vary by context. To capture this richness, a multi-dimensional 'Regreening Action Index' was developed (Figure 9). This measurement approach is similar to those underpinning the Multidimensional Poverty Index (MPI) and the Women's Empowerment in Agriculture Index (WEAI).

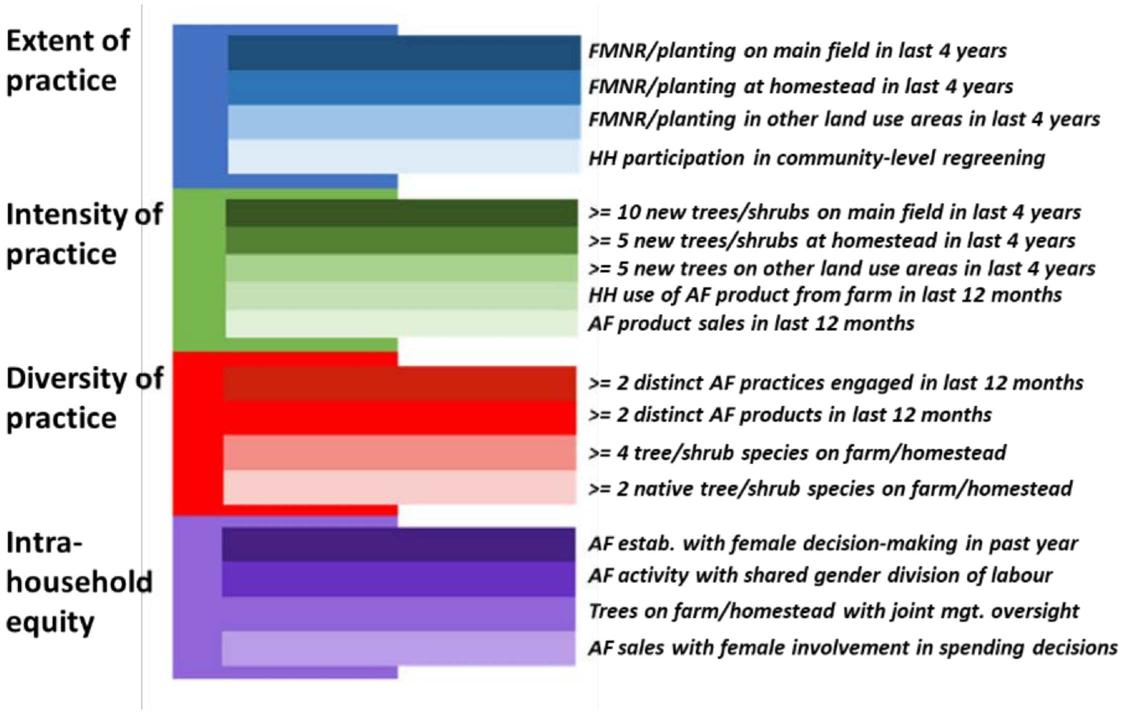


FIGURE 9: Regreening action index (dimensions and indicators) to measure the breadth and depth of household-level regreening efforts

The Regreening Action Index 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 its main field, at its homestead, and on any other land use area (e.g. a secondary field) during this timeframe, as well as 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 practices a household has pursued and/or agroforestry products produced, the higher 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 – **intra-household equity** – gauges the extent to which 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.

Regreening Action Index: Baseline status in direct intervention sites

There was variation across the countries on this index at baseline, and there is considerable room for improvement, as indicated in Figure 10. Kenya has the highest average score, but this is only 0.37, revealing room to scale up regreening action even among the households being targeted in this relatively higher-performing country.

With the Regreening Action Index depicted as a stacked bar graph, one can examine the overall average index score and contribution of each dimension and their associated indicators on one graph. For example, the 'diversity of practice' dimension contributes significantly to the average scores in all countries, save for Rwanda. We see further that, under this dimension, the contribution of two indicators focusing on the numbers of overall and native tree species is relatively greater, while the diversity of agroforestry products contributes the least.

The variation across the countries with respect to the 'extent of practice' dimension is also noteworthy. Relatively fewer households in Ghana, Mali, Niger and Senegal established trees or participated in community regreening initiatives, as compared with the other countries. A final observation, relevant for Regreening Africa's value chain strengthening component, is that agroforestry product sales indicator and the agroforestry product sales with female decision-making indicator contribute little for most countries. Indeed, across all seven countries, only 8% of households reported selling an agroforestry product 12 months prior to the baseline survey and just 5.3% was with female decision-making involvement.

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

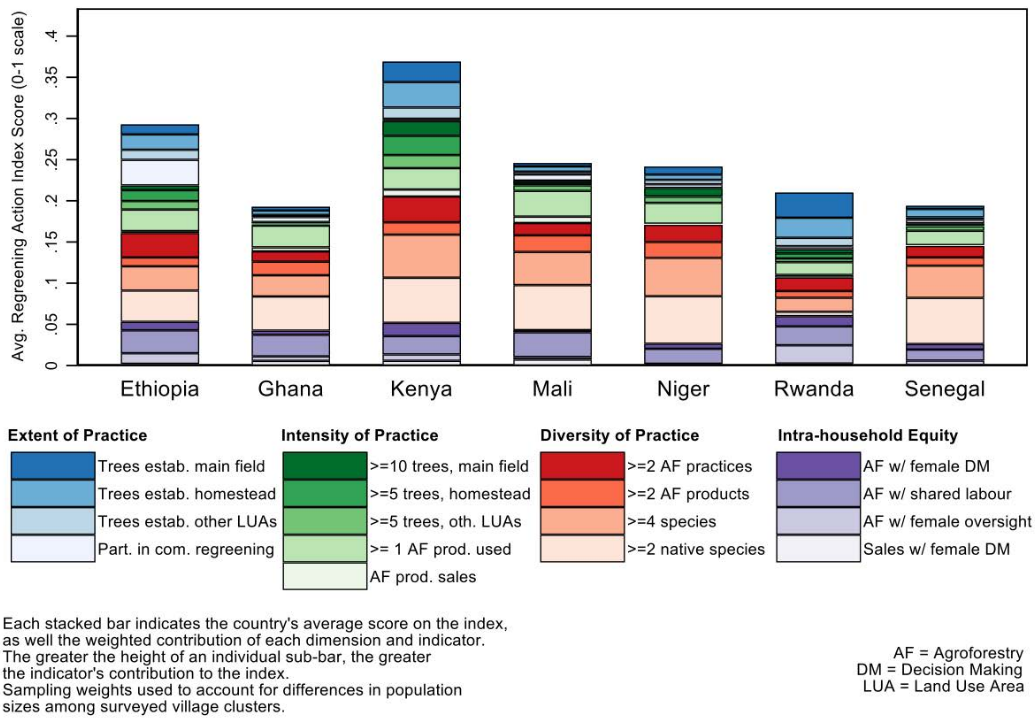


FIGURE10: Regreening action index, with dimension & indicator contribution

Presenting the Regreening Action Index as a stacked bar graph reveals both the depth and breadth of a population's restoration practices.

Focusing only on averages can mask variation across sites within countries and even households within sites. Within most countries, for example, there is variation at the sub-national level (Figure 11). Ethiopia, for example, is characterised by significant variation across the six surveyed woredas (districts).

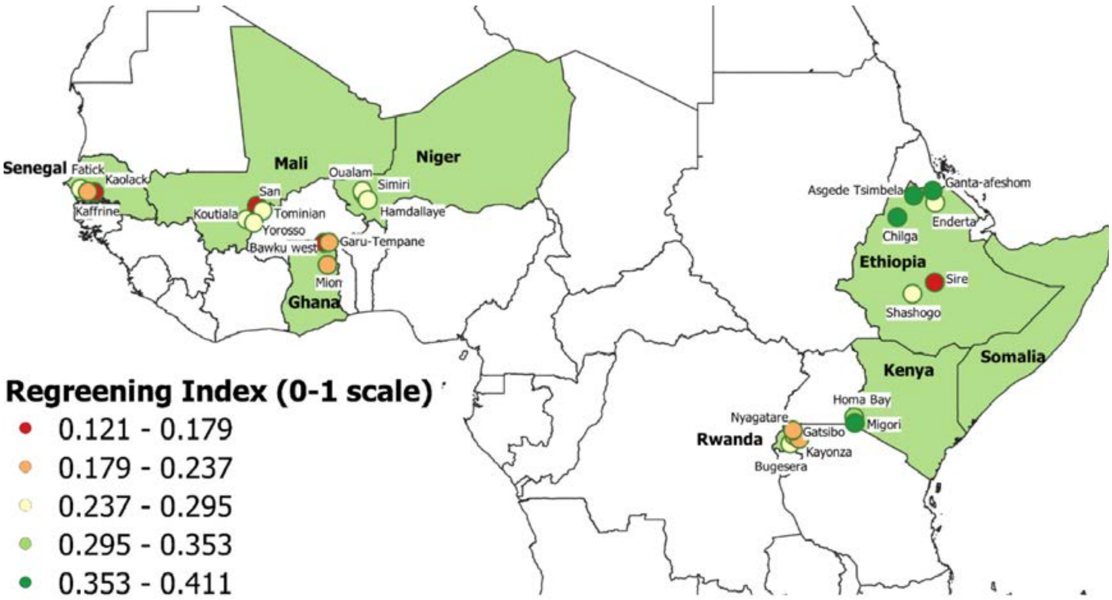
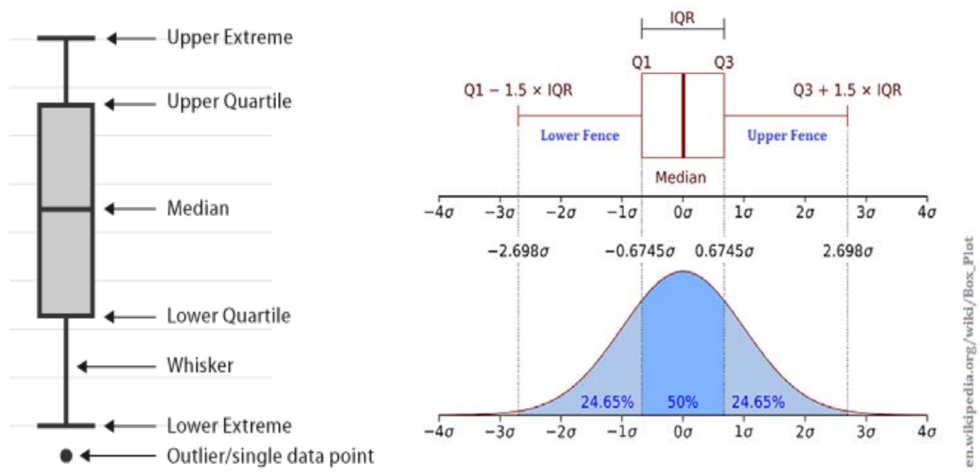


FIGURE 11: Ranges of regreening action index scores by district and commune

The box plot

A good way to explore quantitative data and understand variation across units is through the box plot. From bottom to top, the first whisker to the box represents the first quartile (25th percentile), the start of the box to the median (middle line) represents the second quartile (50th percentile or median), the median to the end of the box represents the third quartile (75th percentile), and the end of the box to the end of the last whisker is the fourth quartile (100th percentile). Beyond the whiskers are outside values (outliers), which are 1.5 times the inter-quartile range.

The box plot is a highly informative way to explore variation in quantitative data.



There is also considerable variation on the extent of regreening practice across households. The box plots presented in Figure 12 reveal this clearly. The pattern across the countries is similar to Figure 10. However, there are at least several households within each country that are serious agroforestry practitioners.

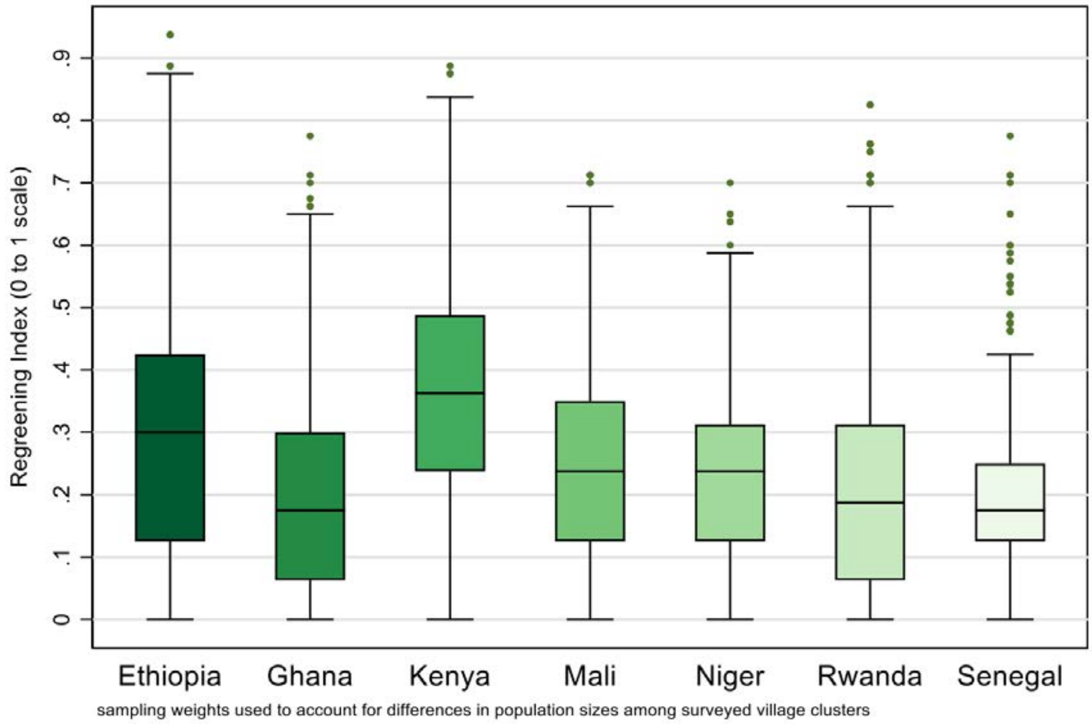


FIGURE 12: Box plots for regreening action index by country

Tree products obtained on-farm

Two of the Regreening Action Index's indicators are associated with the collection of agroforestry products, i.e. a) household use of an agroforestry product in the last 12 months; and b) collection of at least two agroforestry products. The corresponding data of what these agroforestry products are were collected (Figure 13) too.

Fuelwood, followed by fruits and nuts, were the most popular tree products accessed by households. These categories are broad and the tree species involved in providing these products are diverse.

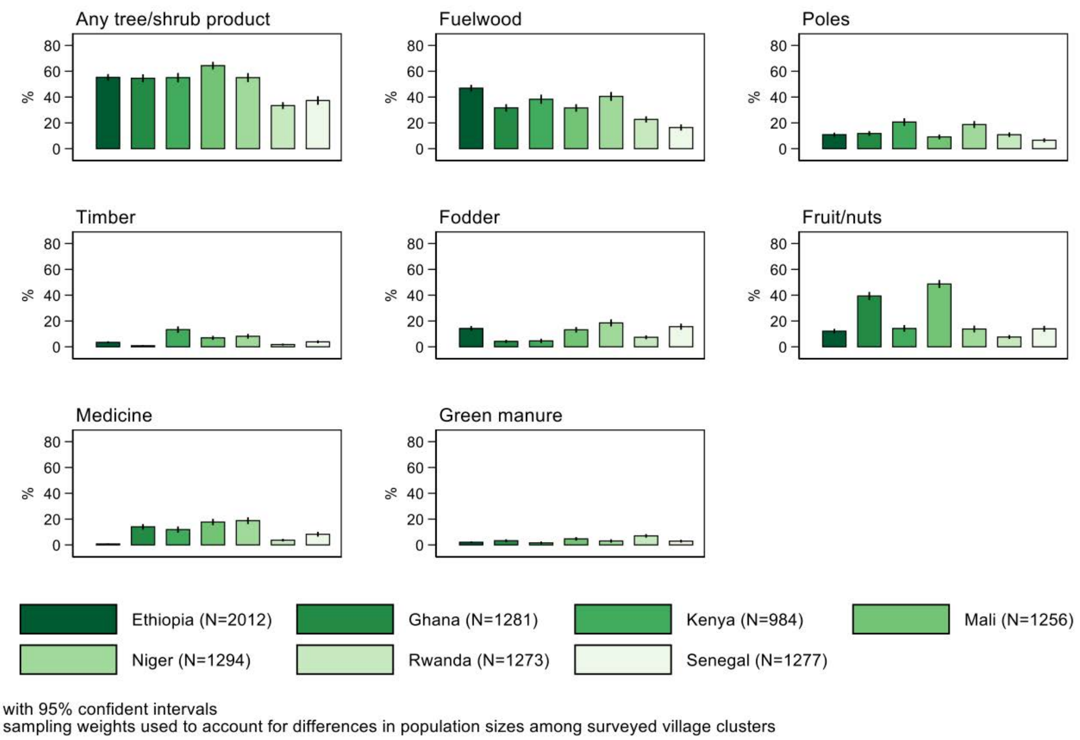


FIGURE 13: Tree products obtain on-farm by country

Overall, 48% of households harvested at least one agroforestry product from their farms in the previous year, with some variation across the countries. Fuelwood was the most popular product, obtained on-farm by 33% of households overall. Fruit and nuts were also popular for Ghana and Mali, likely reflective of the high number of Shea trees found on-farm in these countries (see below).

Fuelwood access and collection time

Fuelwood is a critical tree-based product for the vast majority of households targeted by Regreening Africa, given that 92% rely on it as their primary energy source for cooking. Increasing its availability on-farm is therefore expected to reduce collection time and labour burden, thereby benefiting women given culturally defined divisions of labour. It is also expected to reduce pressure on local forests and trees in common land, as well as save households money in cases where it is purchased. Respondents were therefore asked several follow-up questions about fuelwood in the baseline survey, key results for which are presented in Figure 14.

Of those reliant on fuelwood, 36% access it on-farm, while 26% reported to have purchased it in the 30-day period prior to data collection. Moreover, 37% of respondents reported that the time spent collecting firewood over the past three years has increased, while only 4% reported a decrease. As is clear from Figure 14, there is significant variation across the seven countries.

Overall, just over one-third of respondents reported that they meet all or most of their fuelwood need from on-farm sources.

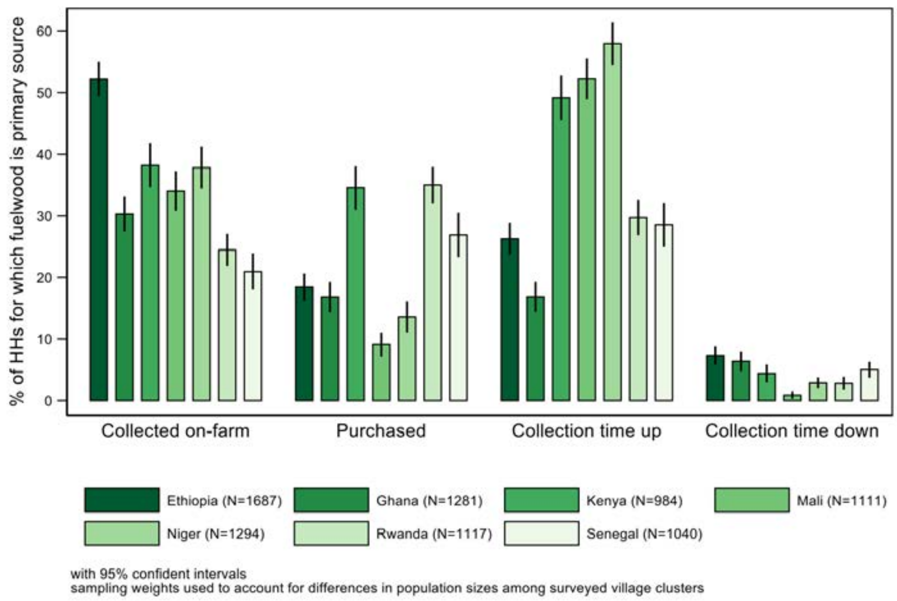


FIGURE 14: Key Results for Fuelwood by Country

For most countries, more time is likely to be spent collecting fuelwood among households that access it from off-farm sources. Off-farm sources include communal and public forests, and other kinds of forests, which indicates the pressure these areas face when there are not enough trees on-farm.

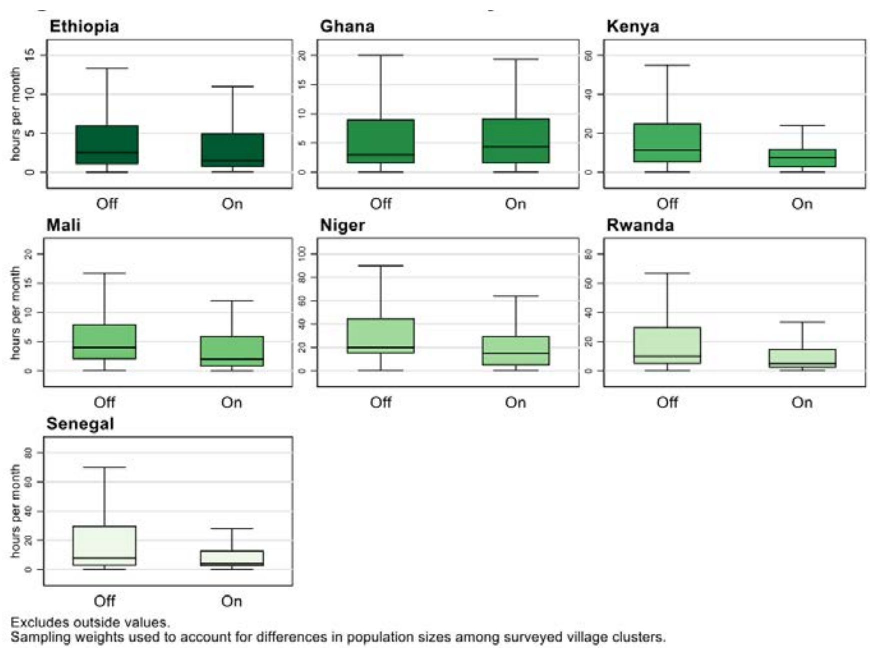


FIGURE 15: Fuelwood collection time by off-farm and on-farm source

Respondents were further asked how many times their household collected firewood in the last month and approximately how long it took to complete each trip. As noted above, a key expectation is that by increasing trees on-farm, fuelwood collection time will be reduced. While there are limitations on what we can conclude causally, we can explore the extent to which this was the case at baseline for households that obtained all or a significant proportion of their fuelwood on-farm with those that did not. As can been seen from the box plots presented in Figure 15, households that obtained firewood from off-farm sources were more likley to report spending more time collecting it in six of the seven countries. In the case of Ghana, it may be that households that do not collect firewood on-farm have readily available alternative sources nearby their homesteads.

Gender aspects in land restoration: A focus on decision-making and labour

External development interventions can inadvertently generate adverse gender impacts. For example, value chain strengthening work may target commodities traditionally under the control of women, and this control may be undermined as the perceived or actual importance of these commodities changes. Given that Regreening Africa does not desire to generate adverse gender impacts and is, indeed, seeking to empower women, follow-up questions were asked in the baseline survey about household member involvement in regreening decision-making and actions (Figure 16).

In general, women are less likely to be involved in both tree management decisions and labour provision, especially in the Sahelian countries of Mali and Niger.

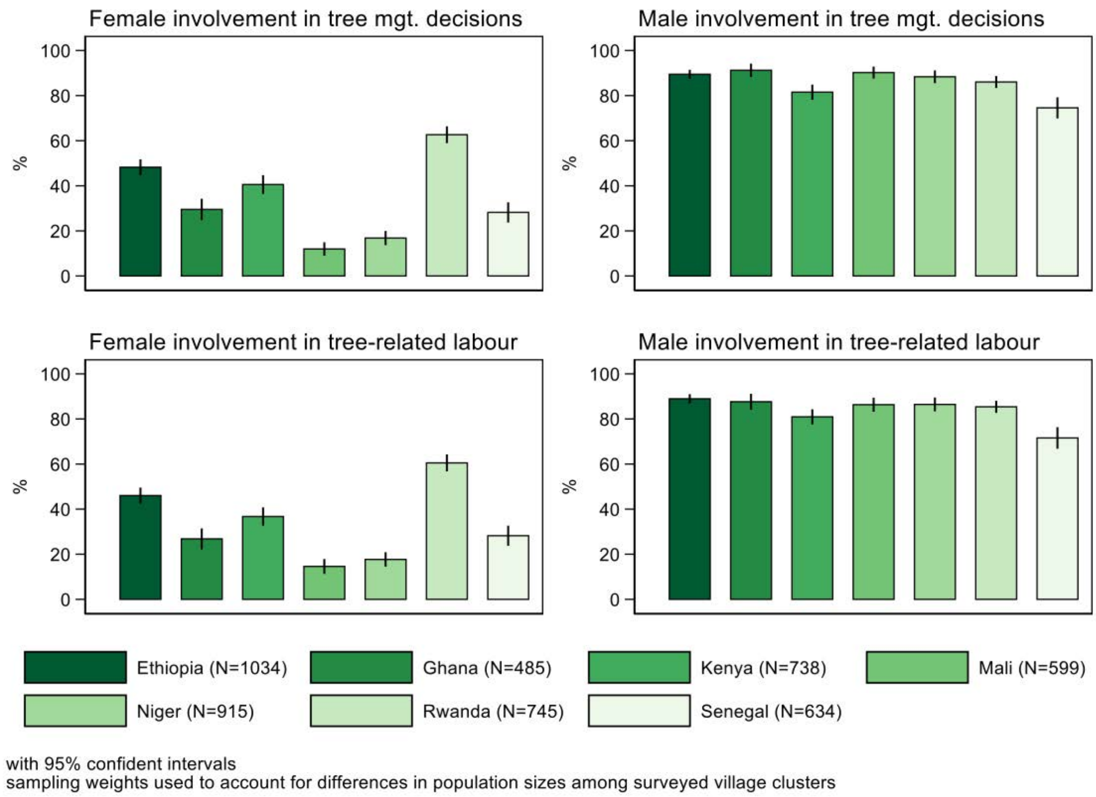


FIGURE 16: Female vs. male tree-related mgt. decision-making & labour

As is clear from Figure 16, women were reported to be significantly less involved in tree management decision-making as compared to men. However, there is significant variation across the seven countries. The results are nearly identical for labour. While further exploration is needed, involvement in tree management decision-making and labour appear to be strongly associated, and men were more likely to dominate both.

Photo: Joseph Bidiar, World Vision Senegal / A farmer collecting firewood from her FMNR field.

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 survey to capture data on tree numbers and tree species.[17] Figure 17 presents the approximate average numbers of trees and shrubs per household, both overall and by hectare. Kenya clearly stands out above the others with an estimated average of 318 trees per household, followed by Ethiopia with an estimated average of 149 trees per household.

Significant variation across the countries was found on the average number of trees on-farm and homestead, both overall and per hectare.

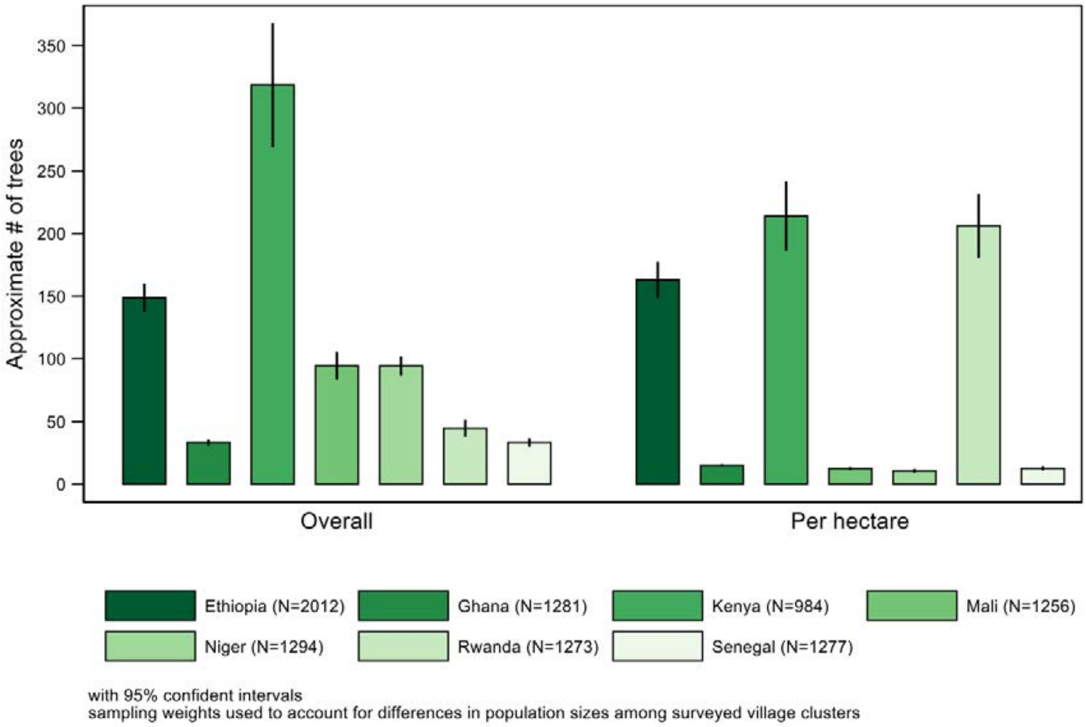


FIGURE 17: Approximate average number of trees on farm & homestead

The average approximate number of trees change significantly when adjusted for farm size. The farm sizes for Rwanda are relatively smaller than the other countries, so the average numbers per hectare increases considerably, whereas for countries, such as Mali and Niger, there is a big drop given their much larger farm sizes.

The box plots presented in Figure 18 reveal that the bulk of trees for many households are present in niches of the farm/homestead other than the main cropping field. This has two potential implications for Regreening Africa. First, it reveals that there are opportunities to enhance appropriate tree establishment outside the main cropping field. Second, it may reveal the importance of exploring with farmers which appropriate tree species can be more effectively integrated and scaled up in their cropping systems, provided this is something that is desirable and beneficial for the farming context in question.

[17]Given the need to minimize 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 mid-point 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 for a household's main field. For other land use areas, the total number of trees in the above ranges and the specific species were captured separately.

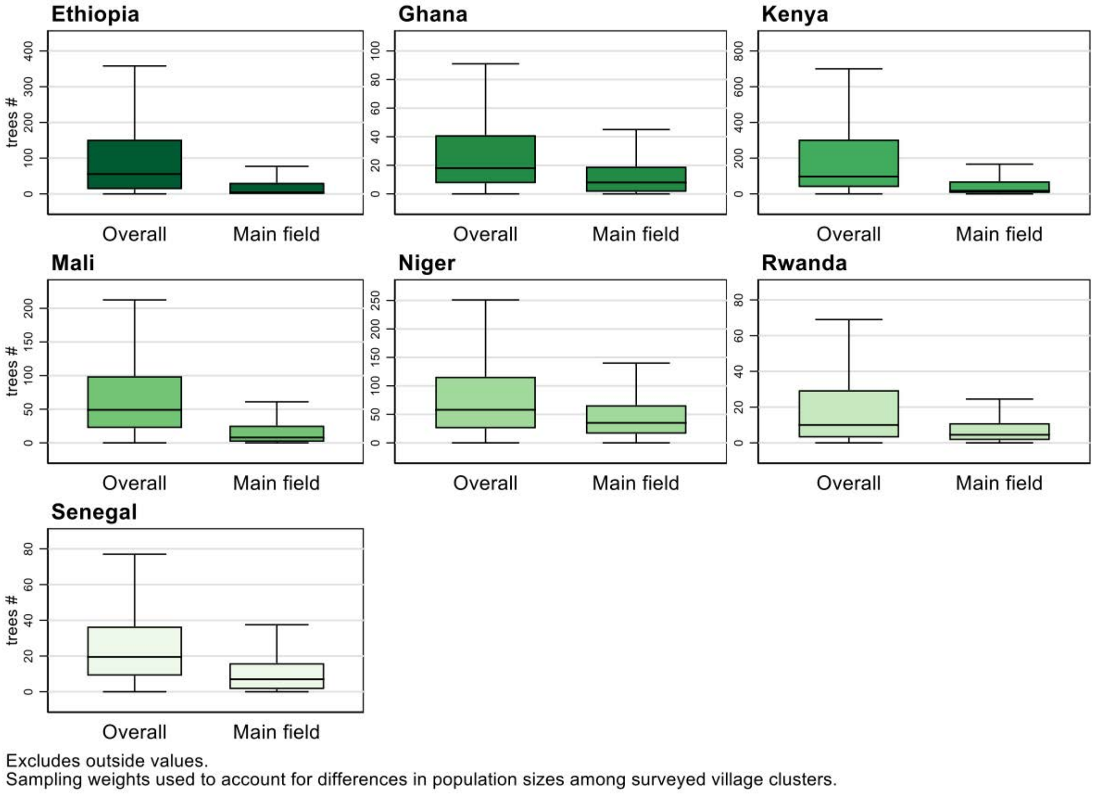


FIGURE 18: Approximate number of trees, overall vs. main cropping field

Native tree species were found to be more prominent than exotics in all countries except Rwanda.

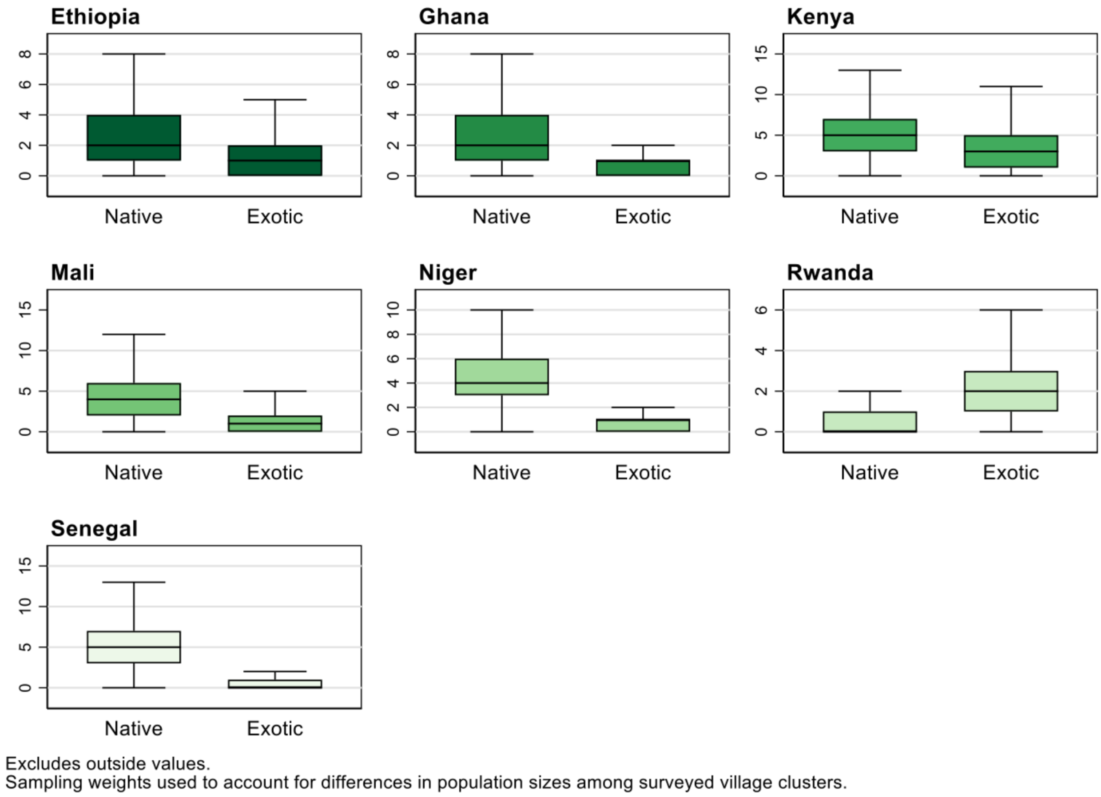


FIGURE 19: Number of native vs. exotic tree species on farm & homestead

Data were collected not only on approximate numbers of trees but also tree species. Indeed, Regreening Africa desires to ensure that its value chain strengthening component does not lead to a displacement of indigenous tree species. Moreover, promoting diversity of tree species is important for resilience and land health. In Figure 19 we see that the number of native tree species found on-farm is relatively higher than exotics for all countries, save for Rwanda. The median number of native tree species for Kenya, Mali, Niger, and Senegal is between four and five, while it is zero for Rwanda.

Table 1 concludes this section by presenting the five most common tree species by country, defined by their presence or absence on-farm and homestead. Exotic tree species tend to predominate more in the sites of East Africa than West Africa. Exotic species (neem, latana and whitebark senna) are invasive, and were found among the top five in the sites of four countries: Ghana, Kenya, Rwanda, and Senegal.

Photo: Mohammed Dicko, Oxfam Mali / Landscape view of a farm in Mali.

Scientific name	Common name	% of HHs with spec.	Native or exotic	Principle uses
Ethiopia				
Eucalyptus spp.	Eucalyptus	44%	exotic	Timber, poles, fuelwood, medicine
Cordia africana	E. African cordia	43%	native	Fodder, food, timber, medicine
Croton macrostachyus	Croton	19%	native	Fuelwood
Acacia abyssinica	Flat-top acacia	19%	native	Fodder, fuelwood, timber
Opuntia ficus indica	Cactus, opuntia	19%	exotic	Forage, fruit
Ghana				
Vitellaria paradoxa	Shea	74%	native	Shea butter, nuts, fruit, fuelwood, timber, medicine, fodder
Mangifera indica	Mango	32%	exotic	Fruit, fuelwood, fodder, medicine
Lannea microcarpa	African grape	27%	native	Dye, leafy vegetables, forage, fuelwood, timber, medicine
Parkia biglobosa	African locust bean	26%	native	Leafy vegetables, fuelwood, fruit, medicine, condiment
Azadirachta indica	Neem	25%	exotic*	Medicine, fuelwood, timber, poles, fodder, pesticide
Kenya				
Grewia bicolor	False brandy bush	57%	exotic	Poles, tools, handles, fuelwood, fruit, timber, medicine
Eucalyptus spp.	Eucalyptus	47%	exotic	Timber, poles, fuelwood
Acacia seyal	Gum arabic	44%	native	Gum arabic, fuelwood, fruit, poles, timber, medicine, honey
Rhus natalensis	Natal rhus	39%	exotic	Firewood, farm tools
Lantana camara	Lantana	35%	exotic*	Live fence, firewood, fruit, medicine
Mali				
Vitellaria paradoxa	Shea	88%	native	Shea butter, fruit, soap
Parkia biglobosa	African locust bean	51%	native	Condiment (soumbala), seeds, fruit powder
Adansonia digitata	Baobab	45%	native	Leafy vegetables, seeds, fruit pulp, oil
Mangifera indica	Mango	38%	exotic	Fruit, juice
Azadirachta indica	Neem	34%	exotic**	Medicine, fuelwood, poles, pesticide, oil, mulching
Niger				
Guiera senegalensis	Guiera	64%	native	Medicine, firewood, fodder
Combretum glutinosum	Combretum	61%	native	Textile dye, fuelwood
Balanites aegyptiaca	Desert date	52%	native	Fruit, fuelwood, fodder, oil
Piliostigma reticulatum	Camel's foot tree	43%	native	Fibre (bark), medicine, fruit, firewood, fodder
Ziziphus mauritiana	Jujube	34%	native**	Fruit, juice, firewood, fodder
Rwanda				
Mangifera indica	Mango	37%	exotic	Fruit
Eucalyptus spp.	Eucalyptus	25%	exotic	Poles, timber, fuelwood
Euphorbia tirucalli	African milk tree	15%	native**	Hedge plant
Senna spectabilis	Whitebark senna	12%	exotic*	Poles, firewood
Markhamia lutea	Markhamia	11%	native	Poles, timber
Senegal				
Azadirachta indica	Neem	54%	exotic*	Medicine, fodder, pesticide, fuelwood, poles, oil
Adansonia digitata	Baobab	47%	native	Fruits, leafy vegetable, fiber, fodder
Faidherbia albida	Faidherbia	45%	native	Fodder, fuelwood, timber, fertilizer
Cordyla pinnata	Bush mango	35%	native	Fruits, fuelwood, timber
Piliostigma reticulatum	Camel's foot tree	27%	native	Poles, timber, bark, fodder

TABLE 1: Top 5 most common tree and shrub species on farm and homestead

*invasive; **invasive other parts of Africa/World (Source: CBI ud)
Sampling weights used to account for differences in population sizes among surveyed village clusters

ASSESSMENT OF LAND AND SOIL HEALTH

The assessment and surveillance of land degradation dynamics are key to the prioritization and spatial targeting of land restoration options and for assessing the effectiveness of such options, including tree planting and FMNR. Indeed, the evidence provided through such assessments is critical for informing decision-making on investments in, and the scaling up of, cost-effective land restoration interventions. Understanding the effects of land restoration options on biophysical indicators and livelihood trajectories can also be used to improve food security and reduce poverty. Using tree-based restoration as an entry point, Regreening Africa aims to not only increase tree cover but also increase soil organic carbon and decrease soil erosion prevalence.

Regreening Africa has identified and measured key indicators of land and soil health in order to understand drivers of degradation, prioritize areas for interventions and monitor changes over time.

These indicators are:

1. Science-based;
2. Readily measurable (quantifiable);
3. Rapid;
4. Based on field assessment across multiple scales (plot, field, landscape, region); and
5. Representative of the complex processes of land degradation in landscapes.

Baseline assessments of vegetation cover, soil organic carbon (SOC) and soil erosion prevalence were conducted across all of the farmer fields of households surveyed in the household baseline survey. Maps of each indicator were produced using the global network of Land Degradation Surveillance Framework (LDSF) sites, coupled with Earth Observation (EO) data (Figure 20). This includes the LDSF sites surveyed in Rwanda, Senegal and Niger under this project.

During the household baseline 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 to form the baseline assessment of land and soil health presented here. (See Figure 21 as an example.) These biophysical data will be compared with the endline assessment to track changes over time. The interventions implemented in the project aim to ultimately increase SOC, increase vegetation cover and decrease soil erosion. In turn, sustainable increases in crop productivity are expected, together with greater household resilience to shocks, such as dry spells and excessively heavy rain.

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 above ground vegetation, application of compost and nodal nitrogen fixation.

Understanding effects of land restoration options on biophysical indicators and livelihood trajectories of smallholder households can be used to improve different kinds of ecosystem services.

FIGURE 20: 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. The Normalized Difference Vegetation Index (NDVI), which was proposed by Rouse et al. (1974)[18] and later called the NDVI by Tucker (1979)[19] , is perhaps the most widely used. Vegetation indices rely on the reflectance of the land surface measured from satellite or aerial sensors at different spectral bandwidths or bands. In the case of the NDVI, a normalized difference index is calculated using the red and near-infrared (NIR) bands:

$$NDVI = \frac{NIR - red}{NIR + red}$$

Despite the popularity of the NDVI, it is generally not well suited for assessments of vegetation canopy cover in drylands due to the generally low vegetation cover and strong soil background signal, which influence NDVI strongly (Smith et al. 2019)[20] . As a result, a number of other indices more suitable for drylands and grasslands have been proposed, including the Soil Adjusted Total Vegetation Index (SATVI) (Marsett et al. 2006)[21] :

$$SATVI = \frac{SWIR1 - red}{SWIR1 + red + L}(1 + L) - \frac{SWIR2}{2}$$

This index uses two shortwave infrared bands (SWIR1 and SWIR2) and the red band, with SWIR1 substituting the NIR band in the NDVI above. This index has been found to be sensitive to both green and senescent vegetation, which is important for assessing vegetation cover in drylands, including rangeland systems. We apply the SATVI, scaling the index to reflect fractional vegetation cover to range from 0% to 100%, to estimate fractional vegetation cover based on Landsat 8 satellite imagery for 2018, based on the annual median reflectance of each Landsat band. This index is sensitive to chlorophyll in general and captures changes as a result of increases in shrub and tree cover, as well as increased productivity. By overlaying farmer field polygons onto a map of fractional vegetation cover, values for each field were extracted and the weighted mean calculated for each field.

Figure 21 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.

Despite the popularity of the NDVI, it is generally not well suited for assessments of vegetation canopy cover in drylands. Hence, this project is using the Soil Adjusted Total Vegetation Index (SATVI) to track vegetation shifts over time.

[18]Rouse, J. W., R. H. Haas, J. A. Schell, and D. W. Deering. 1974. “Monitoring vegetation system in the great plains with ERTS.” In Proceedings of the Third Earth Resources Technology Satellite-1 Symposium, 3010–7.
[19]Tucker, Compton J. 1979. “Red and photographic infrared linear combinations for monitoring vegetation.” Remote Sensing of Environment 8 (2): 127–50. https://doi.org/10.1016/0034-4257(79)90013-0.
[20]Smith, William K., Matthew P. Dannenberg, Dong Yan, Stefanie Herrmann, Mallory L. Barnes, Greg A. Barron-Gafford, Joel A. Biederman, et al. 2019. “Remote sensing of dryland ecosystem structure and function: Progress, challenges, and opportunities.” Remote Sensing of Environment 233 (December): 111401. https://doi.org/10.1016/j.rse.2019.111401.
[21]Marsett, Robert C., Jiaguo Qi, Philip Heilman, Sharon H. Biedenbender, M. Carolyn Watson, Saud Amer, Mark Weltz, David Goodrich, and Roseann Marsett. 2006. “Remote Sensing for Grassland Management in the Arid Southwest.” Rangeland Ecology & Management 59 (5): 530–40. https://doi.org/10.2111/05-201R.1.

Farm field polygons were overlaid on land health indicator maps, with the weighted average pixel value computed for each. This is an example of the vegetation cover map using the SATV index.

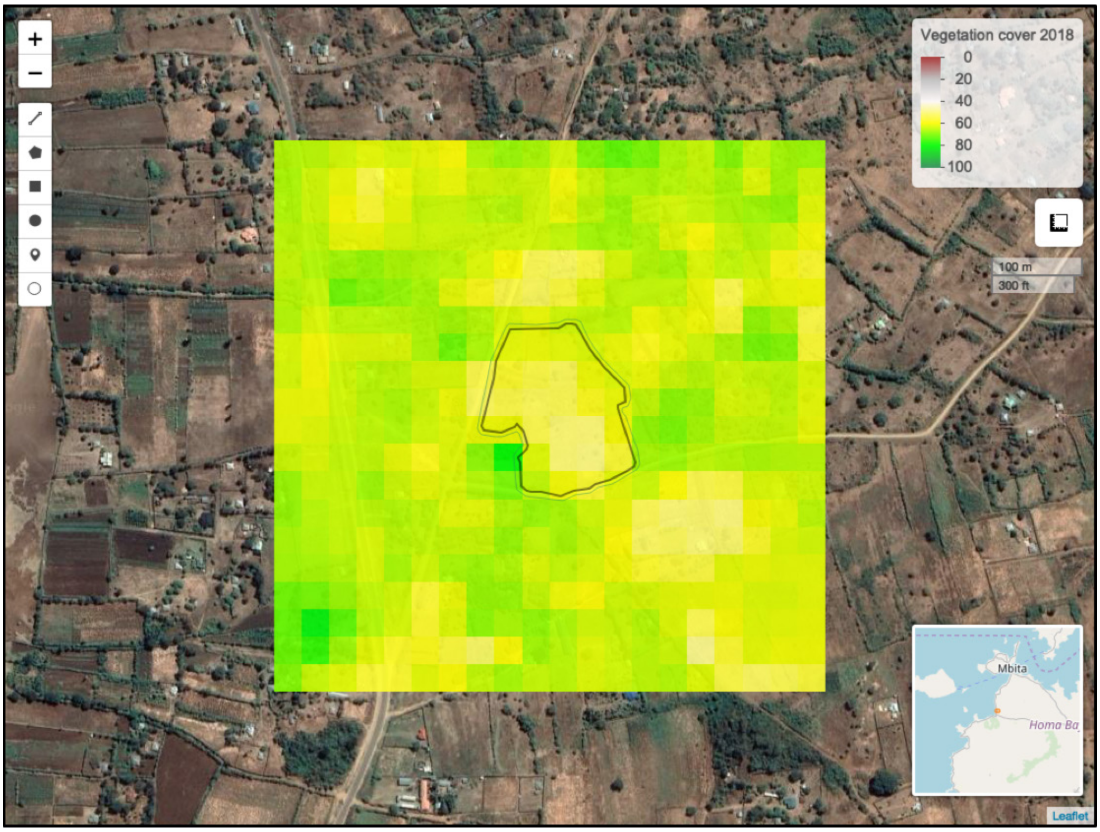


FIGURE 21: Vegetation cover, using SATVI, for a farm polygon in Migori County, Kenya

Figure 22 shows there is a strong gradient in fractional vegetation cover going from the drier countries in the Sahel (Senegal, Niger and Mali) to Ghana, Ethiopia and Kenya. The narrow distribution for Niger shows low variation and overall low vegetation cover (i.e. the average is 3%). In contrast, the average vegetation cover in Mali, Ghana, Ethiopia and Kenya was more variable with averages of 6%, 44%, 54%, and 63% respectively.

Vegetation cover in sampled cropping fields was highly variable, both across and within the seven countries.

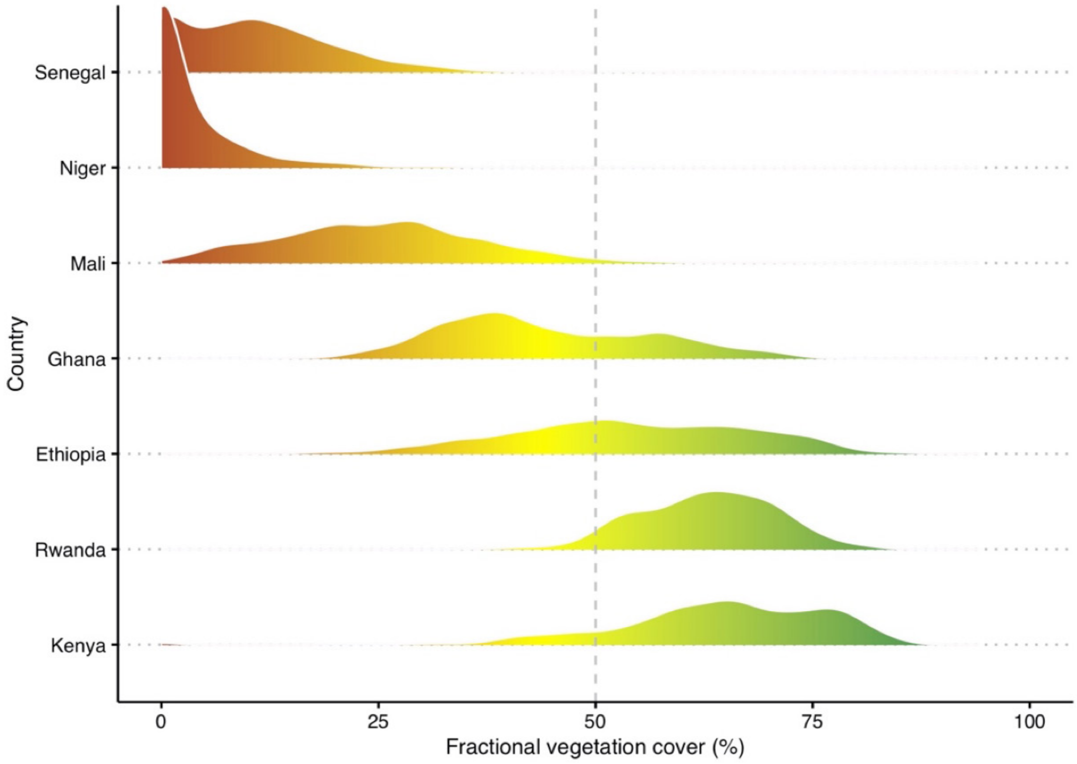


FIGURE 22: Distribution of fractional vegetation cover values extracted from farmers' fields by country. The vertical line shows 50% fractional vegetation cover.

Soil Organic Carbon (SOC): A key indicator of soil health

Soil organic carbon (SOC), expressed as the grams of organic carbon per kilo of soil (gC kg^(-1)), was estimated based on soil data from a global network of Land Degradation Surveillance Framework (LDSF) sites and Landsat remote sensing data. Machine learning algorithms (models) were trained to predict SOC based on a satellite image reflectance values.[22] The accuracy of the SOC maps is greater than 80%, which is high.

As shown in Figure 23, there are large variations in SOC between the six countries, and also large variations within countries such as in Kenya (Figure 24). The map in Figure 24 shows SOC for Rwanda, which was created using a combination of LDSF field data and remote sensing (Landsat 8) at a spatial resolution of 30m. This map was used to extract the information in Figure 23 for each of the farmer fields included in the baseline survey. Note the spatial variations in SOC across Rwanda with high SOC in protected areas such as Nyungwe Forest National Park in the west of the country and in Akagera National Park in the east of the country. There is generally lower SOC in agricultural areas, but with high variation.

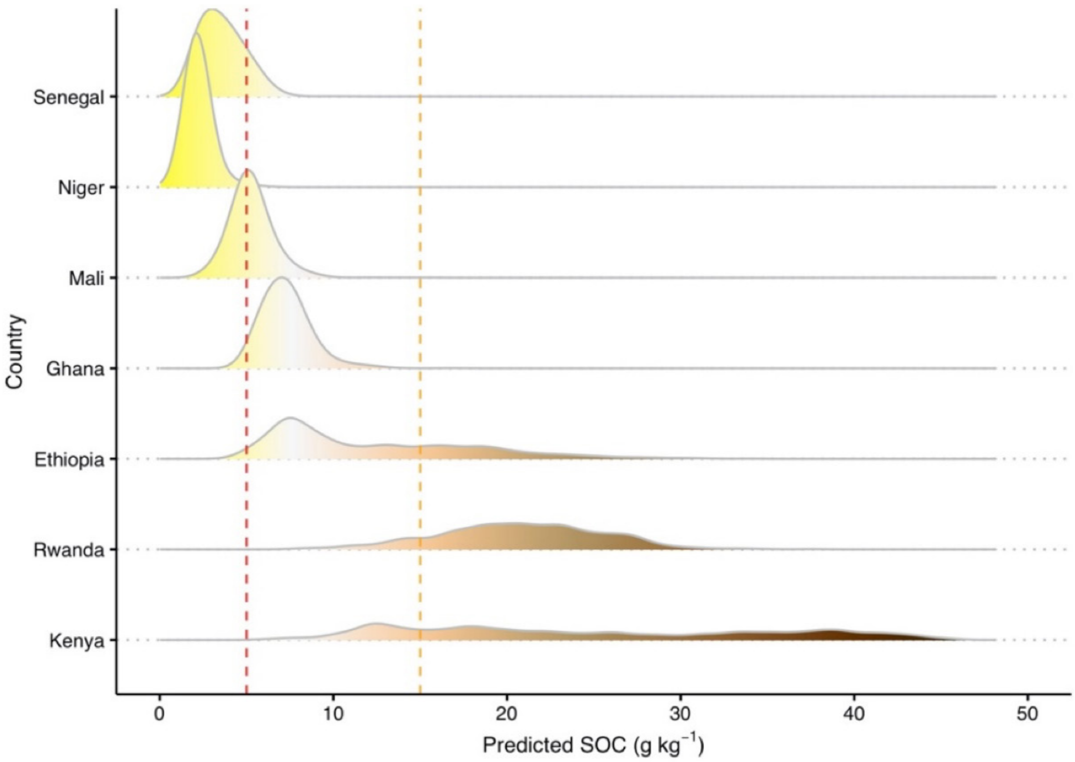


FIGURE 23: Distribution of soil organic carbon (SOC) extracted from farmers' fields by country. The vertical lines show low SOC (orange) and critically low (red) thresholds for SOC.

Note the low SOC content in Senegal and Niger and the high variation in SOC across Kenya.

[22]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.

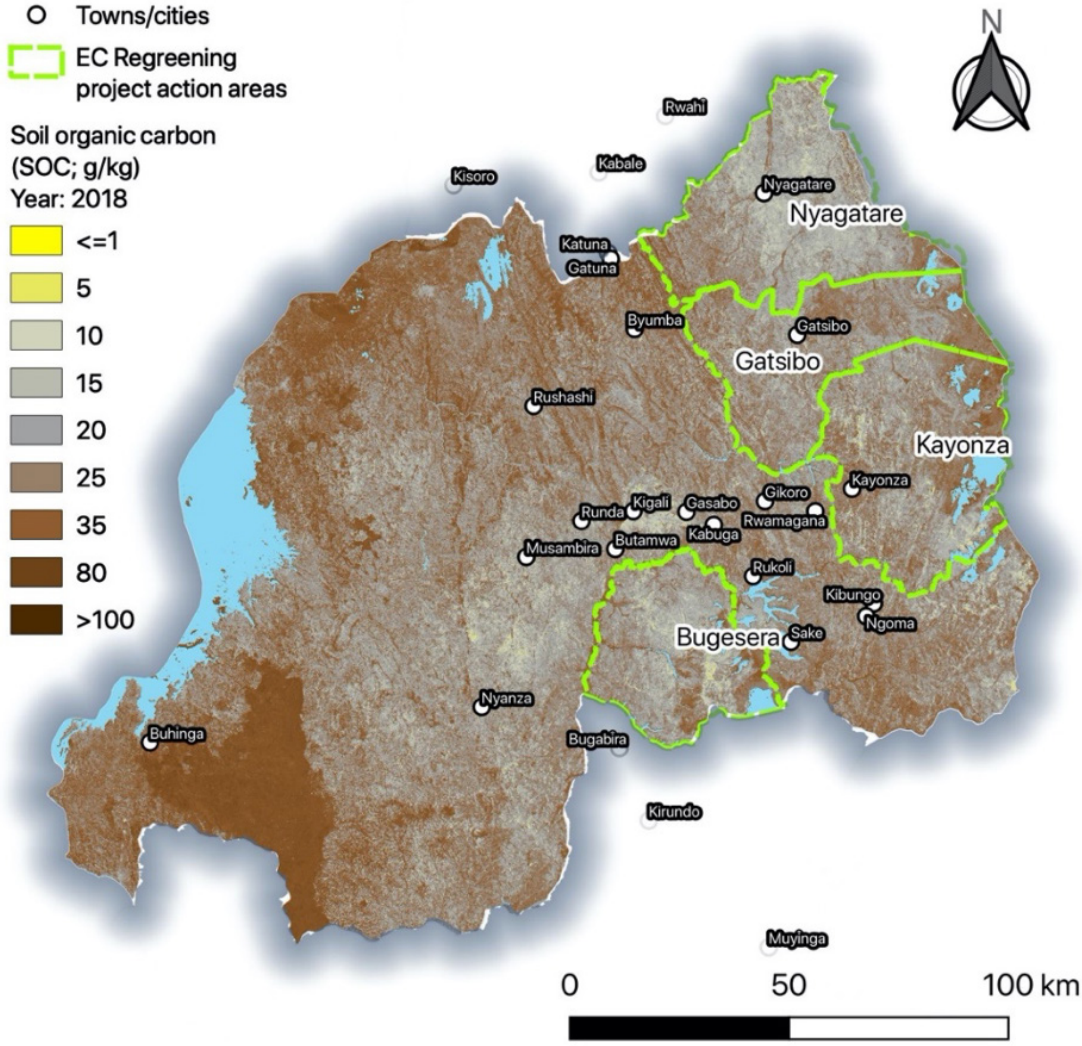


FIGURE 24: Soil organic carbon (SOC) map of Rwanda generated using soil data from LDSF field surveys and remote sensing (Landsat 8)

These density plots show the variation between subcounties in Kenya, note the wide distribution of SOC in Suba South and Nyatike and the peak at 40 g kg-1 in Suba North. It is important to acknowledge this variation in order to accurately establish baselines.

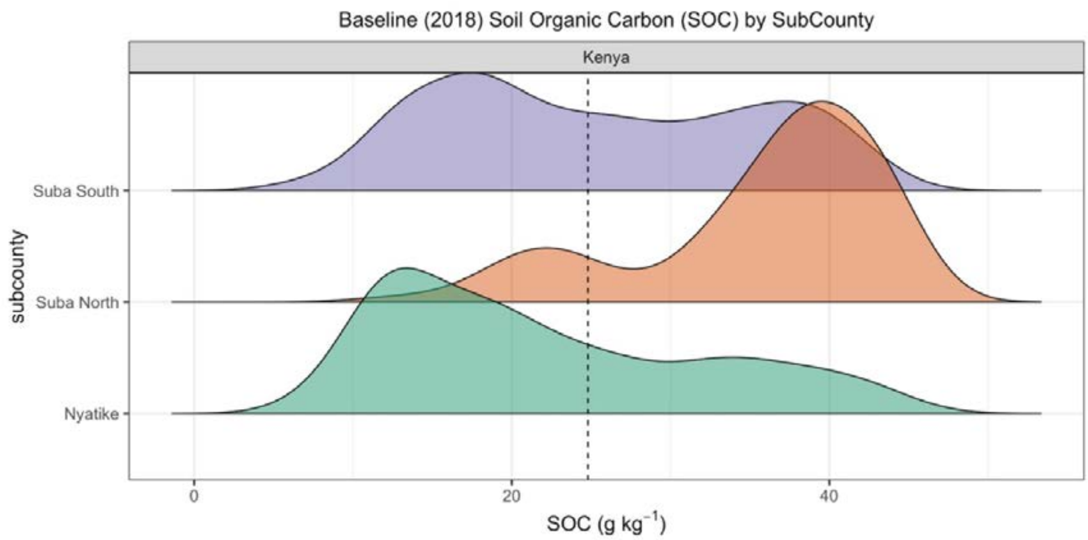


FIGURE 25: Distribution of soil organic carbon (SOC) extracted from farmers' fields by subcounty in Kenya. The vertical lines show average SOC content across the three sub-counties (24.8 g kg-1).

Generally, variations between countries follow the variations in fractional vegetation cover, as expected. In Niger and Senegal, the majority of the farmers' fields have SOC concentrations that are lower than 5 gC kg^(-1) (red line in Figure 23), which is considered critically low in terms of crop production. In practice, this means that the majority of famers' fields are considered marginal in terms of soil fertility status. Areas with SOC less than 15 gC kg^(-1) are generally considered low for agricultural productivity.

The options scaled-up in the project aim to ultimately increase soil organic carbon, increase vegetation cover and decrease soil erosion.

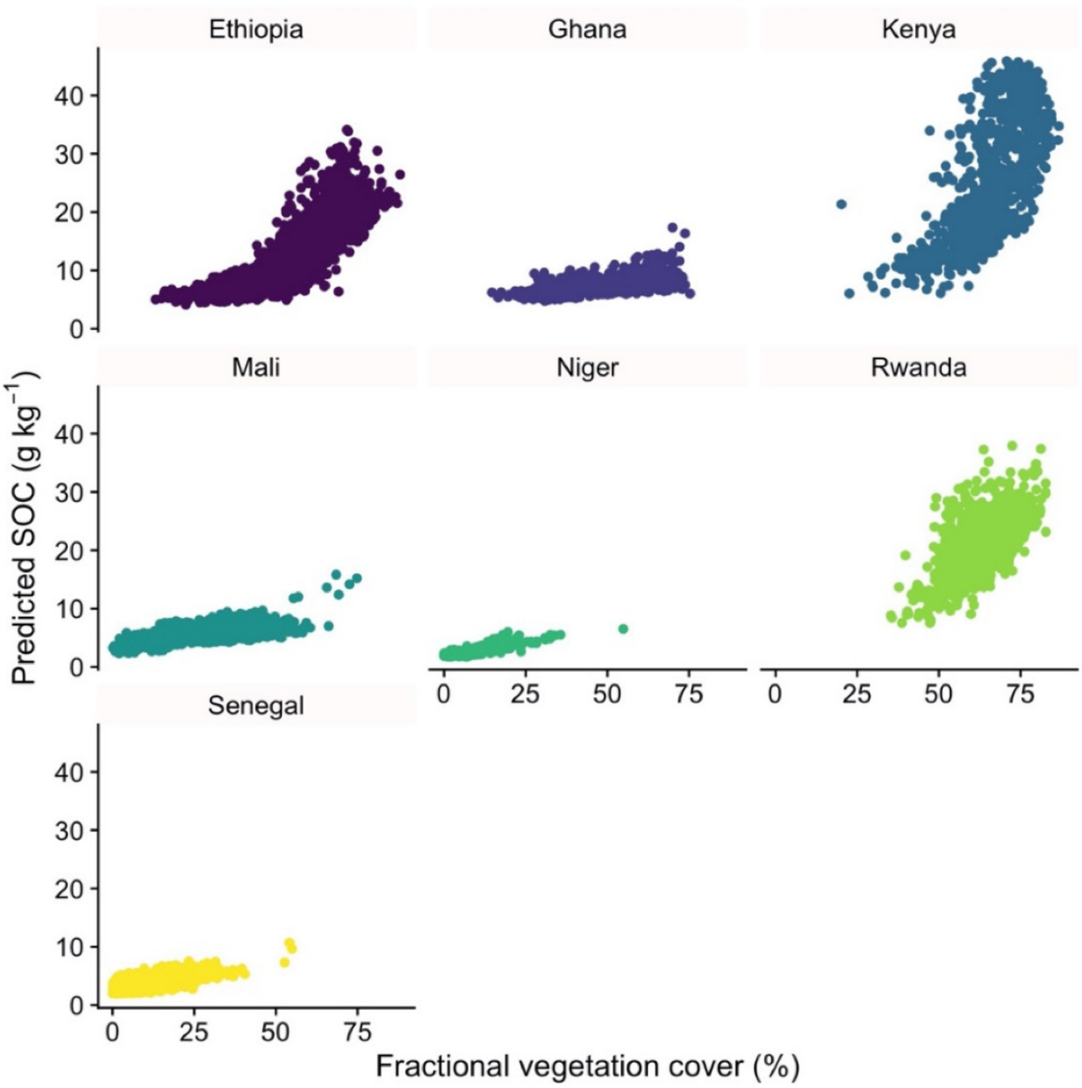


FIGURE 26: The relationship between fractional vegetation cover and SOC in the project intervention sites, by country.

The content of SOC varies in response to multiple factors, including vegetation cover (biomass inputs), soil properties, such as texture (for example, sand content) and climatic factors (temperatures and rainfall). We do not report sand content here as this variable is not sensitive to management. However, higher sand content generally means that the ability of the soil to store carbon is less than where it is lower with more clay or finer soil particles. We can see the response of SOC to increased fractional vegetation cover in Figure 26 for the different countries.

It is important to keep in mind the factors mentioned above when assessing changes in SOC for project intervention areas as the potential to store SOC differs across the countries and intervention areas. In other words, we need to assess the impacts of interventions relative to local potential. If we take the example of Niger (Figure 26), we see that we have low overall fractional vegetation cover (also see Figure 22) and low SOC overall. However, we also notice that SOC concentrations start to increase quite strongly even at less than 15% fractional vegetation cover, which shows the importance of even small increases in vegetation cover (biomass production) for SOC content and soil health within dryland systems.

This scatterplot highlighting Niger shows that even a marginal increase in vegetation cover beyond 10% can result in a relatively strong increase in SOC in marginal dryland systems.

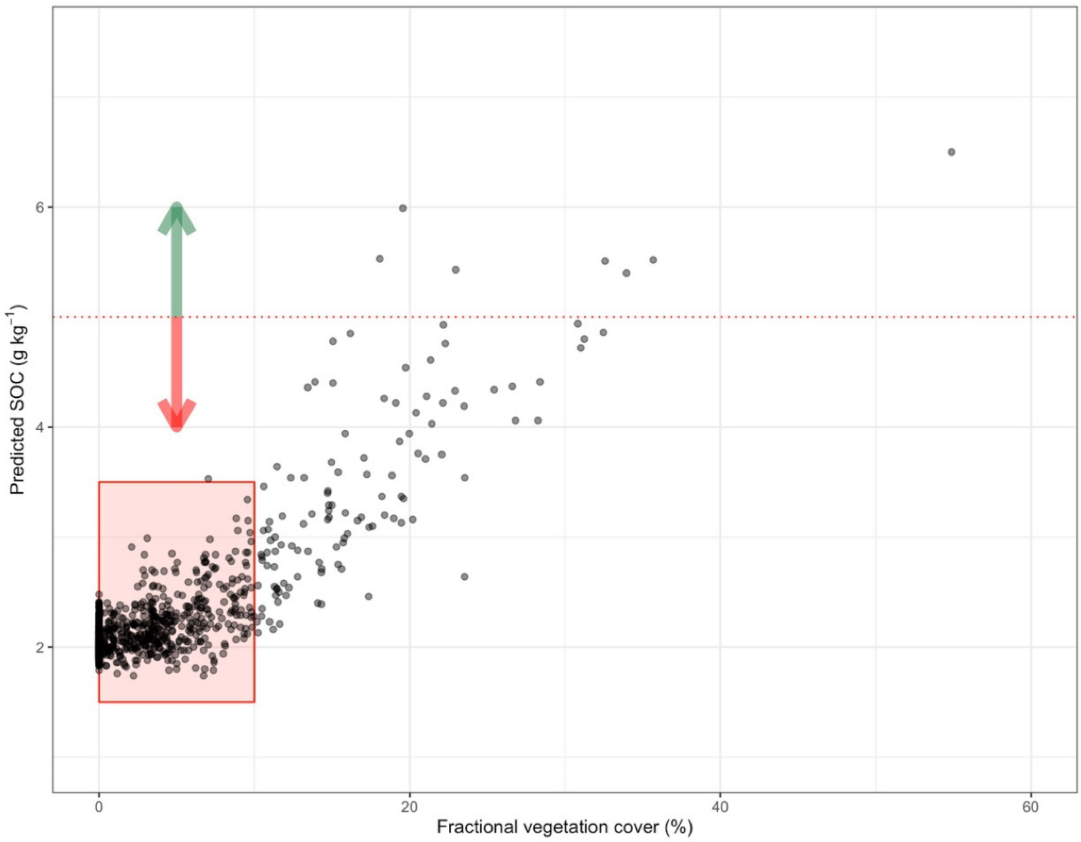


FIGURE 27: Results of extracting LDSF and remote sensing-based predictions of soil organic carbon (SOC) and fractional vegetation cover for farmer fields in Niger, showing that even a marginal increase in vegetation cover beyond 10% can result in a relatively strong increase in SOC in marginal dryland systems. The 5 g C/kg threshold (red dashed line) is generally considered a critical threshold for crop production.

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[23] 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

[23] 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

network of LDSF sites and Landsat remote sensing data. The accuracy of the soil erosion prevalence maps is greater than 86%.

In LDSF, erosion is classified into different forms of erosion (none, sheet, rill, gully/mass) and scores are generated at the plot level based on the number of subplots with observed erosion. Overall, soil erosion prevalence was high across all direction intervention areas in the seven countries, with the highest prevalence in Niger and the highest variation in Kenya.

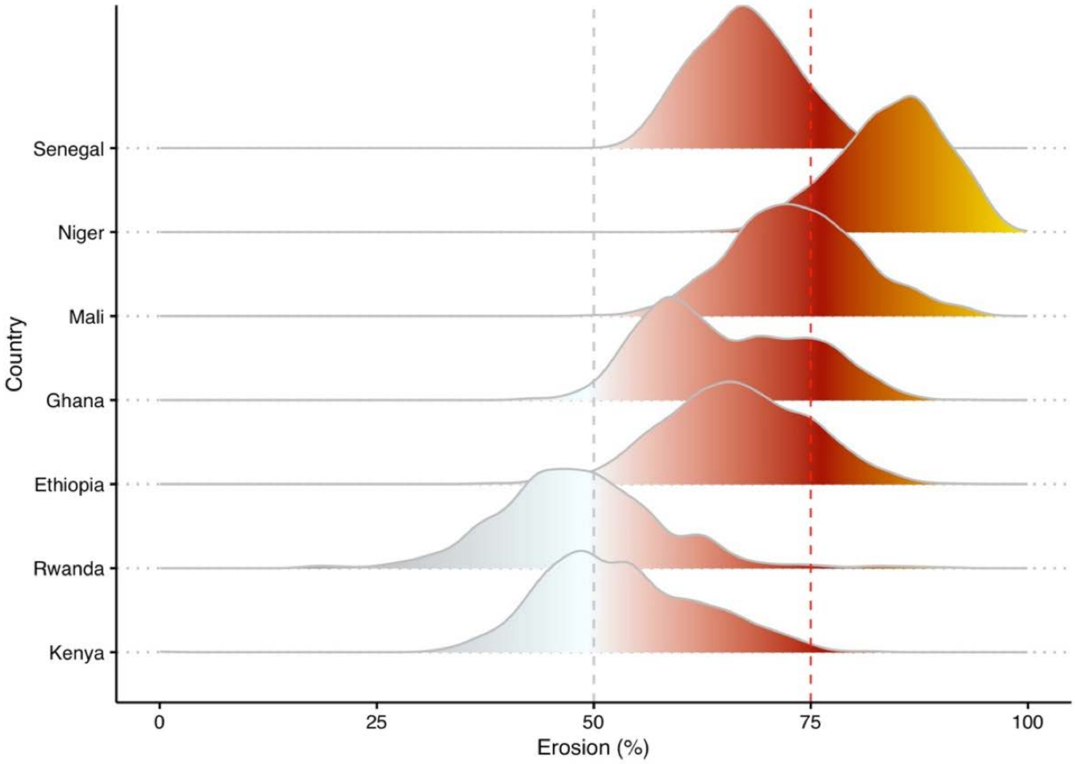


FIGURE 28: Distribution of soil erosion prevalence (%) extracted from farmers' fields by country. The grey vertical line shows 50% erosion, with higher values indicating moderate to high erosion prevalence. Areas with values higher than 75% (red line) have severe erosion.

These density plots highlight the severity of soil erosion across the countries and the need for a systems approach that addresses multiple indicators simultaneously to improve landscapes and livelihoods.

Photo: Gilberte Koffi, World Agroforestry / Officials from the Forest Department in Senegal taking soil samples for analysis of soil organic carbon and other land degradation indicators.

PROJECTED BASELINE FARM INCOME

As mentioned in Section 1, a key impact evaluation challenge for Regreening Africa (or any agroforestry promotion effort for that matter) is that the full potential impacts of its direct community engagement work will not manifest until several years after project closure. Consequently, FarmTreeServices was engaged to model what these impacts are likely to be, with a particular focus on income from crops and agroforestry products.

This work started with the baseline survey, and the results are presented in this section. Using the model depicted in Figure 28, this involved projecting what returns each surveyed household would likely experience based on the crop and tree combinations grown on-farm at baseline, the Business as Usual (BAU) scenario. These projections will then later be compared with similar projections at the end of the project, as well as between the Year 1 and Year 4 household groups. If Regreening Africa proves successful in supporting the participating households to set themselves up for generating significantly greater returns in the future, the changes in projected income of Year 1 households should be significantly greater in comparison with Year 4 households.

The FarmTree® Model is being used to model future projected income at the farm level both before and after project implementation, thereby enabling changes in such income to be measured and compared.

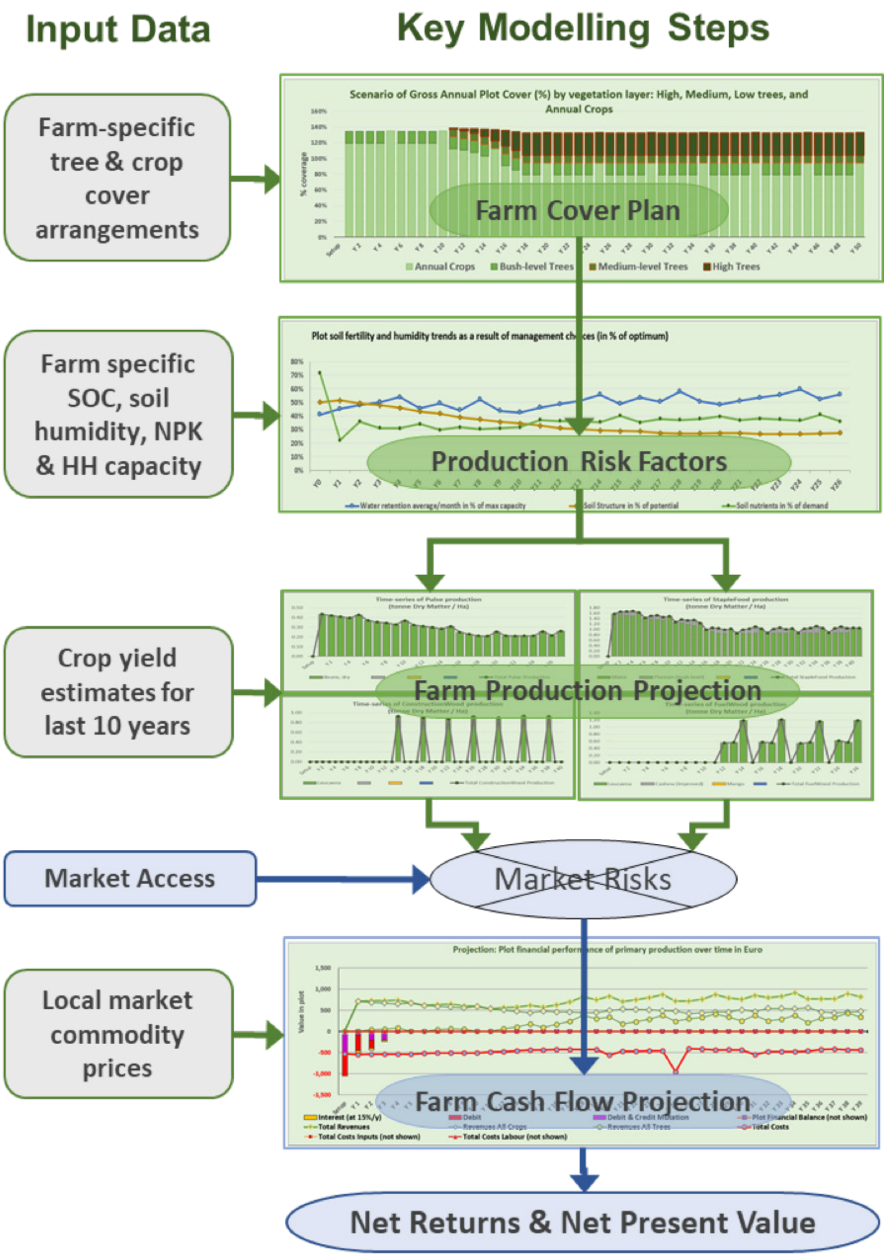


FIGURE 29: Agroecological economic model for projecting farm income

The steps involved in the modelling effort were:

1. The tree and crop cover for each surveyed household's farm (often comprising several land use areas) was obtained from Regreening Africa's household survey data. These tree-crop configurations were held constant and used to estimate tree cover over time. Smaller trees (such as calliandra and moringa) were allotted less area per tree than bigger trees (such as mango and eucalyptus). This enabled an estimation of the fraction of the farm area under tree cover. The remaining area was allotted to the crops cultivated during the previous year. Where no crops were defined for the land use area in question, it was treated as not being under crop production.
2. From the above, a farm cover plan was generated for each surveyed farm. This was used to simulate future tree and crop cover, holding the baseline tree-crop configuration constant. The extent of tree cover was projected to change over time based on the established growth cycle of each tree species, resulting in corresponding changes in cropping area. By extension, when trees are expected to be harvested or die (according to their species-specific life cycles), the model 'fills' the remaining space again with the indicated crops.
3. The tree and crop production estimates generated for each farm took into account four farm-specific production risk factors:
    i. SOC as a measure of baseline soil fertility[24] ;
    ii. Soil humidity (determined monthly rainfall patterns[25] interacted with SOC and tree cover);
    iii. Soil mineral availability (determined by the extent of fertilizer and manure application and intercropping of nitrogen fixing crops and trees); and
    iv. Household capacity (determined by education levels, labour availability, and group membership). The model starts with the country maximum average yield over the last 10 years for the crop or horticultural tree species[26] in question, documented by the Food and Agricultural Organization (FAOSTAT). These maximum average yields are then adjusted downwards based on the above production risk factors and are calibrated towards average crop production values for each country to generate farm production projections.

    In other words, the crop and horticultural tree species yield estimates were adjusted based on the production risk factors, but the overall averages per hectare were calibrated to match those of the national level. (See Annex 2 for a more detailed description of how these farm-specific production estimates were generated.) The yield estimates were further projected to change over time based on estimated changes in soil fertility and humidity. For example, the more tree cover, the less evaporation, the more soil organic matter is built up, and the more water soil can hold, the less erosion, and the more nitrogen that remains in the system.

4. Local market prices were obtained from local informants in each of the seven countries, which were triangulated by the implementing partners. The model assumes that farm gate prices are 75% of the local market prices and corrects for seasonal price fluctuations as fallows: -70% on average for vegetables; -50% for tubers; -30% for grains and pulses; and -10% for woody products. Farmers with better market access (e.g. via cooperative membership or market proximity) were allocated better prices than farmers with poorer market access.
5. The resulting price estimates were then multiplied by the annual production estimates, while subtracting out input costs. This resulted in annual farm cash flow projections over 25 years, thereby enabling the computation of annual net farm returns and Net Present Value (NPV) projections presented below.

The results presented below are projections assuming that the surveyed farming households continue with their baseline (BAU) tree-crop systems into the future. However, Regreening Africa, as explained above, is seeking to support these households to integrate trees and other complementary sustainable land management options to better optimize these systems, thereby pivoting these projections upwards.

The modelling effort took the baseline tree-crop portfolios of each farm and average national production values as starting points. These were then adjusted considering farm-specific production risk factors.

[24] Values taken from the farm field estimates described in Section 6.
[25] Based on the farm's location, the model uses monthly rainfall patterns from 2008 to 2017 to inform future for productivity projections, sourced through the World Bank's Climate Change Porthole.
[26] Most non-horticultural tree crops are not as sensitive to the production risk factors, so their average values and growth trajectories for the regions in question were not adjusted accordingly.

If participating households continue with the same tree-crop portfolios they had at baseline, their net returns are projected to be generally low.

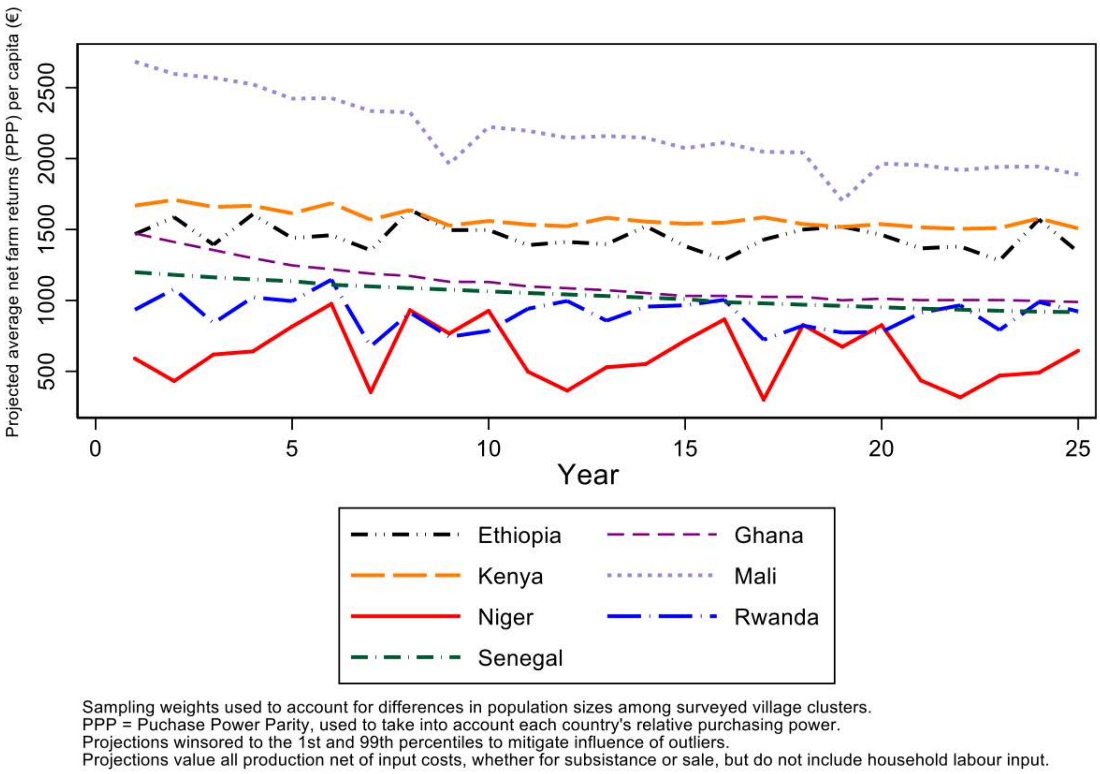


FIGURE 30: Projected 'Business as Usual' Net Farm Returns (PPP) over time

Figure 30 presents the average BAU net farm returns per capita [27] projections 25 years into the future. The returns are presented on a per capita basis, as opposed to a per farm or per hectare basis. This is because of an explicit concern about Regreening Africa's social welfare impact. Household sizes differ, both within and across the participating countries, and farms supporting larger families need to produce more, holding off-farm livelihood sources constant. Moreover, agroecological conditions vary considerably, particularly across the seven countries. Farms with poorer soils and less rainfall, for example, need to be larger in order to support the same number of people. Hence, while examining returns on a per hectare basis is important for evaluating different production options for a single farm or set of relatively homogeneous farms, it is preferable here to focus on per capita figures. In addition, given that purchasing power in the participating countries differs from that in industrialized countries, the projections – as is standard practice in poverty measurement – were also adjusted to take this into account [28].

The overall average and median projected per capita figures are, respectively, €1,387 and €934 in Year 1 dropping down to €1,215 and €770 (based on present prices) in Year 25. These values are generally consistent with what is found elsewhere in the literature [29]. As is clear from Figure 29, there is variation across the seven countries in the annual values, as well as in the projected changes over time. The lowest figures are for Niger, which translate to an average of €1.62 per capita per day, which is about on par with the US $1.90 poverty line. However, while the projected returns are low and fluctuate over the years, they are not projected to significantly decline for this country over the 25-year period.

[27] A recommended formula for computing household size for this purpose is: HH size =(A+αK)^θ where A is number of adults in the household; K is the number of children; α is the cost of a child relative to an adult; and θ controls the extent of economies of scale. For low income countries, is recommend that α be set at 0.25 or 0.33 and θ be set at 0.9. For this baseline survey: θ = 0.33 and θ = 0.9. Source: Deaton, A and S. Zaidi. (2002) "Guidelines for constructing consumption aggregates for welfare analysis," Working Paper No. 135. The World Bank, Washington, D.C.
[28] Purchase Power Parity (PPP) takes into account each country's idiosyncratic purchasing power, i.e. the quantity of currency required to purchase a given basket of goods and services. The PPP conversion rates—which were 0.3 for Rwanda and 0.4 for the six other countries—were source from: http://data.worldbank.org/indicator/PA.NUS.PPPC.RF
[29] See, for example: Harris, D. and Orr, A. (2013). Is rainfed agricultural really a pathway from poverty? Agricultural Systems https://doi.org/10.1016/j.agsy.2013.09.005

The principle driver for the projected inter-annual fluctuations in net returns, particularly in Niger, Rwanda and Ethiopia, is expected inter-annual rainfall variation, given the patterns experienced in the intervention areas of these countries over the past 10 years. However, given that past rainfall patterns are unlikely to be precisely replicated in the future, the model is not able to predict the exact year when fluctuations in returns will occur, only that there is likely to be such fluctuations. Increasing conditions of climate variability additionally complicate the situation. Unfortunately, this was not modelled, given the absence of reliable data on how local rainfall patterns are likely affected by climate change.

Reverting to Figure 30 Mali starts, particularly in Year 1, at the highest position at €7.35 per capita per day, well above the international poverty line. However, this is projected to drop to €5.17 by Year 25. The is largely due to expected losses in soil fertility over time, given a lack of relevant management practices practiced at baseline by the surveyed households of this country, e.g. fertilizer and manure application.

Another way to measure the returns of a farming system is to measure its Net Present Value (NPV). This is the difference between the present value of cash inflows minus outflows over a given period. A discount rate (e.g. 5% or 10%) is typically included to take into account the returns that could be earned through alternative investments. Figure 31 presents box plots for each country's 10-year NPV projections. This is the sum of the first 10 years of annual projected returns, less the 10% discount rate applied to each annual projection. The pattern across countries is like Figure 30 but the variation across households is now apparent. Niger has the lowest projected NPV, with the least inter-household variation, while Mali has the highest projected NPV, with the greatest inter-household variation. There are small percentages of households (particularly in Mali and Senegal) with negative NPVs, meaning that are projected to put more into their farms than they will get out.

10-year projected net farm returns vary considerably across both households and countries. The gap between Mali and Niger is particularly noteworthy.

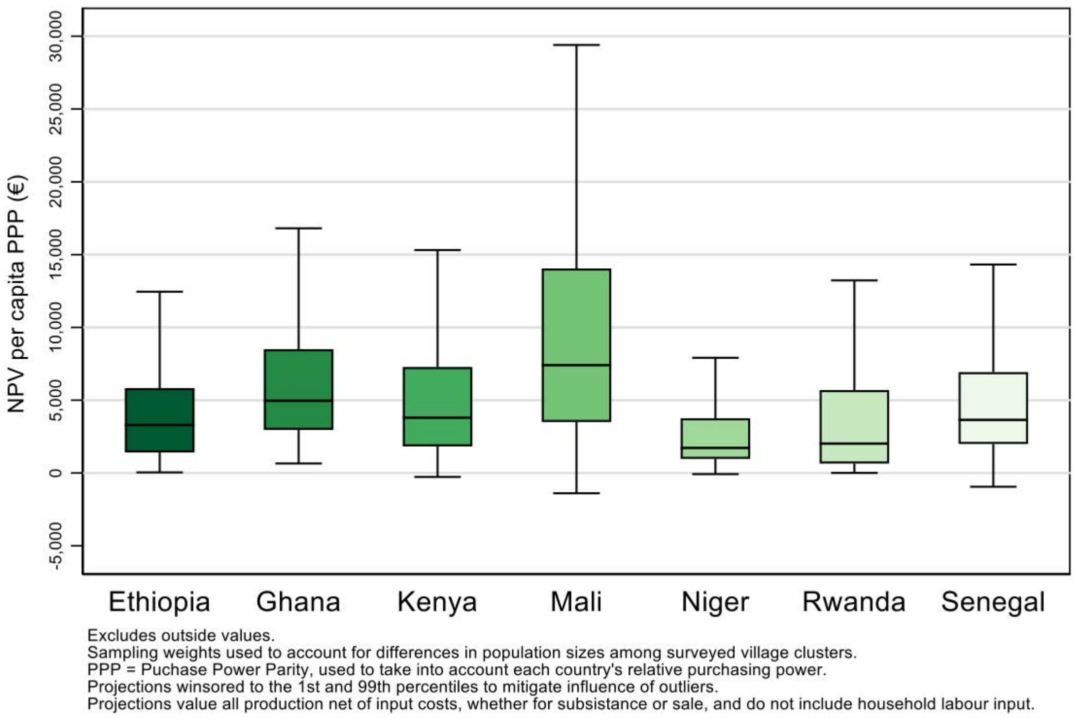


FIGURE 31: Farm Net Present Value (PPP) 10 year projection

Figure 32 presents similar projections focusing only on tree products. Given challenges in their estimation, these projections do not include input costs, hence the use of present value, rather than net present value. Interestingly, Rwanda stands out as the highest, followed by Kenya and Mali. The monetary value of tree products found on-farm in Niger and Senegal at baseline was projected to be low.

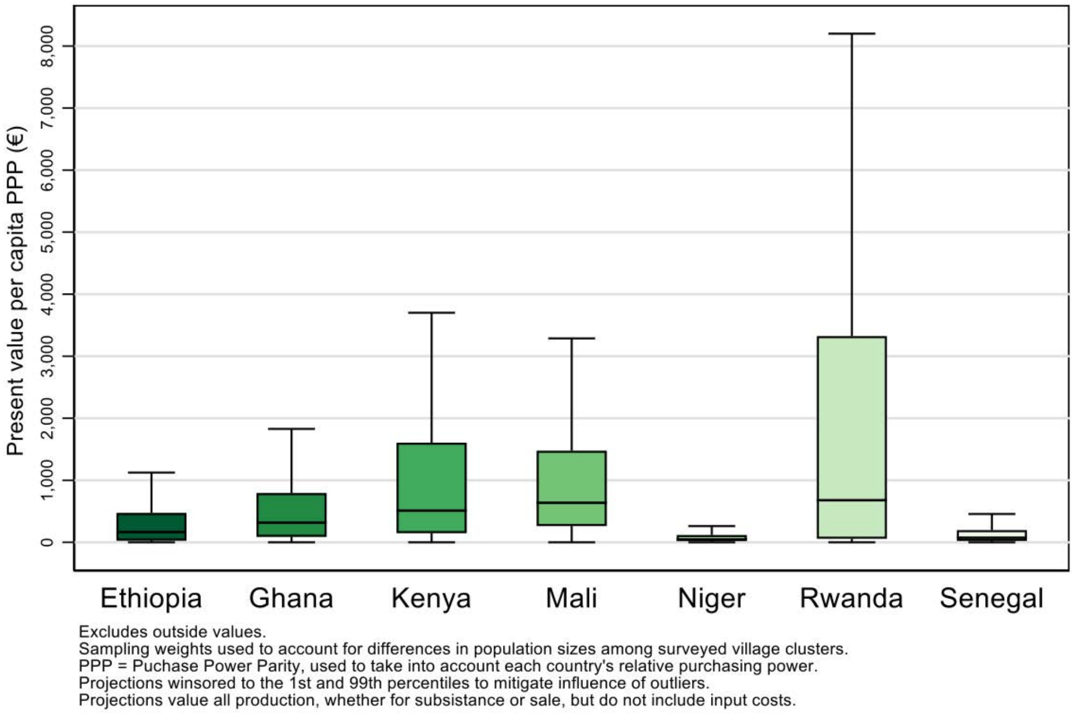


FIGURE 32: Present Value (PPP) of Trees Products, 10 year projection

Figure 33 is particularly revealing. It presents box plots for the 10-year present value of annual crops and tree products found on-farm in each country. We see clearly that the present value of the former dominates in all countries, save for Rwanda where there is much more of a balance. Exploring opportunities to increase the income generating potential of trees on-farm to complement the contribution of annual crops is a clear priority.

The relative contribution of tree products to farming system returns was low in all countries at baseline, save for Rwanda. Regreening Africa is seeking to change this.

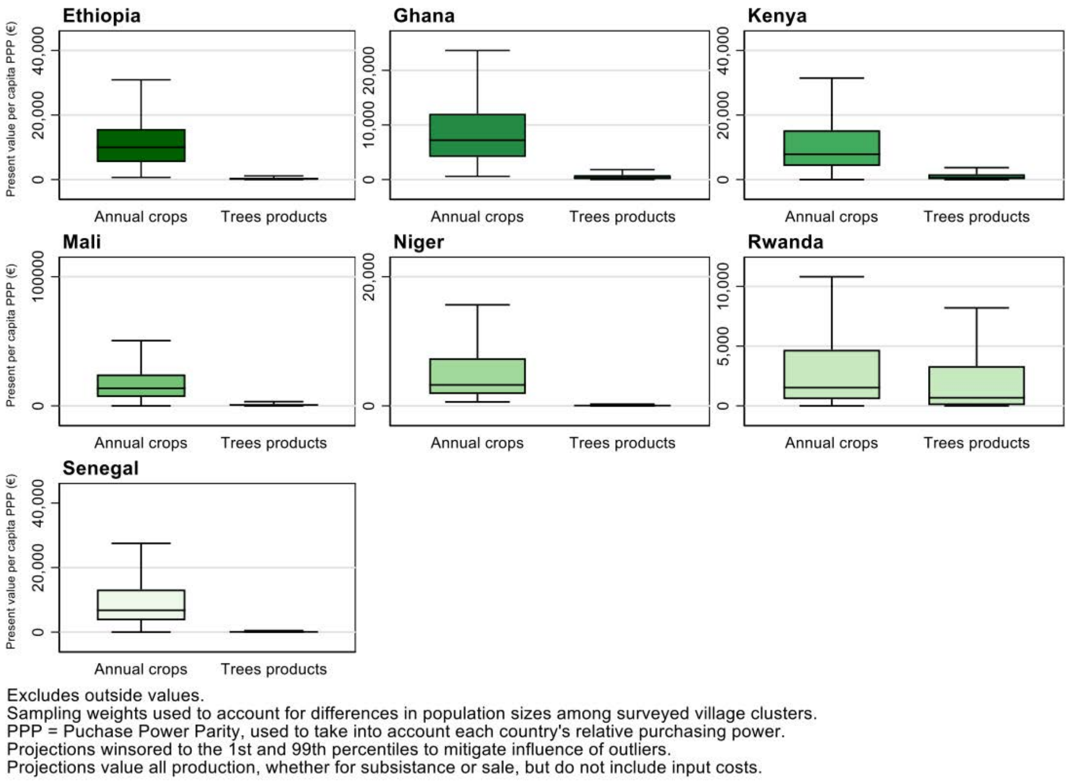


FIGURE 33: Annual crop and Tree Product present Value (PPP), 10 year projection

Photo: Elisee Bahati, World Agroforestry / A farmer uprooting weeds at the RRC in Gatsibo District in Rwanda.

FOOD SECURITY AND HOUSEHOLD WEALTH STATUS

Food security indicators

The baseline survey captured information from respondents on two individual-based and popular measures of food and nutritional security: the Minimum Dietary Diversity-Women (MDD-W) and the Food Insecurity Experience Scale (FIES). The latter is used to measure Sustainable Development Goal (SDG) Indicator 2.1.2 (Severity of Food Insecurity).

MDD-W is a proxy for measuring micronutrient adequacy. Capturing 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 (Figure 34). The resulting data were analysed as a binary variable using this measure's 'official' cut-off of five or more food groups (Figure 35).

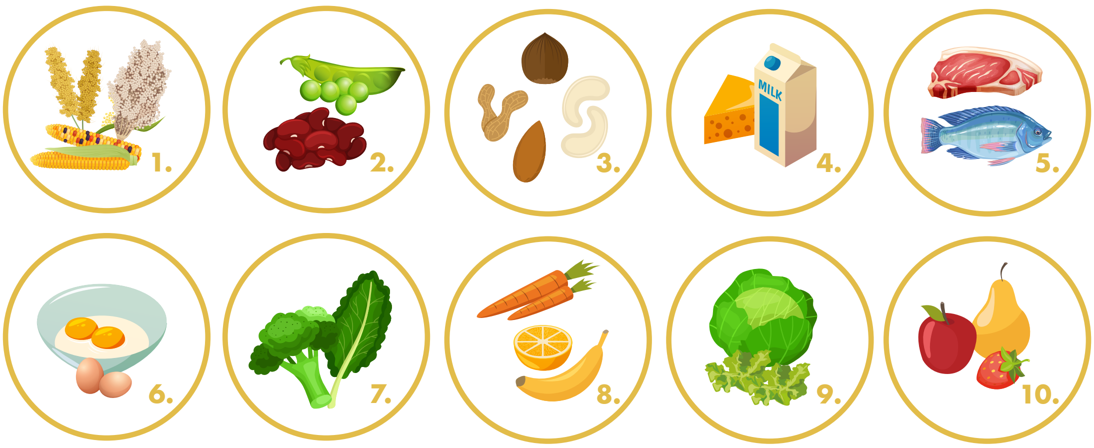


FIGURE 34: MDD-W's 10 food groups 1) grains, 2) pulses, 3) nuts & seeds, 4) dairy, 5) meats & fish, 6) eggs, 7) dark greens, 8) vitamin A rich vegetables & fruits, 9) other vegatables, 10) other fruits

Dietary diversity appears low across all programme areas, but with significant variation across countries.

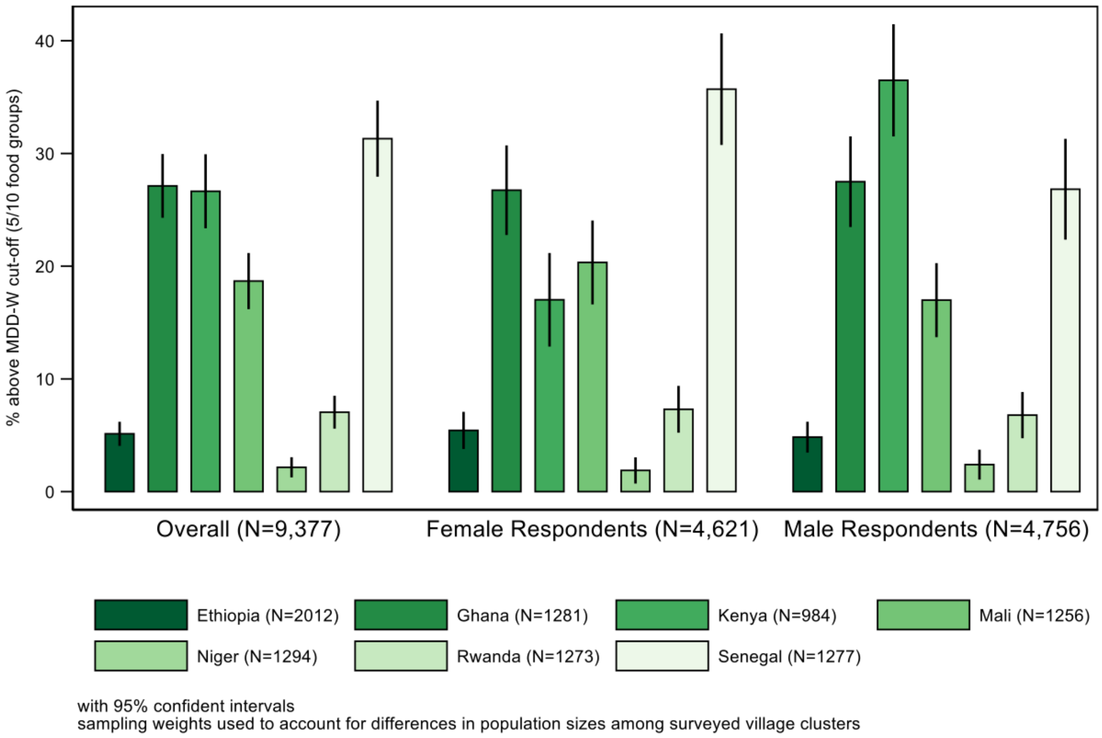


FIGURE 35: Minimum Dietary Diversity Woman (MDD-W)

Across all seven countries, only 13% of respondents reached the MDD-W cut-off, with a small, yet statistically significant, difference in favour of male respondents (14.3% versus 11.8%). What is particularly noteworthy is the large variation across the seven countries. For example, only 2.2% of male and female respondents reached the cut-off in Niger, compared with 31% in Senegal. It is interesting to note that women were more likely to surpass this cut-off than men in this latter country. The situation is the reverse in Kenya, where men were more likely to surpass the MDD-W cut-off than women.

Information about FIES, and the specific questions asked for FIES are presented in the box below. It is recommended that the data drawn from the responses be aggregated using a psychometric statistical model knows as the Rasch model. However, for the ease of interpretation, the raw score out of eight points is presented in Figure 36

The FIES Survey Module

Eight questions are asked that refer self-reported behaviours and experiences associated with increasing difficulties in accessing food due to resource constraints.

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 Food Insecurity Experience Scale (FIES) is being used to measure SDG Indicator 2.1.2: Prevalence of moderate or severe food insecurity in the population.

The overall average score across the seven countries is 4.5 out of 8 possible points, indicating moderate food insecurity according to FIES's eight-point scale. Like MDD-W, there is no overall significant difference between female and male respondents. Again, such averages mask variation both across and within the seven countries, as revealed by the box plots presented in Figure 34. Both female and male respondents in Kenya, Niger, and Rwanda reported high levels of food insecurity experience, with 50% responding affirmatively to at least seven out of the eight questions. This percentage was significantly less for Ethiopia, Mali and Senegal.

Figure 37 complements Figure 36y presenting a map with average FIES scores at the village level. The enables an examination of the extent of spatial variation in reported insecurity.

Levels of food insecurity experience were reported to be generally high, but with significant variation both across and within the seven countries.

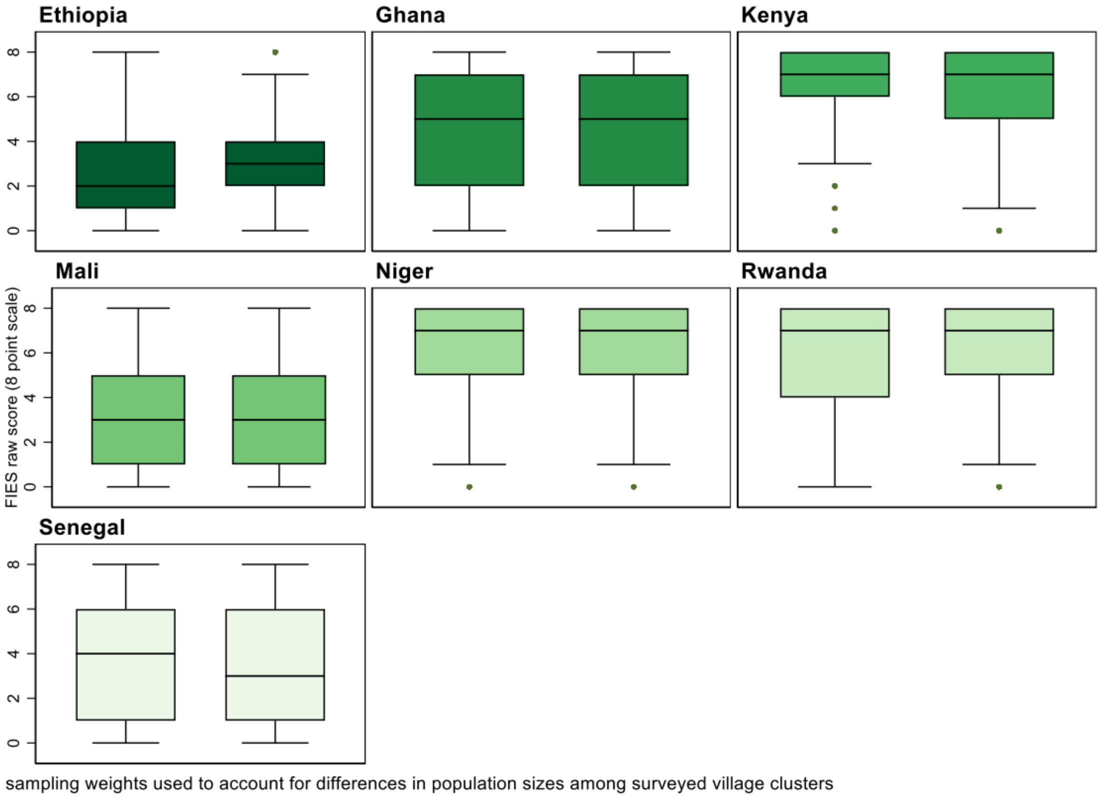


FIGURE 36: Food Insecurity Experience scale raw score

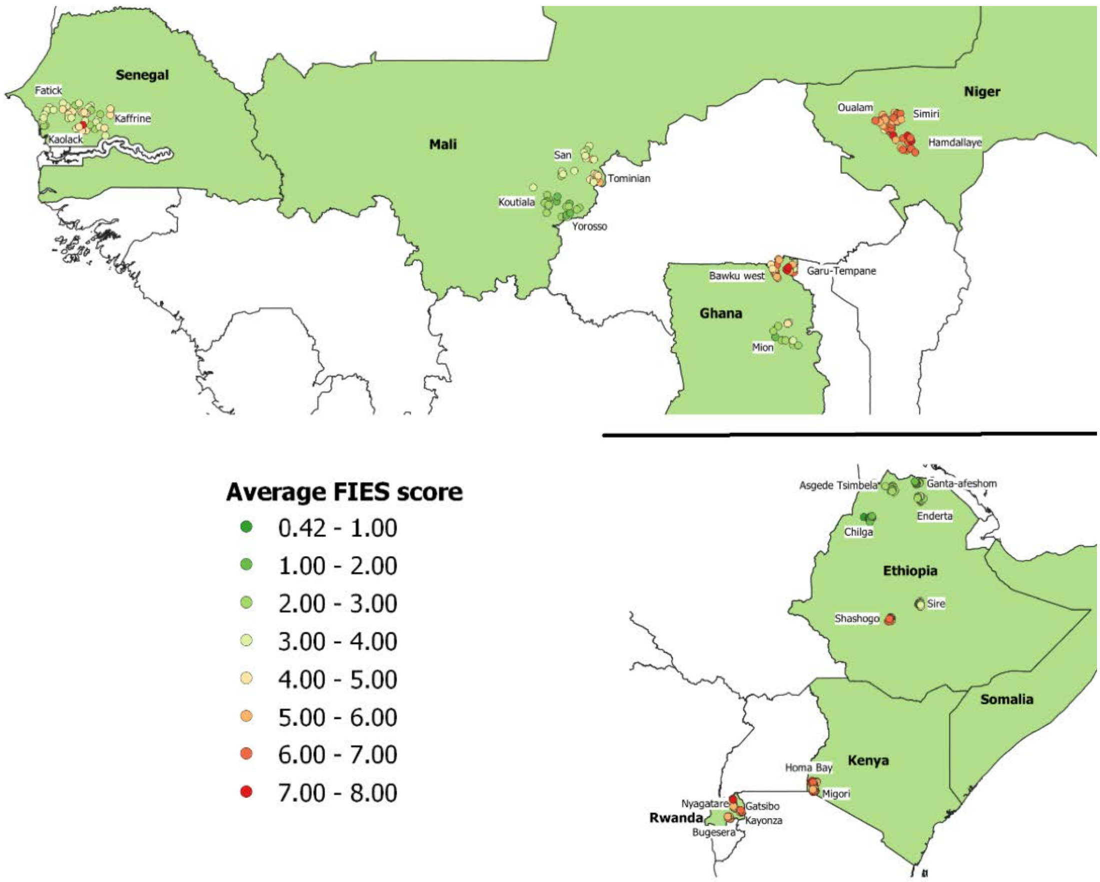


Figure 37: Average FIES scores at village level

Household wealth status

One way of measuring a household's established wealth status is by examining the assets it owns. More wealthy households tend to have more items that are deemed valuable in the local context, such as livestock, farm equipment and 'modern' household durables. They also tend to live in homes constructed of more valuable materials.

To measure household wealth status, country-specific asset indices were created based on between 75 and 106 correlated asset items via principal component analysis.

During the survey, respondents were asked whether they or anyone in their households owned or possessed assets and other household wealth indicators from long predefined lists, adapted to each country as necessary. The correlation among these various items was then tested, with only those significantly correlated with the others retained (inter-item test correlation > 0.2). Depending on the country, this resulted in between 75 and 106 shortlisted asset items in total. The resulting asset lists were found to be well correlated with one another, with inter-item correlations (α) ranging from 0.83 to 0.91. For each country (or region in the case of Ethiopia), the binary indicators were placed on a tetrachoric correlation matrix, and principal component analysis (PCA) was used to narrow in on the variation shared among these indicators to create a household wealth index. The resulting indices are appropriate for comparing the relative – rather than the absolute – established wealth status of households within their respective countries but not between.

Because the household wealth index is a relative, rather than absolute, measure, it is useful for comparing relative differences between groups or how conditions have changed over time. It is also useful to see how household wealth status is associated with other indicators. Figure 37, for example, shows that there is an expected negative association between household wealth states and food insecurity experience.

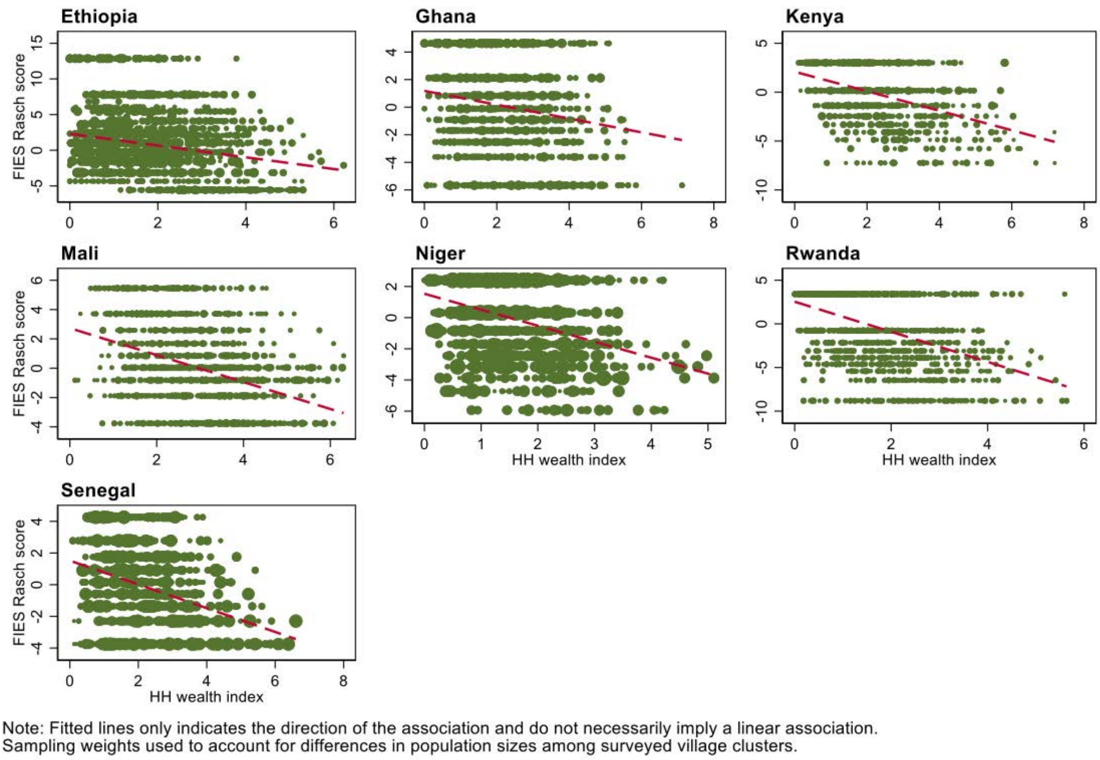
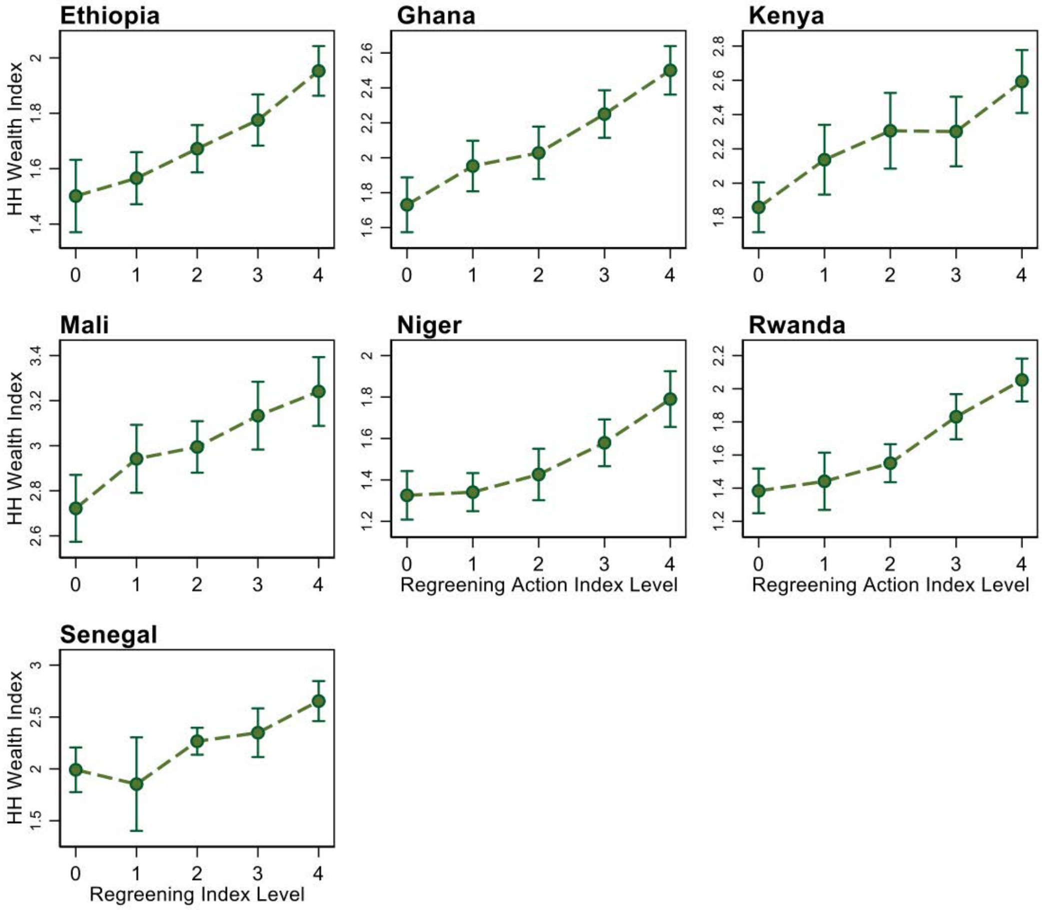


Figure 38: Association between wealth index & FIES Rasch score

One interesting association is between the wealth index and the Regreening Action Index. The association is not only highly statistically significant but also close to being linear. In other words, households that have higher scores on this index tend to have higher levels of asset wealth. Figure 38 shows the association between five levels of the Regreening Action Index and household wealth. With each level of the former, there is a corresponding increase in the latter. Statistical tests (linear contrast and departure from linear trend) reveal that the association between the two indices is highly linear in all seven countries, as illustrated visually in Figure 38. This does necessarily mean that regreening action leads to higher levels of household wealth, but the relationship is a noteworthy one.

A strong, near linear association exists between the Restoration Index and the household wealth index; households that have undertaken more regreening action tend to be relatively wealthier.



Regreening Action Index level predictions with 95% confidence intervals.
Sub-national program area (e.g. district) fixed effects used in all models.
Sampling weights used to account for differences in population sizes among surveyed village clusters.

Figure 39: Association between Regreening Action Index and HH wealth index

Photo: May Muthuri, World Agroforestry / A member of Bishola Women Group in Ethiopia potting tree seedlings for the nursery.

08

Photo: Neil Palmer (CIAT)

TREE-BASED VALUE CHAINS

Regreening Africa is seeking to identify and strengthen key tree-based value chains to reinforce and incentivise regreening and broader land restoration efforts by participating communities and beyond. A schematic presentation of the various value chain development stages and examples of elements involved in the overall development frame is shown in Figure 40. To identify promising tree-based value chains, a value chain assessment exercise was undertaken to:

1. Identify relevant tree-based value chains
2. Prioritize product chains of interest to restoration stakeholders
3. Identify the role of gender in prioritized value chains
4. Determine constraints, opportunities and feasible strategies to strengthen value chains development, such as capacity development, linkage facilitating, brokering, and financing.

To inform the selection of tree-based value chains, focus group discussions were carried out with nearly 2,000 male and female farmers.

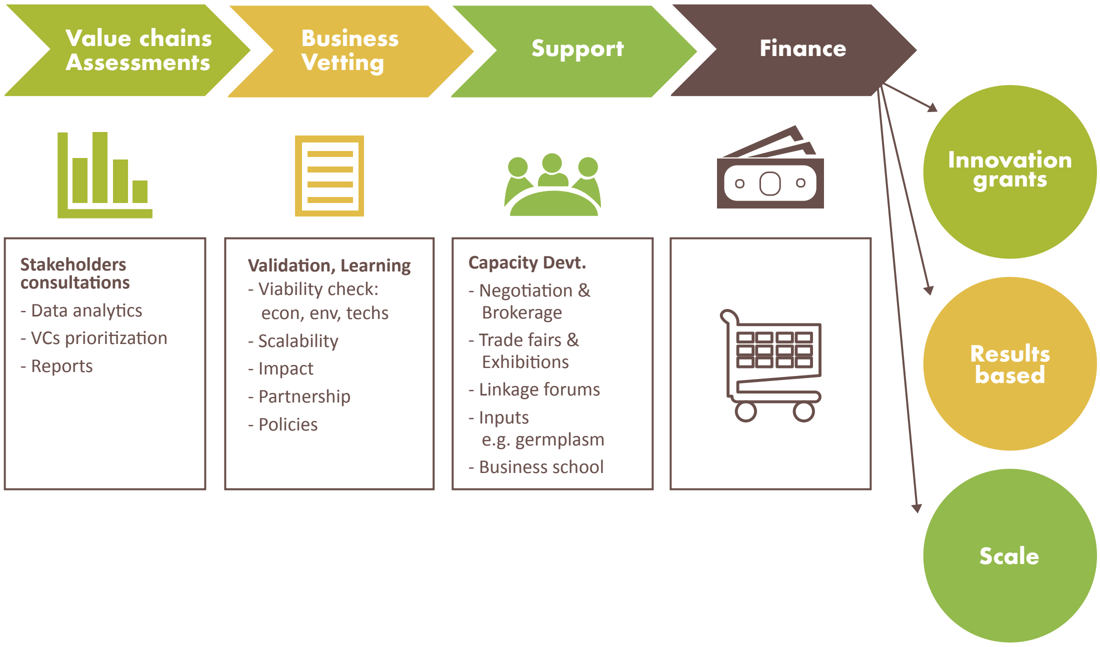


FIGURE 40: Schematic presentation on the key elements involved in value chain identification strengthening approach

Methods

Data were collected in the intervention sites of six out of the seven countries[30] through gender-disaggregated focus group discussions (FGDs) at the village level. To facilitate the identification of suitable value chain development options given varying degrees of market access, two categories of villages were purposively selected for the value chains prioritization exercise: i) village with good market access (i.e. those close to markets for agricultural produce and regional and urban centres and with accessible road networks); and ii) village with poor market access (i.e. those relatively remote with poor road networks). In total, 97 female FGDs (995 participants) and 95 male FGDs (974 participants were conducted across the six countries (Table 2). A tree-based value chain identification and ranking exercise was facilitated during each FGD, followed by an aggregation of the results at country level.

[30]A value chain assessment study was carried out in Rwanda by World Vision for another Forest and Land Restoration (FLR) project covering geographical areas similar to those where Regreening Africa's direct community engagement interventions are being implemented. Consequently, information and insights obtained from this study were used to inform value chain prioritization in this country.

Country	Focus Group Discussion Women		Focus Group Discussion Men	
	No. of FGD	No. of participants	No. of FGD	No. of participants
Ethiopia	25	198	26	228
Kenya	13	138	11	125
Mali	16	166	16	152
Niger	18	185	18	193
Ghana	13	174	12	144
Senegal	12	134	12	132
Total	97	995	95	974

TABLE 2: Village-level value chain assessment participant numbers

Results

Table 3 presents the aggregated results by gender and country. Timber and fuelwood were identified as a top priority in East Africa. Fuelwood i.e firewood and charcoal, is mainly sourced from Acacia spp, Ziziphus mauritiana, Balanites aegyptiaca, Schinus molle, Rhus spp, Cordia africana and Eucalyptus spp. Timber is obtained from Eucalyptus, Cordia Africana and Olea europaea. In West Africa, priority value chains include Vitellaria paradoxa (Shea for its fruits and firewood in Ghana and Mali), Moringa oleifera (leaves for household consumption and sale in Niger), Adansonia digitata (for fruits and leaves in Senegal and Mali), Mangifera indica (mainly for fruits in Niger and Senegal), Parkia biglobosa (for pulp and valuable seeds in Mali), Ziziphus mauritiana (fruits) and other fuelwood species. For five of the countries, the aggregated ranking is very similar for men and women. However, the results were significantly different across gender groups for Niger and, to a lesser extent, Senegal. In Niger, women prioritized products associated with Ziziphus mauritiana, Balanites aegyptiaca and Hyphaene thebaica, while men ranked those associated with moringa, mango, and eucalyptus. In Senegal, women ranked baobab and tamarind, while their male counterparts prioritized baobab and mango (Table 3).

Gender	RANK	Ethiopia	Kenya	Mali	Niger	Ghana	Senegal
MALE	1st	**Timber** (Eucalyptus, Cordia, Olea)	**Fuelwood** Acacia, Balanites, Rhus)	**Shea butter** *(V. paradoxa)*	**Moringa vegetable** *(M.oleifera)*	**Shea butter**	**Baobab vegetable**
	2nd	**Fuelwood** (Acacia, Eucalyptus, Cordia)	**Timber** (Grevillea, Balanites, Ficus)	**Soumbala** *(P. biglobosa)*	**Mango fruit** *(M. indica)*	**Fuelwood**	**Mango fruit**
	3rd	**Food** (Rhamnus, Cordia, Ficus)	**Food** (Carissa, Citrus, Carica)	**Baobab vegetable** *(A.digitata)*	**Timber** (Eucalyptus spp.)	**Fruit**	**Cashew nuts** *(A. occidentale)*
	4th	**Fodder** (Faidherbia, Cordia)	**Medicine** (Balanites, Markhamia)	**Mango fruit**	**Ziziphus fruit** *(Z. mauritiana)*	**Charcoal**	**Fuelwood**
	5th	**Fence materials** (Eucalyptus, Opuntia, Ficus)	**Fodder** (Leucaena)	**Tamarind juice** *(T.indica)*	**Baobab vegetables** *(A.digitata)*	**Medicine**	**Ziziphus fruits**

TABLE 3: Aggregated ranking of village level value chain prioritization options

Gender	Rank	Ethiopia	Kenya	Mali	Niger	Ghana	Senegal
Female	1st	**Fuelwood** (Acacia, Eucalyptus, Cordia)	**Fuelwood** (Acacia, Albizia, Balanites)	**Shea nuts**	**Ziziphus fruits**	**Shea nuts**	**Baobab vegetables**
	2nd	**Timber** (Eucalyptus, Olea, Cordia)	**Timber** (Grevillea, Eucalyptus)	**Baobab vegetable**	**Balanites fruits**	**Dawadawa Parkia seed**	**Tamarind juice**
	3rd	**Food** (Rhamnus, Cordia, Africana)	**Medicine** (Balanit., Leucaena Eucalyptus)	**Soumbala** (Parkia seed)	**Timber Hyphaene thebaica**	**Fruit**	**Mango fruit**
	4th	**Fodder** (Cordia, Opuntia, Faidherbia)	**Food** (Citrus, Mangifera, Carica)	**Tamarind juice**	**Faidherbia**	**Fuelwood**	**Ziziphus fruit**
	5th	**Fence materials**		**Saba fruit Saba senegalensis**	**Moringa vegetable**	**Charcoal**	*Cordyla pinnata*

TABLE 3 CONT: Aggregated ranking of village level value chain prioritization options

Final list of prioritized value chains and key developmental constraints

The final list of prioritized value chains was informed by both the above community consultation process and considerations such as potential profitability and market access and demand.

Following the above and other considerations (e.g. income generation potential and market access and demand), Table 4 presents the final list of prioritized value chains by country, as well as the major constraints associated with the development of each in consultation with implementors. Key cross-cutting constraints include: scarcity of trees products on farmland and community areas due to excessive logging of indigenous species; lack of appropriate collection equipment; inadequate post-harvest transportation facilities; and uncontrolled livestock grazing.

The ban on free exploitation of tree products by forester agents remains a major constraint mainly in the Sahel. On tree products processing, the major challenges are related to the lack of adequate processing equipment and the lack of training on processing techniques and standards of NFTP at village level. FGDs revealed that market access for tree products and services is hampered by poor access to consumer centres, market saturation and low prices fetched at the local markets. To unlock performance for priority value chains, strategies include facilitating market linkage, capacity development on value addition, entrepreneurship, business planning, strengthening producer organisations for aggregation, facilitating access to quality germplasm, improving vertical coordination through contracting or private sector engagement, reviewing existing logging policies to inform policy dialogue with relevant authority and advocating for improved infrastructure to support collection, storage, processing, and marketing.

Country	Priority value chain	Targeted gaps to be addressed
Ethiopia	**Bamboo**	• Limited value addition skills; poor market linkages
	Cactus	• Production, harvesting, financial management challenges
	Firewood	• Lack of business development plans; limited value addition skills; market linkage
	Fruits	• Lack of knowledge on financial and cooperative management; production harvesting, financial management challenges; low access to quality germplasm
	Gesho leaves *(Rhamnus prinoides)*	• Limited value addition skills; market linkage; production harvesting, financial management challenges

Country	Priority value chain	Targeted gaps to be addressed
Ethiopia	Honey	• Lack business development plans; limited value addition skills; market linkage; Poor infrastructure for collection, storage, processing, sales & transport; production, lack of protective clothing and equipment for safe harvesting, financial management challenges
	Poles and timber	• Lack of management skills; market linkage; production harvesting, financial management challenges; poor access to quality germplasm
	Firewood	• Lack of business development plans; limited value addition skills; market linkage
	Fruits	• Lack of knowledge on financial and cooperative management; production harvesting, financial management challenges; low access to quality germplasm
Ghana	Firewood	• Depleting tree-stock; poor infrastructure for collection, storage, processing, sales & transport; production, lack of protective clothing and equipment for safe harvesting in the forest, financial management challenges
	Fruits	• Limited value addition skills; Poor infrastructures for collection, storage, processing, sales & transport; quality germplasm
	Medicinal tree products	• Lack of knowledge on appropriate dosage; production harvesting, financial management challenges
	Shea	• Depleting tree-stock; production harvesting, financial management challenges
	Timber	• Identification of preferred & marketable crops to complement long timber rotation cycles; lack tree management skills
Kenya	Honey, mango & pawpaw	• Limited access to quality germplasm (mango and pawpaw); inadequate harvest and post-harvest handling skills; equipment, and financial management challenges
Mali	Shea	• Few producer groups; poor infrastructures for collection, storage, processing, sales & transport
	Soumbala	• Depleting tree-stock; poor market linkages; poor infrastructure for collection, storage, processing, sales & transport
Niger	Ziziphus & moringa	• Few producer groups; poor market linkages; low quality germplasm
Rwanda	Fruits (avocado, mango)	• Few producer groups; poorly developed business development plans; poor market linkages; low involvement of women
	Timber	• Gender mainstreaming; lack business development plans; private sector involvement

Table 4: Value chain types and constraints identified per country
*List does not include Senegal pending findings validation by implementors

10

BASELINE STATUS OF POLICY AND INSTITUTIONS

Regreening Africa is seeking to shape the policy and institutional environment to accelerate the scaling up of appropriate restoration options.

As implied in Regreening Africa's Theory of Change, conducive policies and institutions are critical for scaling up land restoration efforts. Barriers for adoption and scaling up are often nested within policy and institutional frameworks. These range from national and sub-national policies to local by-laws in key areas such as land tenure, tree tenure and grazing land management. They also include social and cultural norms around access and use of trees and tree products or communal forest areas.

For Regreening Africa, the key institutional and policy issues were identified through the following methods:

- Cross-country inception workshop;
- Desk review of policy documents across the participating countries;
- National level stakeholder workshops and associated survey;
- Discussions with local communities and field observations by project staff.

Photo: Aadan Maxamed Caqli, World Vision Somalia / Staff from World Vision Somalia and farmers engage in discussions on successes, challenges and opportunities, during the JRLM field visits.

NGO and partner perspectives of key barriers to regreening

During the project inception period, a cross-country workshop and a series of national level workshops took place to develop country implementation plans. During these events, NGO implementers and their partners identified several priority barriers to scaling land restoration through natural regeneration and tree planting. These barriers were classified as behavioural if they related to people's perceptions, beliefs and behaviours, or structural if they were created by circumstances. The identified barriers are outlined in Table 5. While this is not an exhaustive list, i.e. additional barriers are likely to exist overall and in specific countries, it does demonstrate a wide range of barriers. Restoration programmes must address barriers relevant to a particular context, often necessitating change to the policy and institutional environment.

Implementing partners identified multiple structural and behavioural barriers that militate against the scaling-up of tree-based restoration.

Barriers	Ethiopia	Ghana	Kenya	Mali	Niger	Rwanda	Senegal	Somalia
STRUCTURAL								
Biophysical								
Land degradation, invasive species, clearing for biomass, insecurity, mechanization, bushfires, flood/ drought	✓	✓	✓	✓	✓	✓	✓	✓
Protection of seedlings, water access	✓	✓	✓	✓			✓	✓
Lack of seed/ seedling/scion stock including indigenous	✓		✓			✓	✓	✓
Socio-Economic								
Inadequate markets and investment, lack of economic incentive, long timeframe for returns (poverty)	✓	✓	✓	✓	✓	✓	✓	✓
Lack of knowledge or enforcement of policy, breakdown of traditional systems, poor governance	✓		✓	✓	✓		✓	✓
Absence of secure land/tree tenure		✓	✓	✓	✓		✓	✓
BEHAVIOURAL								
Low women's decision-making power					✓	✓	✓	
Free grazing mentality and conflict with cattle herders or over natural resources	✓		✓		✓			✓
Perceptions of restoration, roles, wildlife, and tree clearing impacts	✓	✓	✓				✓	
Perceptions of trees as competition with crops and lack of short-term return	✓	✓	✓		✓	✓	✓	✓

TABLE 5: Behavioural & structural barriers to scaling land restoration options identified by implementing NGOs and partners during project inception

Most countries have high-level policies favouring regreening but multiple areas for improvement were identified.

Policy status at the national level

A desk review of policy documents linked to agroforestry[31] was undertaken in each country and validated through NGO partners, National Oversight and Coordination Committee (NOCC)[32] members, and national workshops. A summary of the results is presented in Table 6. Almost all countries had policy documents that mentioned agroforestry, but only half had specific agroforestry strategies or policies (either finalized or under development). Policies pertaining to tree tenure were also absent in many of the countries, particularly in the Sahel but also in Ethiopia. Agriculture or environment institutions coordinate agroforestry efforts in most of the countries but coordinating mechanisms to bring in other sectors and stakeholders were largely absent.

Country	Agroforestry consideration in national policies		Tenure		Coordination of agroforestry	
	Agroforestry policy or strategy	Level of consideration of agroforestry in national policies (HML)	Secure tree tenure	Secure land tenure	Coordinating sector	Coordinating mechanism
Ethiopia	Strategy drafted	M	No	No	Agriculture	Platform
Ghana	Policy 1986	H	No	Yes	Not clear	None
Kenya	Strategy under development	H	Linked to land	Legally yes, culturally no	Agriculture	None
Mali	None	L	No	Some	Environment	None
Niger	None	H	No	Yes	Environment	None
Rwanda	Strategy and action plan	M	Linked to land	Yes	Environment	Platform under development
Senegal	None	L	No	Some	Environment/ Agriculture	None

TABLE 6: National level agroforestry policy and coordination status, as well as security of tenure by country[33]

Activity area categories	Kenya	Rwanda	Ethiopia	Niger	Mali	Senegal	Ghana
Policy and strategy	✓	✓	✓	✓	✓	✓	✓
Communication, capacity and advisory	✓	✓	✓	✓	✓		✓
Coordination		✓	✓		✓	✓	✓
Evidence, monitoring, evaluation and learning	✓	✓	✓				✓
Investment	✓			✓	✓		✓
Value chains / markets			✓			✓	

TABLE 7: Activity areas for scaling agroforestry and regreening of countries as identified during national level workshops[34]

[31] The desk review focused on agroforestry as it is a key restoration mechanism and includes a range of practices such as farmer managed natural regeneration (FMNR) and tree planting which the project is promoting.
[32] NOCCs were established in each country to ensure strong connection to government, the donor and related stakeholders
[33] Adapted from Bourne et al. forthcoming
[34] Ibid.

During national SHARED[35] workshops, which took place in late 2018 and early 2019, participants from NGOs, government, civil society and academia identified a number of activity areas to enhance restoration efforts in the country. These activities are grouped as shown in Table 7 and indicate that policy work and communication efforts were considered a priority across all the countries.[36]

Outcome mapping

Project teams in each country have identified several policy and institutional priorities, building on the barriers identified at the local level and the policy options at the national level. The Outcome Mapping approach was used, in particular, to support country teams in identifying relevant stakeholders that need to be engaged to address prioritised barriers and strategies for undertaking such engagement. The approach will also be used to support Regreening Africa to track progress towards bringing about a more conducive enabling environment for the scaling of land restoration options and not only focus on monitoring activity implementation.

Stakeholders at national SHARED workshops in each country were asked through a survey to identify other stakeholders they work with on regreening and restoration. Analysis gave the total number of stakeholders in each network and the density of the network. This is a measure of how connected stakeholders are, with a fully connected network scoring 1 (Table 8). The low-density scores across the networks (0.1-0.2) demonstrates that, while there are many organizations working on regreening (between 29 and 77 in each network), they are not well coordinated or connected. Social network analysis combined with Outcome Mapping provides a strategic way for the project partners to identify the stakeholders with whom they must engage in order to shift important policy and institutional dimensions are relevant to scaling. In this way, they focus on stakeholders with the most connections.

Network analysis revealed the need to improve the coordination and connectivity among actors spearheading restoration in the participating countries.

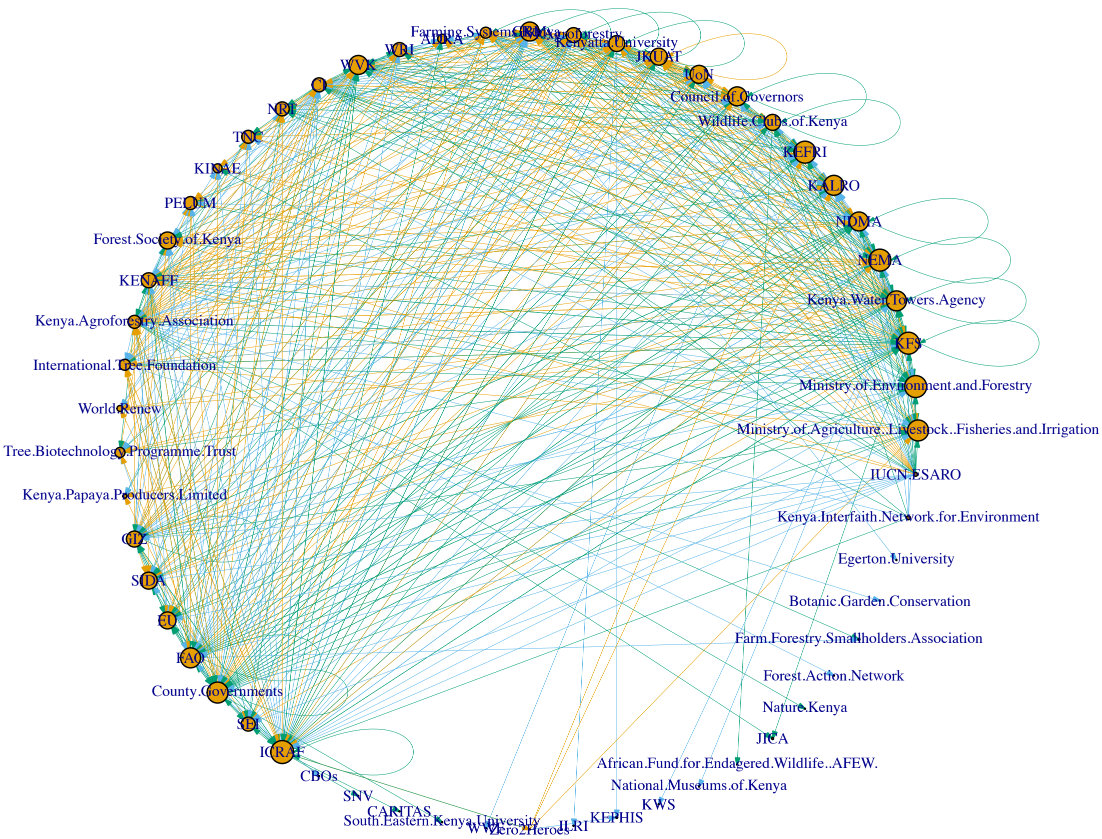


FIGURE 41: Example of social network sociogram for Kenya regreening/restoration stakeholders. Circle sizes are dependent on how connected the stakeholders are with larger circle indicating greater connection. Line colours represent level of collaboration with orange limited, blue some and green close.

[35]SHARED is the Stakeholder Approach to Risk informed and Evidence-based Decision-making (http://www.worldagroforestry.org/shared)
[36]Detailed action plans for each of the seven countries can be found at https://regreeningafrica.org/reports-and-publications/

Country	Number of stake-holders surveyed	Stakeholders identified linked to regreening/ restoration	Network density score
Ethiopia	19	70	0.14
Ghana	23	61	0.20
Kenya	33	57	0.20
Mali	12	29	0.14
Niger	25	72	0.10
Rwanda	24	46	0.20
Senegal	36	77	0.10

TABLE 8: Number of stakeholders identified in each country and network density

Network analysis revealed the need to improve the coordination and connectivity among actors spearheading restoration in the participating countries.

Use of evidence

Stakeholders at national SHARED workshops in each country were asked through a survey about their use of evidence (Figure 38). Many of the stakeholders were restricted in the quality and availability of data. Within the project we will use online decision dashboards to make evidence more accessible for informed decision making.[37]

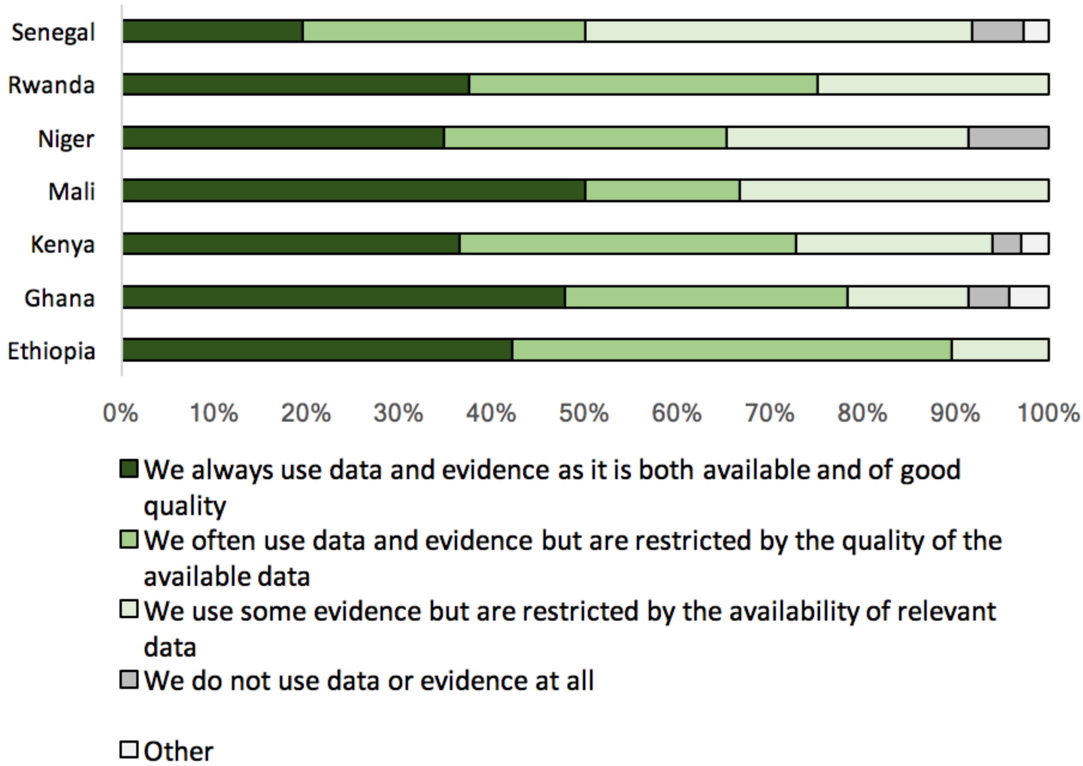


FIGURE 42: Organizational use of data and evidence for priortization and planning (%)

[37] See: http://landscapeportal.org/tools/

ANNEX 01

LOGFRAME MATRIX (REGREENING AFRICA)

	Results chain	Indicators	Baselines	Targets	Sources and means of verification	Assumptions
Overall objective: Impact	1 *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 **II 2.** Soil erosion prevalence **II 3.** % of tree cover within and along the boundaries of farmer fields (changed to fractional vegetative cover)	• Balanced • Balanced • Small difference (0.7%; p<0.05)	• 10% average increase over comparison households • 5% decrease over comparison fields • 10% increase over fields in non-scaling comparison sites	• 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.
Specific Objectives: Outcomes[38]	2. *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**. Number 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.
	3. *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.** Number of households taking new regreening practices up **SOI 3.2.** Number of hectares where new regreening practices are being applied **SO 3.3.** Number of country implementation areas with demonstrably strengthened agroforestry	• 0 • 0 • 0	• 500,000 households (281,650 direct; 218,350 leveraged[39]) • 1,000,000 hectares (527,083 direct; 472,917 leveraged) • 6 country intervention areas	• 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. Existence and motivation of value chain actors to engage. Political and security situations of participating countries sufficiently conducive.
Outputs	1. Viable and promising evergreening options identified for targeted scaling sites **R2.2**	**OI 1.1.** Number 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 and community interest in prioritizing evergreening options, with open questions to be answered through project M&E and learning.

[38]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.

[39]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 organization 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
Outputs	2. Project stakeholders equipped with new knowledge, skills, tools & resources to effectively promote prioritized regreening options **R3.2**	**OI 2.1.** Number 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 organizaiton 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.
	3. 500,000 households supported with viable & inclusive regreening options **R3.2**	**OI 3.1.** Number 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 and uptake surveys	High community participation and interest in the project's various training, extension and capacity development activities.
	4. Targeted agroforestry value chains assessed and provided with relevant regreening support **R3.3**	**OI 4.1.** Number of value chains identified and assessed per country **OI4.2.** Number of targeted value chain actors (e.g. traders, processers, and farmer associations) reached by interventions to strengthen targeted value chains	• 0 • 0	• 2 value chains per country • At least 3 types of actors supported per country	• Country activity reports	Market conditions for the identified value chains remain the same throughout the project. Risks associated with value chains investment/ participation will be minimal or well managed.
	5. Implementation and uptake monitoring data for adaptive management **R3.2**	**OI 5.1**. Number of Joint Quality Monitoring missions per country per year **OI 5.2.** Number of rounds of uptake surveys over life of the project per country	• 0 • 0	• 2 • 3	• Country activity reports • Uptake survey reports	Partners and ICRAF staff will have the time, capacity and resources to carry out the field monitoring and rapid uptake surveys. Security issues do not prevent the carrying out of these surveys.
	6. New evidence on the effectiveness of regreening is generated to inform wider policy and practice R 3.1	**OI 6.1.** Number of countries where policy or regulatory gaps for evergreen agriculture are assessed, identified and communicated **OI 6.2.** Number of learning events in which cost-effective ways to promote regreening have been disseminated **OI 6.3.** Number of country-level project impact policy briefs developed and disseminated	• 0 • 0 • 0	• 8 • 4 • 6	• Consolidated report on policy gaps • Scaling option comparison reports • Impact assessment reports	Sourcing of appropriate enumerators in each country will be possible, as well as capturing of biophysical data, given budgetary resources available. Security issues do not prevent the execution of impact assessments.

	Results chain	Indicators	Baselines	Targets	Sources and means of verification	Assumptions
Outputs	7. Land degradation dynamics, dimensions in all countries assessed **R2.1**	**OI 7.1.** Number of land health baseline datasets compiled, including LDN indicators **OI 7.2.** Number of intervention areas where land degradation dynamics have been assessed in coordination with in-country LDN assessments	• 0 • 0	• 8 (at least one per targeted country) • 8	• Databases of land degradation indicators developed • Maps of land degradation hotspots and dynamics/changes	Data, including remote sensing and local project data, are accessible and suitably meta-tagged.
	8. Countries equipped with surveillance and analytic tools (i.e. dashboards) **R2.1**	**OI 8.1.** Number of dashboards co-designed and available **OI8.2.** Number of stakeholders engaged and using dashboards and other tools	• 0 • 0	• 4 • 60	• Online dashboard beta versions • Online monitoring of dashboard access/ use via Google Analytics	Data, including remote sensing and local project data, are accessible and suitably meta-tagged. All stakeholders are willing to participate in innovative modes of land use planning.
	9. Regreening successes are compiled and communicated to policy makers, government and project stakeholders **R2.3; R 3.1**	**OI 9.1.** Number of structured evidence sharing events **OI 9.2.** % of targeted policy makers and other actors reached by re-greening success messages **OI 9.3.** Number of media pieces disseminated/ generated on regreening successes (i.e. via online videos, media coverage)	• 0 • 0 • 0	• 8 • 80% • 80 online or offline media pieces	• Workshop reports • Country and overall progress reports • Online video viewing data	Suitable evidence exists or can be created on existing re-greening successes and, if so, policy makers and other actors will find such evidence credible and relevant.

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

ANNEX 02

GENERATING TREE AND CROP PRODUCTION ESTIMATES

The procedure to estimate tree and crop production is one of the more complex aspects of the FarmTree® Model. Its purpose is to mimic the agroecological processes that determine tree and crop production on farms with agroforestry.

The procedure is as follows:

- Multiple product production is mimicked through an overall biomass production model, for selected trees or crops per year or per cropping cycle, that is distributed over roots, leaves, fruits, tubers, grains, branches, stems, etc., as per tree or crop definition.

- The country potential production per tree or crop is the average of the global maximum production, and the local high production as per FAOSTAT records. If no national records are available, an African average is used.

The country potential production then is the basis for estimating the farm production per year or per crop cycle. Figure A2 shows how the model arrives at an estimate of the simulated actual productivity in flowchart format.

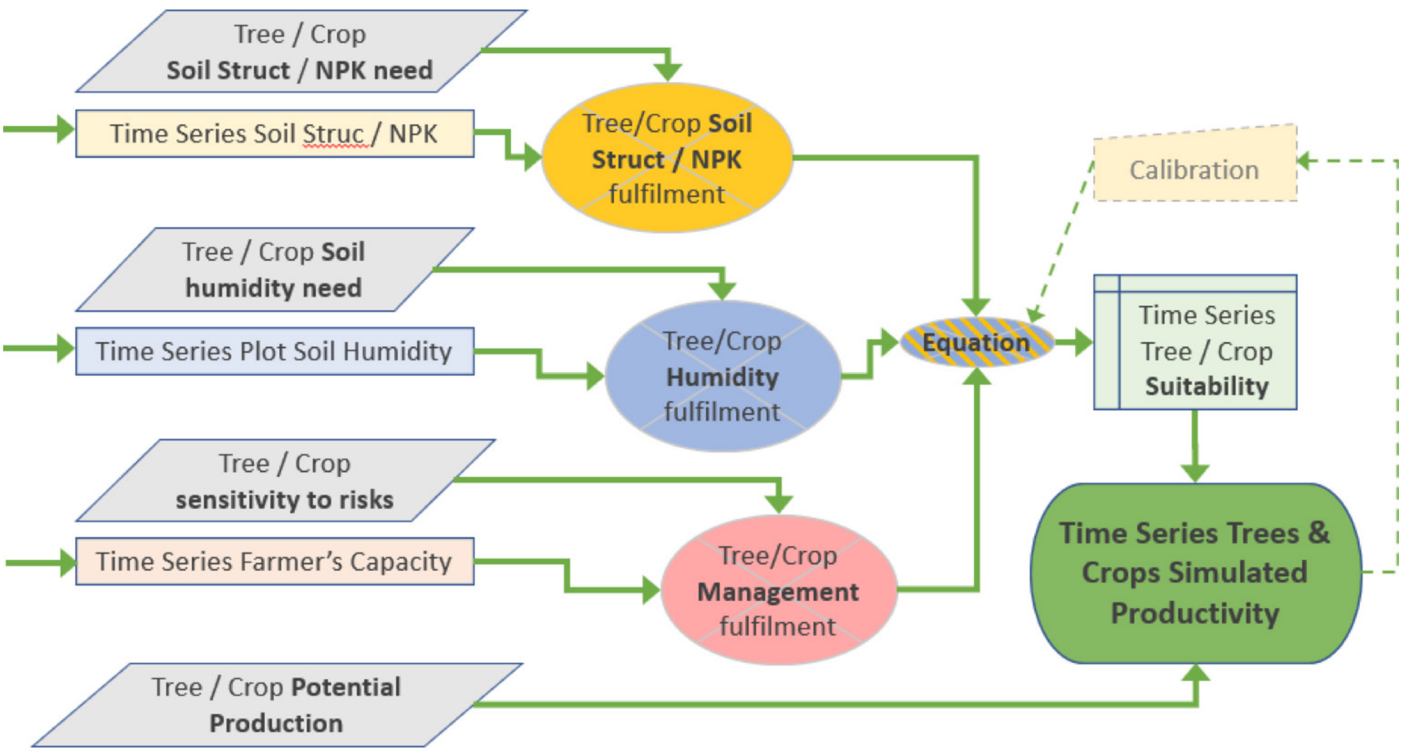


FIGURE A2: The individual tree or crop potential production is discounted towards simulated actual production by comparing tree /crop production needs, and on-farm realisation; and processing these into a time-series of tree and crop suitability.

The FarmTree® Model uses several monthly 'production risk' time-series to discount the potential production towards the simulated actual production. The number of 'risks' can be expanded, as per the system characteristics, for example, in some systems direct sun is a risk, in others it is salinization, or excess rain.

The model accounts for risks as follows:

- The soil fertility model generates a time-series of monthly NPK (kg/ha) and soil structure (rating), that depend on soil properties, inputs, SOC, etc.
- The soil humidity model generates a time-series of monthly humidity-in-top-soil (mm), that depends on rainfall, crop and tree cover, SOC, etc.
- The management risks model generates a time-series of annual fulfilment of management capacity, that depends on farmers' expertise, education, membership of cooperatives, access to extension, etc.
- Such farm characteristics are compared with the minimum requirements of the crop or tree, according to a quantitative tree/crop database. For each tree/crop, the fulfilment of conditions – as a fraction of a maximum 100% – is calculated on a monthly basis.
- An equation is used to combine multiple constraints into a tree/crop suitability rating. This equation may be something like [most constraining factor] * [3*next constraining factor*2*next constraining factor, etc.]/n, resulting in a tree/crop suitability rating for the particular year. (If calibration is applied, this constraining factor may be raised to the power of 1, 1.5, 2, etc.)
- The time-series of the tree/crop suitability rating (which is a decimal between 0% and 100%) is then multiplied by the local potential production of the tree or crop, which results in a time-series of tree or crop overall production, and the related product-wise production.

Box A1 presents a calculation example with the above equation.

Let's assume that maize has the following production 'needs' to yield optimally:

- 150 kg NPK/cycle; 80 mm humidity/month; an 80% management rating

Let's assume that a farm has the following production 'conditions':

- 90 kg NPK/cycle; 100 mm humidity/month; a 60% score in farmer management capacity

Then, the resulting maize suitability is:

- (90/150 = 60%) (100/80 =>100%) (60/80=75%); so 60% * (3*75%+2*100%)/5 = 60% * 85% = 51% suitability

If, then (hypothetically) the local potential total biomass production of maize is 12 t/ha /cycle, of which 40% is grains, 45% is stem/leaves and 15% is roots, then the resulting maize crop production is:

- 12 t/ha biomass/cycle * 51% suitability * 40% grains = 2.5 t/ha grains
- 12 t/ha biomass/cycle * 51% suitability * 45% stem/leaves = 2.8 t/ha (low-quality) fodder
- 12 t/ha biomass/cycle * 51% suitability * 15% roots = 0.92 t/ha SOC

The resulting SOC will contribute to next year's soil structure, and, when degrading, to NPK availability in the soil. As such, in the following season the production 'conditions' will be slightly changed for all trees and crops on the farm.

BOX A1: Calculation example

The same calculation principle is applied to multi-annual crops or trees; with the difference that trees often have more products, and that some products (such as roots and stems) remain on the farm over the tree's life cycle; with consequences for both SOC and soil conservation. In this way, tree and crop production performance 'feedback' into the farm agroecological system.

Regreening Africa