Regenerative Agriculture

An opportunity for businesses and society to restore degraded land in Africa

A REPORT BY THE
AFRICA REGENERATIVE AGRICULTURE STUDY GROUP

Foreword & Acknowledgements

"It's 2050 and aerial photos with other sources of evidence reveal a verdant planet full of healthy forests, thriving wetlands, bountiful grassland biomes and diverse, sustainable farmland. This remarkable picture of natural abundance is the direct result of years of conscientious sustainable land management. One of the first – and most obvious – steps that governments took was to reverse deforestation and to restore land that had been degraded. By 2030, this twin policy had already seen an impressive 350 million hectares under restorative actions. None of this would have been possible without major changes to our agriculture and food systems."

– **UNFCCC,** Climate Action Pathway

Recent research has shown the severe costs of land degradation to crop production and supply chains in Africa. What is less clear is the solution. This report presents the case for one approach, which could play a role within broader land restoration activities, through contributing to mitigating risks in supply chains and building resilience to climate change by 2030 and beyond.

Regenerative agriculture broadly encompasses both conservation agriculture and more sustainable agroforestry techniques. These practices increase crop productivity, enhance soil fertility, improve water retention, and create other ecosystem services, generating extensive economic, mitigation, adaptation and social benefits. This report shows that regenerative practices in Africa could be adding more than $15 billion in Gross Value Added[1] per year by 2030, increasing up to $70 billion by 2040 (one fifth of the current agricultural GDP of sub-Saharan Africa). This in turn could create upwards of 1 million additional full-time jobs by 2030, reaching nearly 5 million jobs by 2040[2].

Although regenerative agriculture can initially be time and labour intensive, businesses that stick with it are seeing yield impacts ranging from 68% up to 300%[3]. Companies that engage local communities, extend investment and financing across the supply chain, and leverage digital access can significantly scale regenerative practices, with programs in the case studies examined having already reached over 100,000 farmers.

Large agribusinesses in Africa, whose supply sources are tied to small farm holders, can drive the uptake of these practices to ensure the long-term viability of their supply chains. To further incentivise business, it will be important to provide access to finance, mobile digital tools, and other mechanisms to support regenerative agriculture and other food systems transitions, whilst also driving change in lands and rights issues, so that farmers themselves directly benefit from sustainable land restoration strategies. The implementation of the African Continental Free Trade Area (AfCFTA) can also offer a framework to further prioritise these opportunities.

[1] GVA measures the additional output contribution to an economy or sector

[2] Jobs includes those created, displaced and safeguarded

[3] All programs include a focus on regenerative practices but can also include increased access to other agri-inputs

This report makes clear that regenerative agriculture offers multiple evident benefits to both businesses and society. When complemented with broader land restoration initiatives, regenerative agriculture could significantly contribute towards the long-term viability of food production in Africa for people, with significant benefits for the environment and climate.

Private and public stakeholders need to act now, in this decade of climate action, to take advantage of this potential and create the enabling environment to truly accelerate this transformation across Africa's farmlands.

Signed,

Dr. Ibrahim Assane Mayaki, Chief Executive Officer, AUDA-NEPAD, and

Dr. Vera Songwe, United Nations Under-Secretary-General and Executive Secretary of the Economic Commission for Africa

Quotes

"The Food Systems Summit processes have shown that our current production systems are unsustainable and must be rethought for better health of people, environment and to deal with poverty. We need agriculture systems and practices that are affordable, can achieve scale, minimise impact on climate while achieving multiple yield benefits. We need practices that can raise incomes, increase resilience, improve food security, are inclusive and protect biodiversity. It is exciting to see how forward thinking companies are in adopting sustainable agricultural models like regenerative agriculture that hold enormous potential to restore soil health and productivity in degraded landscapes. This report is timely as it comes out at a time we are faced with unprecedented development challenges in the form of climate change, biodiversity loss, pollution, poverty and inequalities. The report gives impetus to the growing momentum to shift current unsustainable production and consumption patterns towards regenerative and more equitable systems in Africa's agriculture and food systems transformation at scale by 2040. The report shares important lessons and knowledge for all to use and impact millions on the continent."

– **Dr. Agnes Kalibata,** President, AGRA

"The estimated return on investment from regenerative agriculture in Africa outlined in this report is very encouraging. Of course, it will not be realised at a meaningful scale without the buy-in of millions of smallholder farmers. Agribusinesses and governments need to step up their investments and their supportive policies to give agency to the small farmers who, collectively, can make big changes. Maybe then, the report's best case scenario will become a reality."

– **Elizabeth Nsimadala,** President, the Pan African Farmers Organization

"The African Climate Foundation supports this excellent analysis which shows that regenerative agriculture is good for business, society and the environment. It could increase yields by 170% in some regions in Africa. Smallholder farmers who produce 80% of our food are central in the transition towards a fairer, healthier more sustainable farming model. Along with fintech advances, this study should spur agribusinesses, investors, donors and governments to accelerate support and reward farmers to transition to regenerative agriculture and improve the futures of us all."

– **Saliem Fakir,** Executive Director at the African Climate Foundation

"Governments will not be able to meet targets of the Paris Agreement or other commitments such as AFR100 without non-state actors like agribusinesses and smallholders. Regenerative agriculture is empirically connected to economic benefits, but also helps sequester carbon - all the while stabilising the security of international supply chains through fostering resiliency in land and communities. This is the type of evidence that we need to accelerate action for net zero."

– **Nigel Topping,** High-Level Climate Action Champion

"We now have tangible evidence of the value of investing in landscape restoration interventions to address land degradation. This new report brings to light the multitude of benefits of regenerative agriculture, undeniably linked to improved ecosystem services such as pollination, better water quality or soil fertility while offering alternative and additional revenues to local communities."

- **Bruno Oberle,** Director General, International Union for Conservation of Nature and Natural Resources (IUCN)

Suggested citation

Africa Regenerative Agriculture Study Group (2021).
Regenerative Agriculture: An opportunity for businesses and society to restore degraded land in Africa. 62pp.

Steering group members:

Alliance for a Green Revolution in Africa

African Climate Foundation

CIFOR-ICRAF Research Centres for the Consultative Group for International Agricultural Research

Partnerships for Forests

United Nations Economic Commission for Africa

Thanks also to **Susan Chomba from the WRI** for input and guidance.

This report is a product of the Africa Regenerative Agriculture Study Group, 2021. It was commissioned by the IUCN for the UN High Level Champions, with support and analysis from Vivid Economics.

International Union for Conservation of Nature

High Level Champions, UNFCCC

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

AFR100

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Executive Summary

Severe land degradation in Africa negatively impacts nearly half of all productive land, affecting well over 650 million people.[4] Practices resulting in land degradation have removed almost a third of the world's arable land from production over the last 40 years, and sub-Saharan Africa (SSA) is experiencing the brunt of this crisis. Continued inaction to improve and restore land could lead to further losses of USD 4.6 trillion over the next 15 years.[5]

To restore degraded lands, regenerative agriculture practices such as crop diversification, tree planting, reduced tillage, mulching, and water conservation techniques spur benefits for both agribusinesses and society. These techniques improve yields via increased soil nutrient and organic content, reduced soil erosion and improved water retention. Broader environmental benefits also emerge through these practices, including more resilient ecosystems, carbon sequestration, improved water management and stronger biodiversity.

Regenerative agriculture practices are a smart way to stem risk in supply chains. Risks, including climate risks, are on the rise, potentially inhibiting growth and creating supply disruptions for large agribusinesses. Regenerative practices are comparatively cost effective, relying largely on knowledge, time and labour. These practices enable farmers to adapt to a variable climate more easily through adopting climate-smart techniques and crop choices.

Businesses in SSA already reap the rewards of regenerative agriculture in programmes reaching over 100,000 farmers, with yield increases from 68% to 300%. Companies such as Anheuser-Busch InBev (AB InBev), Linking Environment, Agribusiness & Forestry (LEAF) Africa, Nespresso, Olam, Touton and Twiga Foods have already implemented regenerative agriculture programmes in the region. Olam has seen an 80% increase in cotton lint yields through regenerative techniques, which include mulching and crop rotations. Touton boosted annual yields by 68% through its agroforestry programme, using shade-tree planting. Through a Nespresso training programme, the individual farmers who have fully embraced regenerative practices such as pruning and rejuvenation[6] are seeing up to 300% yield increases.

Within just a few years, regenerative farming systems in SSA could greatly increase yields and reduce input costs to farmers. Some benefits can be seen within a single cropping season, though time frames vary significantly, and other impacts can require longer to realise. The natural benefits of regenerative farming also reduce dependence on expensive inputs such as irrigation, fertilisers and pesticides, cutting input costs for farmers and providing alternative fodder sources for livestock. The annual savings to farmers across SSA may be as high as USD 17 billion by 2040.

Increased uptake of regenerative agriculture in Africa could support nearly 5 million jobs by 2040 in addition to increasing revenue and food security for smallholder farmers. Farmers adopting regenerative agriculture can benefit from higher and diversified revenue streams, and may generate additional financial capital that can be reinvested at farm level or help respond to external shocks. Off-farm

[4] Estimate calculated from the SSA 2020 population and range of estimates for the proportion of the Africa population affected by smallholder farming from Agra (2017) and McKinsey (2019)

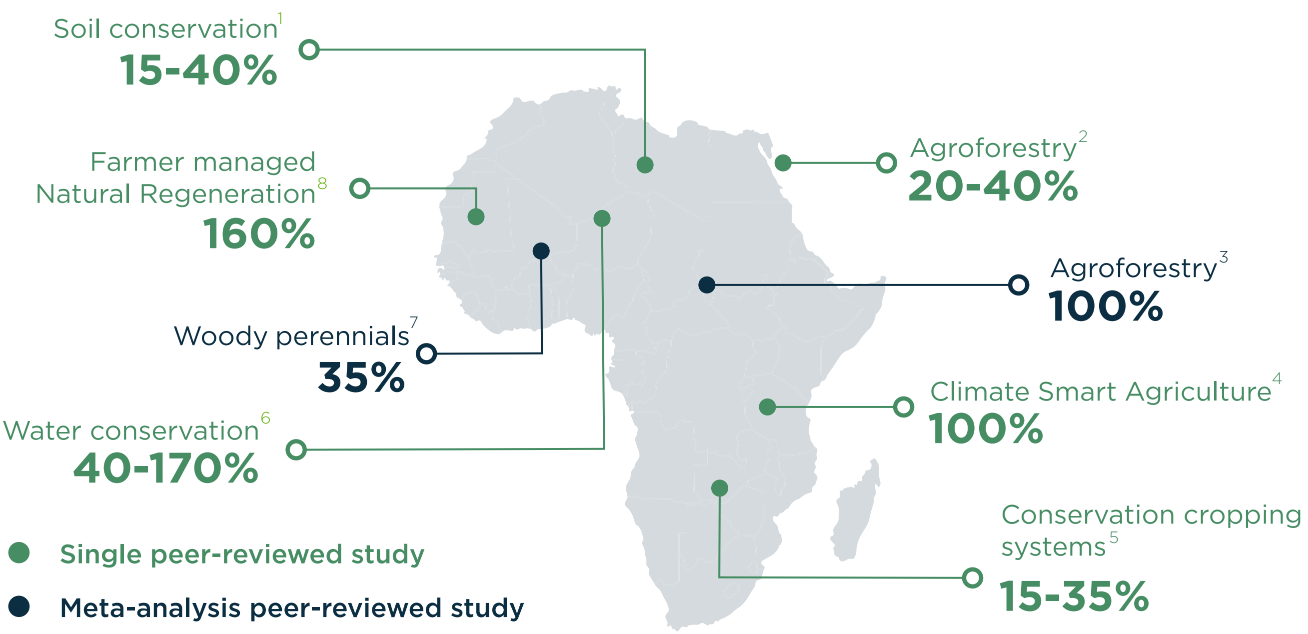
[5] Measured in terms of the value of cereal crops loss due to soil erosion induced nutrient depletion over the next 15 years (2016–30)

[6] Plant rejuvenation and stumping are forms of pruning that remove a large bulk of older low-yield crops while leaving a portion of the plant and roots intact that allows crops to "rejuvenate" new growth with higher associated yields

employment could also increase alongside yields, as larger harvests require more labour to transport, process, transform and sell products. The economic benefits for farmers and the surrounding economies from regenerative agriculture is projected to increase food security through reduction of prices and accessibility of varied and increased food options.

Regenerative agriculture could also sequester large amounts of carbon dioxide, making it a low-cost and effective solution to combat climate change. By 2040, this carbon benefit could equate to a 4.4 $GtCO_2e$ increase in SSA soil-based stock alone. Another 106 $MtCO_2e$ per year could be sequestered by restoring degraded land with agroforestry systems.

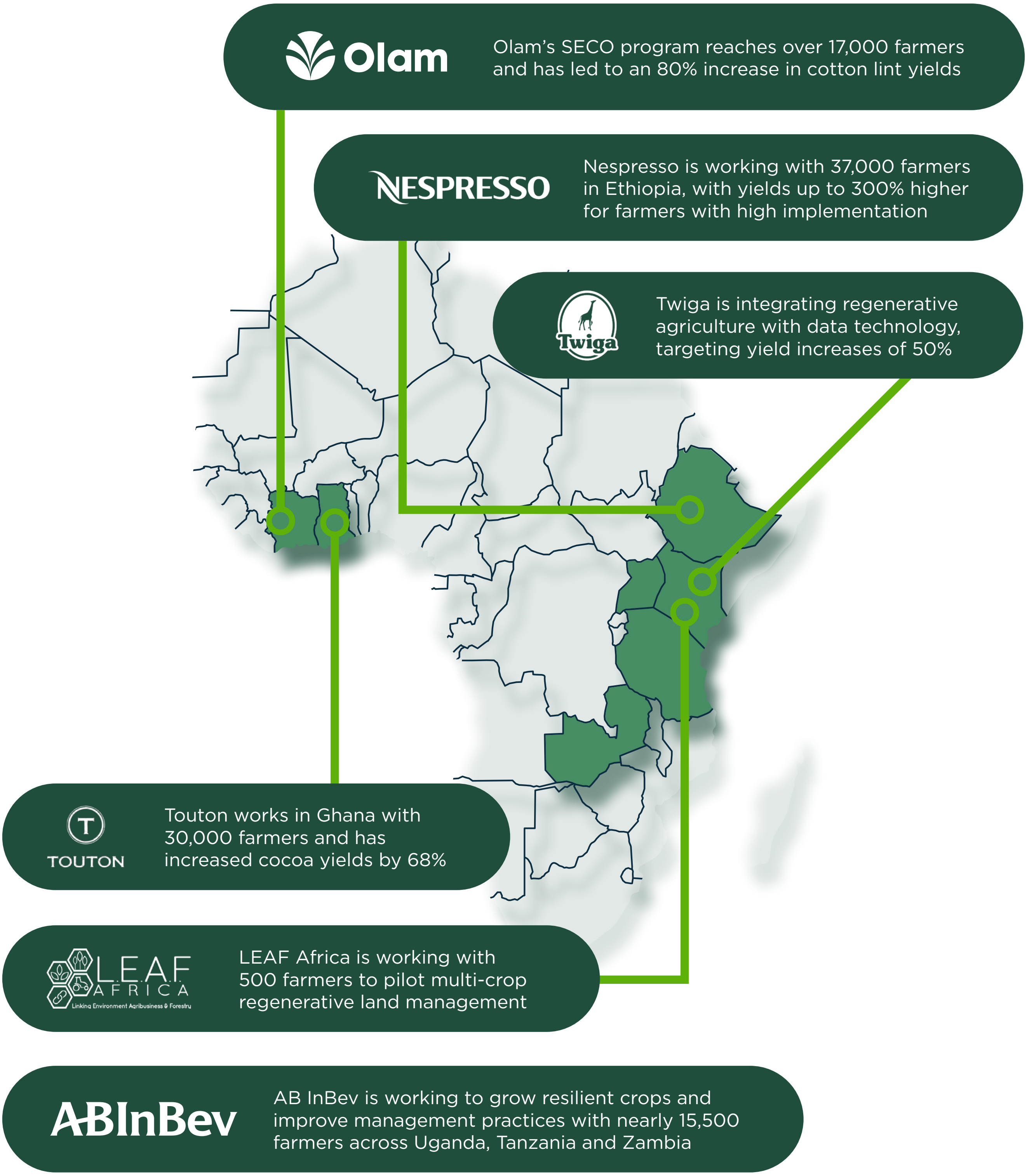
Figure 1: Crop yield increase observed in several regenerative agriculture initiatives across sub-Saharan Africa



Note: Values in the figure are rounded values. 1. Ibrahim et al. (2015), 2. Fahmi et al. (2018), 3. Shem Kuyah et al. (2019), 4. Amadu et al. (2020), 3. Shem Kuyah et al. (2019)5. Thierfelder et al. (2015)., 6. Reij et al. (2010), 7. Félix et al. (2018), 8. Birch et al. (2016) Reij et al. (2010). Thierfelder et al. (2015).

Source: Vivid Economics

Figure 2 : Examples of business success with regenerative agriculture



Source: Vivid Economics

A scenario with increased uptake of regenerative agriculture shows the potential to be supporting 5 million full time equivalent (FTE) jobs by 2040, with over USD 70 billion of gross value being added per year. Modelling of 13% increase in yields from a regenerative agriculture scenario in 2040 (compared to a business-as-usual scenario) equated to 62 million dry matter tonnes of additional crop production per year, with substantial increases in value added and employment. Increased food production translates into improved food security, with increased food supply and lower food prices. Separate modelling estimates that regenerative agriculture could sequester over 6 $GtCO_2e$ of carbon over the next 20 years (300 $MtCO_2e$ per year) and increase resilience through improved soil health. Finally, businesses which adopt regenerative agriculture could also have better access to export markets in the future, and finance, further increasing economic benefits.

Figure 3 : Overview of potential impacts by 2040 under a regenerative agriculture scenario. Percentage changes compare the regenerative vs. non-regenerative scenarios.

Economic Impacts

- **13%** — Increase in crop production across SSA
- **5 mln** — Jobs across SSA*
- **$70 bln** — Gross Value Added across SSA*

Food Security

- **13%** — Increase in per capita food consumption
- **Up to 15%** — Reduction in household food expenditure
- **16%** — Increase in daily per capita calorie intake

Climate Mitigation

- **>6 Gt CO_2** — Sequestration potential by 2040 from cropland management and agroforestry ***
- **20%** — Increase in soil organic carbon ***
- Regenerative systems are a low-cost and effective solution to combat climate change

Climate Adaptation

- **24%** — Increase in crop production across SSA
- **30%** — Reduction in soil erosion ***
- **$17 bln** — Potential avoided farm costs per year across SSA **/***

Access to Finance

The implementation of regenerative agriculture opens the door for smallholder farmers and agribusinesses to receive additional funding and access to financing. The flow of funds into sustainable solutions such as regenerative agriculture is growing rapidly. Growing evidence for the ability of regenerative agriculture to meet climate targets creates the potential for increased access to funding, also through carbon offsets.

Source: Vivid Economics

* *Created, displaced or safegaurded*
** *If 50% of the cropland is managed through regenerative agriculture*
*** *Data refer to the project implementation time - here assumed to be 20 years - which also corresponds to 2040.*

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Acronyms

3PRCL	Partnership for Productivity Protection and Resilience in Cocoa Landscapes
AFR100	The African Forest Landscape Restoration Initiative
BAU	Business As Usual
CAPEX	Capital expenditure
CBPs	Crop Blueprints
CGPs	Crop Growing Protocols
CO_2e	Carbon Dioxide equivalent
CoEs	Centres of Excellence
FMNR	Farmer managed natural regeneration
FTE	Full time equivalent
GDP	Gross Domestic Product
GHG	Greenhouse gas
GVA	Gross Value Added
I3M	Intervention and Investment Impact Model
IG	Integrated Ginning
LMB	Landscape Management Board
MAgPIE	Model of Agricultural Production and its Impact on the Environment
T C/ha/y	Tonnes of Carbon per Hectare per Year
MRIO	Multi-region input-output table
OPEX	Operating expenditure
SECO	Société d'Exploitation Cotonnière Olam
SSA	sub-Saharan Africa
USD	United States Dollar

Introduction

1 : Introduction

Urgent action is needed to address the costs of land degradation in sub-Saharan Africa. There is increasing recognition of the environmental costs of degraded land, as well as the significant gap in production yields restricting economic output. Sub-Saharan Africa has a quarter of global arable land yet only produces 10% of the world's agricultural output (IFAD, 2021). Inaction on this degradation is only compounded by forecasts of substantial future increases in food consumption from a rapidly expanding population.

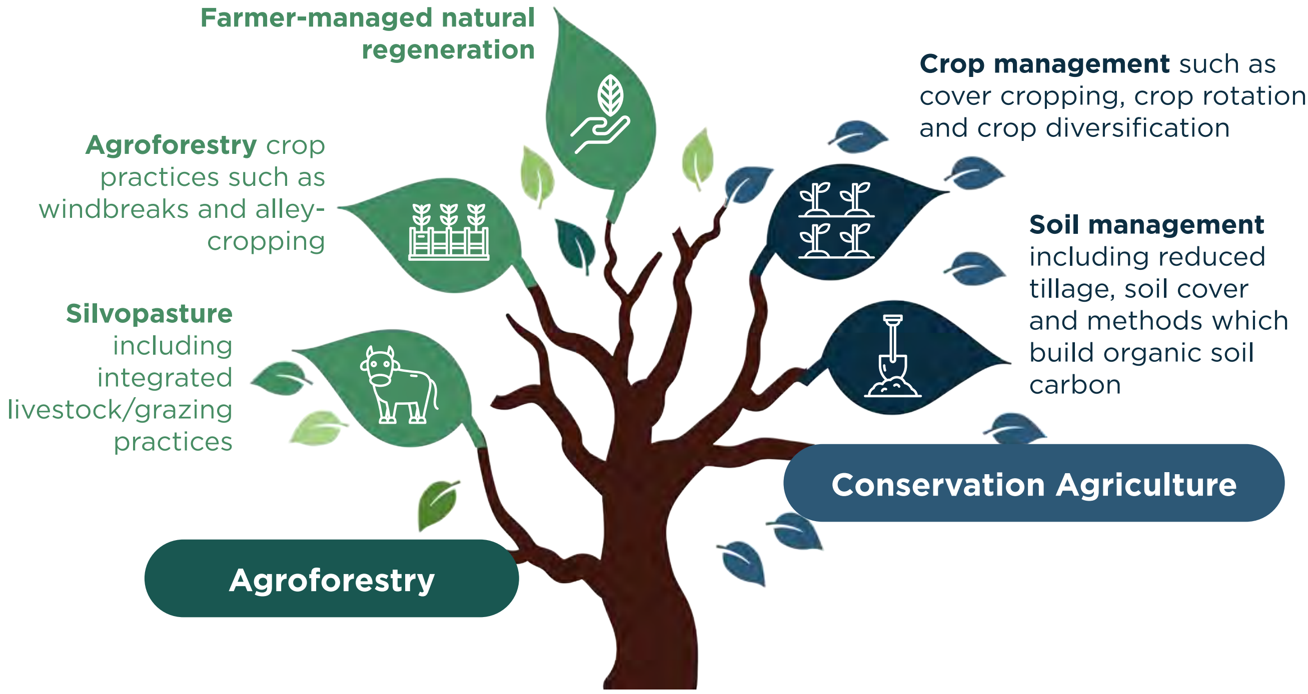
This report was commissioned in advance of the UN Food Systems Summit and Africa Climate Week to investigate the business case for regenerative agriculture, which could contribute towards land restoration goals. Extensive research has focused on the negative impacts of land degradation and unsustainable agriculture, as well as the social benefits of improved agricultural practices. Conversely, regenerative practices offer compelling opportunities for the agricultural, food processing and food retailing sectors and are critical to ensuring the long-term viability of businesses. Increased uptake of these practices could contribute significantly to wider economic and social objectives, as well as government initiatives such as the Africa Land Restoration Initiative AFR100, which is targeting 100 million hectares of land to be restored by 2030.

Regenerative practices are defined broadly to include both conservation agriculture and agroforestry techniques[7]. Conservation agriculture includes soil management practices such as reduced tillage, mulching and manuring, and crop management practices such as cover cropping, improved fallow, crop rotation and diversification. Agroforestry techniques are centred around trees, but can be crop-based, such as alley cropping, livestock-based, such as grazing rotation and integration, or also include farmer managed natural regeneration[8]. This broad definition is shown in Figure 4.

[7]This definition is intended to be as broad as possible to apply to all stakeholders, and is intended to cover practices such as agro-ecology and permaculture

[8]Farmer managed natural regeneration is where farmers use of coppicing and pollarding to regenerate native species and increase farm vegetation cover to protect and manage the growth of trees and shrubs

Figure 4 : Overview of regenerative agriculture



Source: Vivid Economics

This report sets out existing and potential benefits across the agricultural supply chain and broader society. The report draws on practical examples, academic reviews and quantitative modelling to build a comprehensive picture of the business case for regenerative agriculture.

- **Section 2** of this report showcases a few businesses in SSA which have successfully implemented regenerative techniques.
- **Section 3** focuses on the evidence behind the practice, analysing the literature on the benefits of regenerative agricultural practices in the food and farming value chain, from farmers to end consumers, explaining the positive effect on livelihoods, and on climate adaptation.
- **Section 4** presents estimates of the size of opportunity for regenerative agriculture and the magnitude of impact it would have across economic, food security and climate mitigation metrics.
- **Section 5** concludes.

One

Two

Three

Four

Five

Current practices in regenerative agriculture

2 : Current practices in regenerative agriculture

This chapter identifies and describes six business initiatives implementing regenerative agriculture across SSA.

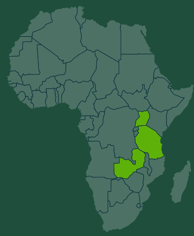
Section 2.1 **outlines the key features and impacts of six business case studies.** Each initiative focuses on different crops, namely cereals, cotton, coffee, fruits and vegetables and multi-crops, and the key features and impacts of each approach are described.

Section 2.2 discusses the lessons learned from the business case studies. The sub-section lays out the success factors and findings from the case studies.

2.1 Business case studies

Players in the agricultural and food processing sector are already employing land restoration strategies such as regenerative agriculture to ensure more resilient and higher yielding crops in SSA. Although agricultural output in Africa has increased significantly with increasing inputs like land and labour, agricultural productivity remains very low and grows slower than in other regions (Udry 2010). Africa's full agricultural potential is therefore untapped, with the potential to produce two to three times more cereals and grains than current volumes (McKinsey, 2019). Meanwhile, the current trend of land degradation and the impact of climate change jeopardise the realisation of this opportunity. Companies involved in African agriculture see this impact first-hand and are beginning to adopt regenerative agricultural practices to ensure that their supply chains are sustainable in the long term. Six business case studies highlight the benefits of regenerative practices: barley and sorghum (AB InBev), cocoa (Touton), coffee (Nespresso), cotton (Olam), fruit and vegetables (Twiga) and multi-crop integration (LEAF Africa).

Cereals



ABInBev

Case Study

This business is working to increase resilience and improve crop management practices through regenerative agriculture and crop variety development.

Alongside the company's 2025 sustainability goals, AB InBev is promoting climate-smart agriculture. It expects farms to benefit through higher crop yields and quality, climate change resilience and lower input costs.

Project Overview

Initiatives promoted by the business relate to improved crop management and use of more sustainable practices aiming at increasing crop and system-wide resilience. The business' initiatives focus on cereals (barley and sorghum) and local tubers (cassava) in Uganda, Tanzania and Zambia.

Initiatives focus on crop management to improve yields, quality of products and resilient agricultural systems, as well as data management to enable scale. Practices such as optimal plant spacing, minimal tillage, planting techniques and crop rotation are tested. Crop varieties are also researched and evaluated to improve crop yields, quality and resilience. Work with a Conservation Farming Unit in Zambia promotes the adoption of sustainable practices and incorporates conservation themes into the crop management protocol shared with farmers and farmer training. The business employs a global data platform to track progress towards achieving soil health impact and encourage continuous improvement across programs, which is being tested and adapted for further rollout in smallholder programs.

Programs are developed with support from model farm data. The business trials and evaluates regenerative agriculture practices at a regional model farm in South Africa. Adoption of no-till practices on the farm have conserved soil moisture reduced soil erosion, all while increasing yields (AB InBev, 2020). Additional practices such as diverse cover crops have also been introduced. Best practices from the farm are shared across countries and extended to farmers through a network of AB InBev agronomists.

Regional planning allows local teams to engage with farmers on the ground and to implement special training. In Uganda, Tanzania and Zambia, local partnerships enable the business to work together with smallholder farmers on the ground. Crop management protocols that are developed through local research trials build farmers' knowledge of regenerative agriculture practices. Protocols are distributed at crop buying centres and also shared through farmer training sessions that are tailored to local contexts. In Zambia, where cassava is cultivated, farmer training focuses on processing and storage techniques which improve quality and reduce post-harvest losses.

Project Impacts

Engagement with more than 15,000 farmers has already been achieved, supporting sustainable practices knowledge and implementation. With 10,000 smallholder farmers in Uganda, 3,000 in Tanzania, and 2,500 in Zambia, local partnerships enable the business to work with smallholder farms.

In Zambia, initial pilot trials testing improved agricultural practices on cassava showed over 350% increase in yield. "Business-as-usual" farming methods were tested against techniques such as improved spacing between plants, improved planting methods, pest management practices and soil fertility management, which generated positive results on yield. Testing of additional practices and improved crop varieties is planned in order to assess the potential for further yield growth.

Going Forward

The business will continue initiatives aimed at trialling regenerative practices and improving crop resilience, as well as engagement with local farmers and partners. In addition to continuing local research and engagement on regenerative agriculture, the business will support initiatives such as crop insurance, climate data services and financial skills training to improve system-wide resilience. The business will also implement its Soil Health Framework, developed in collaboration with The Nature Conservancy, to develop soil health initiatives in SSA programs.

Multi-crop farming

L.E.A.F. AFRICA
Linking Environment Agribusiness & Forestry

Case Study

Agroforestry and regenerative land management are being piloted to revive an abandoned and degraded farm.

LEAF Africa is promoting productive agriculture and forestry, encouraging the adoption of regenerative agricultural practices through demonstrations and training. The pilot farm is the first of a number of projects and demonstration sites that LEAF is developing in Kenya. Across these sites, LEAF works to enact diverse and profitable regenerative agricultural systems by engaging with farmers.

Project Overview

Agroforestry and integrated land-use management techniques are employed to restore a previously abandoned flower farm. The ten-acre site had been lying fallow for twelve years before the business began work to restore its productivity in January 2019 (Mitchell, 2021). Agroforestry techniques such as intercropping are adopted to promote crop diversity, with crops including tomato, maize and potato. In the medium to long term, higher value species such as avocado, guava, and timber trees will be introduced. On the farm, the combination of pasture, animals, tree cover and diversified forests regenerates overgrazed and degraded landscapes (Tamalu Farm, 2020b).

Farmer education and training is core. By directly training the farmers on the landscape, the adoption of regenerative practices is facilitated. This includes live-in apprenticeships and farm tours, which teach regenerative agriculture principles, agroforestry implementation and soil enhancement techniques, among others (Tamalu Farm, 2020a). Over 500 people were trained in 2020, a figure expected to triple once COVID restrictions loosen.

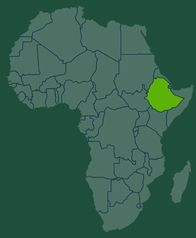
Project Impacts

The project has already seen ecological and economic benefits. The business reports more productive soils, carbon sequestration and richer biodiversity as evidence of positive impacts on the ecosystem (Mitchell, 2021). The business has also succeeded economically, breaking even and enjoying high levels of demand for produce. Its success has encouraged neighbouring farmers to participate in training. As the project is still at an early stage, further ecosystem and economic benefits are expected in the future.

Going Forward

The business aims to expand the pilot and replicate its results elsewhere. The business is currently in the fundraising phase of launching ForestFoods, a premium fresh produce brand that is in control of its supply chain, including logistics and distribution/delivery services. ForestFoods will own and manage core nucleus farm sites and incorporate smallholder farmers, expanding its enterprise to 125 hectares in total over the next 5 to 7 years.

Coffee



Case Study

The business is working with coffee farmers in Ethiopia to improve coffee yields, reduce poverty and increase long term climate resilience.

Nespresso works with over 37,000 farmers and 300 local wet mills to source coffee from Ethiopia. Since 2013, the business' coffee sourcing program has been operated locally and is supported by a range of expert partners on agroforestry. At the heart of the program is a commitment to empower farmers with sustainable agricultural practices (Nespresso, 2021a).

Project Overview

Sustainable and regenerative agricultural practices are promoted via an academy. The academy trains farmers on yield-enhancing techniques and skills for the sustainability of farming businesses (TechnoServe, 2021c). These techniques include mulching, pruning and rejuvenation[9], as well as managing pests with low-cost, locally available materials. Rejuvenation is particularly important to address the current below-potential yields of established older coffee trees in Ethiopia. Techniques such as stumping can increase yields from these older crops without uprooting and replanting.

Farmers are encouraged to adopt rejuvenation practices through the use of 'demo-plots' in the academy, which show farmers increased yields first-hand. Over a period of 19 months, small groups of around 30 farmers from local communities meet on 'demo-plots'. These are small plots of land on which yield-enhancing and sustainability techniques are demonstrated. Farmers often do not believe regenerative agriculture is beneficial, as incomes may be reduced in the short run. The use of demo-plots show farmers the benefits of these practices without putting farmers' income at risk, encouraging adoption (Nespresso, 2021b).

The deployment of agroforestry in coffee farms improves climate resilience. Planting native trees in and around coffee farms confer many benefits to the coffee plants such as protection against extreme weather patterns (drought, hail), soil conservation, most particularly preventing erosion, and regenerating soil fertility. Some trees have been planted as certified carbon sequestration projects in collaboration with a partner.

[9]Plant rejuvenation and stumping are forms of extreme pruning that remove a large bulk of the crop plant while leaving a portion of the plant and roots intact that allows crops to regrow and thus increase yields.

The business works with local wet mills to aggregate, process and supply sustainable coffee. Local supply chains are structured around wet mills (TechnoServe, 2021c), and actions such as treating wastewater in vetiver grass filter beds brings regenerative agriculture into more parts of the supply chain.

Project Impacts

The adoption of regenerative agriculture practices continues to be taken up as the program is expanded. The program has grown from a small pilot in 2013 to engaging more than 37,000 farmers in Ethiopia. As a result, the percentage of trained households in Ethiopia implementing at least half of identified best agronomic practices increased from 10 to 43%, through 2018 (TechnoServe, 2021c). In particular, trained farmers who were offered an incentive of $0.40 per tree, stumped five times as many trees than those who were trained but received no incentive (TechnoServe, 2021b). Over one million shade trees have been planted on 226 km^2 of coffee land (TechnoServe, 2021a).

The promotion of sustainable and regenerative agricultural practices has helped to improve yields and livelihoods. Stumping has resulted in a two- to three-fold increase in yields. This has generated $4.3 million of additional coffee income per year across 36,700 farmers (BioCarbon Fund, 2021; TechnoServe, 2021a). 2020 incomes nearly tripled (270%) under high adoption compared to baseline practices in 2013 (BioCarbon Fund, 2021). The construction of eight vetiver wetlands at wet mills has also prevented 56,000 cubic metres per year of contaminated wastewater from entering rivers (TechnoServe, 2021a). Over 60 women have been trained as agronomists, and the program assists formerly trained agronomists for further education or careers in other sectors. 81% of Ethiopia's 2015 agronomist cohort have pursued further education (TechnoServe, 2021a).

Going Forward

The business will bring these benefits to more farmers and new geographies. The program has allowed the business to attract nearly $4.5m in co-funding from the International Finance Corporation and the Sustainable Trade Initiative (TechnoServe, 2021c). Leveraging these investments, the business is expanding its initiatives within Ethiopia. Beyond Ethiopia, the program is deployed in four other African countries: Kenya, Uganda, Zimbabwe and the Democratic Republic of Congo.

Cotton

Case Study

Cotton yields have increased by 80% in Cote d'Ivoire through training farmers to implement regenerative agricultural practices.

This business sources its cotton from Côte d'Ivoire through its subsidiary, Société d'Exploitation Cotonnière Olam (SECO), which implements best practices across the supply chain. 20% of Olam's cotton is sourced from Côte d'Ivoire (Olam, 2017a), with the subsidiary established in 2008 with the aim of organising supply chain activities efficiently and to create an integrated supply chain.

Project Overview

Farmers are trained in regenerative agriculture practices like mulching and crop rotation to improve their yields and increase resilience to climate change. Temperatures in the future will exceed the range at which rainfed cotton has historically been grown, so training of farmers in soil management that increases the availability of rainwater will be essential (Cunningham et al., 2021). Farmers learn anti-erosion measures, including mulching, which saves water and improves soil quality, and rotate crops more frequently, which maintains soil quality over many harvest cycles.

This model has been implemented in Cote d'Ivoire since 2008, integrating farmer partnerships and community engagement, and in 2019 involved over 17,000 farmers. The model includes an 'outgrower' program, where large-scale and small-scale farms are partnered together, enabling the supply of agri-inputs[10]. These resources are combined with training in agronomic practices through classroom courses and model farms.

Project Impacts

Cotton lint yields have increased by 80%, with an increased number of cotton suppliers and improved livelihoods of farmers. The program as a whole, including the regenerative agricultural practices, increased yields from 250 kg to 450 kg per hectare over a five-year period[11] and has a goal of reaching 538kg per hectare by 2023-24 (Olam, 2017c). In addition, the number of farmers involved in the program has grown to 17,769 in 2019. Olam is also making efforts to overcome existing cultural barriers and include more women farmers. Under the SECO program, farmers' livelihoods have improved. Farmers now receive better prices and produce higher yields, while communities receive additional support including support for growing maize for food, income diversification, health clinics and education.

[10] This may lead to an increase in fertiliser, pesticide and herbicide use, which is not considered or measured in the data

[11] Impacts of regenerative practices can also include increased access to inputs such as fertiliser

Going Forward

The business is rolling out the integrated model to Chad and Togo and is expanding operations in Côte d'Ivoire. The business plans to invest USD 60 million of fixed capital over the next few years to expand its IG footprint organically in Africa and is scaling up lint production from 38,000 MT to 177,522 MT of lint by 2021-22 (Olam, 2017c). This includes both increasing the number of farmers involved and increasing the yield per hectare of farms (Olam, 2017b).

Cocoa

TOUTON

Case Study

The business is increasing cocoa yields in Ghana while protecting forests and improving livelihoods.

Touton is applying regenerative agriculture techniques to cocoa production in the Bia-Juabeso region in Ghana. In May 2017, the company announced its commitment to ending deforestation in its supply chain, signing up to the Cocoa and Forests Initiative and embarking on a pilot for the Partnership for Productivity Protection and Resilience in Cocoa Landscapes (3PRCL) project (Touton, 2018). The Bia-Juabeso-based project aims to restore forests while reducing carbon emissions in the cocoa sector. As part of this, Touton has promoted regenerative agriculture practices such as mulching, pruning and shade trees.

Project Overview

The adoption of regenerative agriculture practices is encouraged by financial incentives. Premium payments for cocoa are offered to local farmers under the condition that sustainable land use and forest protection practices are followed (Food and Land Use Coalition, 2019). Farmers were encouraged to grow a minimum of five different shade tree species on their cocoa farms while also safeguarding riparian areas under the piloted incentive program. The initiative focuses especially on agroforestry, as the planting of shade trees not only improves productivity and contributes to forest ecology, but also can provide higher revenues to farmers through the sale of shade-tree timber. Moreover, practices such as mulching and pruning are promoted as they improve yields and soil quality.

Local training and community engagement supports regenerative agriculture. Farm business schools teach regenerative agriculture techniques as well as farm-level investment planning, while Rural Service Centres act as information hubs (Food and Land Use Coalition, 2019). By working directly with farmers, community buy-in is built for the long-term and helps connect farmers to authorities. The 3PRCL program was designed in close collaboration with Ghana Cocoa Board and the Ghana Forestry Commission. Building relationships in this fashion helps achieve sustained adoption of agronomic systems which have previously met with farmer resistance (Touton, 2021a).

Landscape-wide governance frameworks are employed to tackle landscape-wide challenges. A landscape Management Board (LMB) is established to oversee the whole landscape. This allows the identification of wider challenges and interactions between economic activities, and to work with authorities to integrate satellite-based remote sensing information. The business also works in partnership with experts such as the Agro Eco Louis Bolk Institute, Tropenbos Ghana, and the Nature Conservation Research Centre (NCRC) in Ghana to build region-based agroforestry models with tailored agronomic interventions (Touton, 2018).

Project Impacts

The economic and ecological benefits are felt by a growing supplier network of farmers. Currently, the business works directly with 30,000 farmers and aims to eventually engage 60,000 (IDH, 2018). The establishment of LMBs ensures that sustainable land-use agreements are in place with communities covering 250,000 hectares of land. Average yields have increased from 400 kg/ha/yr to 670 kg/ha/yr. This coincides with other economic benefits, such as diversified income streams from intercropped timber, improved nutrition and improved market access. Local communities have been empowered to tackle deforestation alongside the authorities, keeping production away from protected forest areas (Touton, 2021a).

By the end of the pilot stage, the business aims at extending the benefits of its program to the entirety of the Bia-Juabeso landscape. The project already spans 250,000 hectares through the LMB (Food and Land Use Coalition, 2019). With the support of the UKAID-funded program Partnership for Forests, the aim is to expand socioeconomic benefits to all 150,000 people in the area and to conserve around 160,000 hectares of protected forest reserve (Touton, 2018). By reducing deforestation while increasing yields, the 3RPCL can change perceptions that deforestation is the only way to increase incomes. Meanwhile, the wider adoption of regenerative agriculture brings increased and diversified income. Through improvements to farmer livelihoods, the business also cultivated supplier loyalty. It has created goodwill and trust for the adoption of future regenerative agriculture projects. The company has committed over USD 138 million to source climate-smart cocoa in the region over the next five years.

Going Forward

The business is looking to extend the project to new geographies. The landscape-level approach will be used as a blueprint beyond Ghana, with the blueprint incorporating the development of a National Forest Monitoring System in Ghana and strengthened systems for gender inclusion and social safeguarding (Touton, 2021b).

Fruits & Vegetables

Twiga

Case Study

The business is aiming to increase farmer yields by 50% through regenerative agriculture integrated with data technology.

An online food distribution platform is used to increase supply chain efficiency and for sustainable practice. This Nairobi-based business-to-business food distribution company connects farmers to food vendors through an online platform. A mobile-based platform serves around 3,000 outlets a day, through a network of 17,000 farmers and 8,000 vendors (Bright, 2019). As part of its commitment to implement best practices in agriculture, the business encourages the use of regenerative agriculture on its partner farms.

Project Overview

Twelve demonstration Crop Centres of Excellence (CoEs) are being piloted. CoEs are farms which the business partners with to improve agronomy, irrigation, financial management and control. CoEs target increased crop yields and lower costs of production by unlocking production potential and developing a sustainable business model across five crops: onions, potatoes, tomatoes, bananas and watermelons (Twiga, 2021). As part of this, CoEs implement regenerative agriculture practices such as reduced tillage, integrated pest management[12] and crop rotations.

Through data services and CoEs, regenerative agriculture practices are implemented and tracked. Agronomists, alongside the CoEs, use Crop Growing Protocols (CGPs) and Crop Blueprints (CBPs) to build sustainable practices into conditional contracts with farmers (Twiga, 2021). Contracted farmers receive continuous training, including in agronomy, from the CoEs, to improve productivity and sustainability. Data is collected and analysed from farms and vendors, in order to track productivity improvements, net margins, costs of production and prices.

Project Impacts

Significant increases in yield are expected. The target is to increase yields by more than 50%, which will result in more profits and better living conditions for farmers. 12 farms covering 50 acres are already part of the project, despite the fact that it is still in its early phases. CGPs and CBPs will be expanded to more farmers after the pilot phase, boosting the project's impact.

[12]Pest management practices additional to synthetic pesticides, such as natural enemies, biological pesticides, pest traps, trap crops or targeted weeding.

Going Forward

The business intends to scale up the CoE approach within Kenya and expand it to West Africa. Fuelled by a $30m venture funding round led by Goldman Sachs, the company has plans to bring its technology-led distribution network to more geographies, and begin distributing a wider range of food, including processed goods (Bright, 2019). It will adopt CGPs and CBPs throughout its expansion. By bringing regenerative agriculture into new supply chains, the CoE approach can be replicated as it expands beyond its five original crops.

The approach lends itself to the integration of regenerative practices with data. Data on yields, cost of production, and price can be acquired by providing services across the supply chain. The efficiency of regenerative methods across geographies and crops will be assessed by combining data to quantify and measure performance.

2.2 Lessons from business

The business case studies show strong benefits to regenerative agriculture, with success driven by demonstration of evidence, engagement with communities and holistic integration. Three categories have been identified as broad success factors in these business programs, as summarised in Figure 5.

Figure 5 : Summary of success factors used by businesses

Demonstrate evidence to scale up uptake

- Use **demonstration plots to build farmer trust**
- **Training programs** to support independent implementation
- **Show farmers the value** of regenerative practices

Engage with local communities

- **Tailor engagement** to local context
- Foster **equitable gender participation**
- Build stronger **local governance**

Consider the broader context

- Extend investment across the **supply chain**
- Leverage **digital access**
- Align public and private **finance streams**

Source: Vivid Economics

Training disseminates knowledge and boosts adoption, however implementation of regenerative agriculture does require labour inputs from farmers. Low awareness of the methods and benefits of regenerative agriculture is a major barrier to farmer uptake. Furthermore, practices like stumping and no tillage with an initial drop in yields also creates a significant hurdle. A part of the solution could be demonstration plots that compellingly show farmers longer-term yield improvements without putting farmers' current revenues at risk, as well as training them towards independent adoption and implementation of regenerative practices. Businesses in these case studies have farms trialling regenerative agriculture techniques and examining the effects on yields and production costs, with proven success. In some cases, certain barriers remain around land-tenures being too short to motivate long-term outlooks. It is also worth noting that low-cost technology and practices are often knowledge and labour intensive, requiring significant time from farmers.

Farmer-level engagement builds trust between agribusinesses and farming communities. Engagement directly with farmers and communities on the ground is crucial to build relationships between local communities and businesses, to establish regenerative practices, and sustain reliability and integrity between parties. Businesses in these case studies found that engaging with existing community networks and local governance systems facilitates the adoption of regenerative practices, while improving understanding of local farming traditions and practices. Investments such as healthcare provision and sanitation infrastructure are needed to generate benefits that can be realised by farmers and their families as they embark on the path towards regenerative farming, although the question of land tenure and financial rewards needs addressing to ensure a just transition approach. Fostering equitable gender participation, as some businesses have done, can also reinforce and build trust.

Regenerative agriculture is most effective when combined with broader approaches to landscape and supply chain management. Practices can be integrated into aspects of agriculture beyond crop husbandry. One business uses regenerative practices for mill processing, increasing biodiversity and improving water quality. Another combines regenerative agriculture with wider landscape considerations to protect forests and promote sustainable land use agreements. Data integration has also had benefits for some companies, including working to increase supply traceability, improve farmer price transparency and provide valuable weather data. This is reinforced by global findings from Ferdinand et al. (2021) where investment in digital climate-informed advisory services generates an average 30% increase in productivity for small-scale farmers.

Overall, engaging with farmers to enable access to markets and finance is a win-win for smallholders and large business. Many farmers are isolated from information, markets and capital, which limits business opportunities and makes it more difficult for agribusinesses to engage with them. However, when they organise into cooperatives or associations they develop a stronger collective voice in policy processes, gain access to markets, develop informed business plans, and share sustainable production techniques. Supporting these associations enables agribusinesses to transition to regenerative agriculture in an efficient way at landscape or national scales. The potential of public-private partnerships can be effectively leveraged, as well as funding training through partners such as TechnoServe.

One
Two

Three

Four
Five

Evidence on the benefits of regenerative agriculture

3 : Evidence on the benefits of regenerative agriculture

This chapter sets out the evidence on the benefits of regenerative agriculture to the agricultural value chain, to local livelihoods and to society. The beneficiaries and benefits are illustrated in Figure 6. Evidence on how the benefits of regenerative agriculture flow between different stakeholder groups in the system is structured as follows:

Section 3.1 discusses the impact of regenerative agriculture for farming businesses, food and beverage processors and consumers.

Section 3.2 presents the impacts of regenerative agriculture on local livelihoods and society.

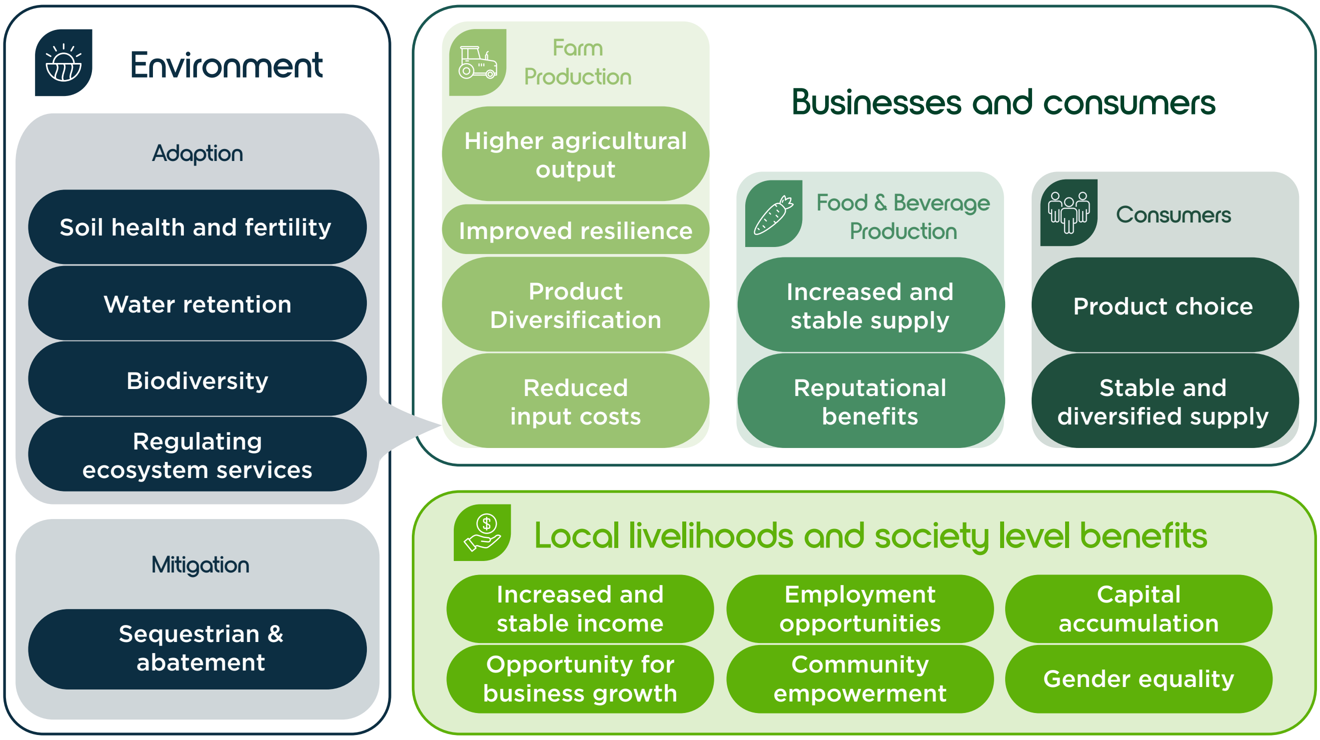
Section 3.3 describes and measures the impacts of regenerative agriculture on environmental benefits, delivering both climate adaptation benefits (including associated reduction of input costs for farming businesses) and mitigation benefits.

Box 1 : Smallholder farmers and agribusiness in SSA

Farmers and agribusiness are closely related across the food production supply chain. Smallholder farmers make up the majority of farm production across SSA. The Alliance for a Green Revolution in Africa estimates that about 70% of the population in Africa are smallholder farmers, and that 80% of food supply is met through them (AGRA 2017)[13]. Agribusiness works with these smallholder farmers in their supply chain, both at a farm production stage and for processing. Farmers and agribusiness share interests in the benefits of regenerative practices and both will gain from recommendations outlined in this report. The terms farmer and agribusiness are therefore used somewhat interchangeably, with benefits focused on the different stages of the production cycle.

[13]Average is across sub-Saharan Africa and Asia

Figure 6 : Benefits accruing from regenerative agricultural practices for different stakeholder groups



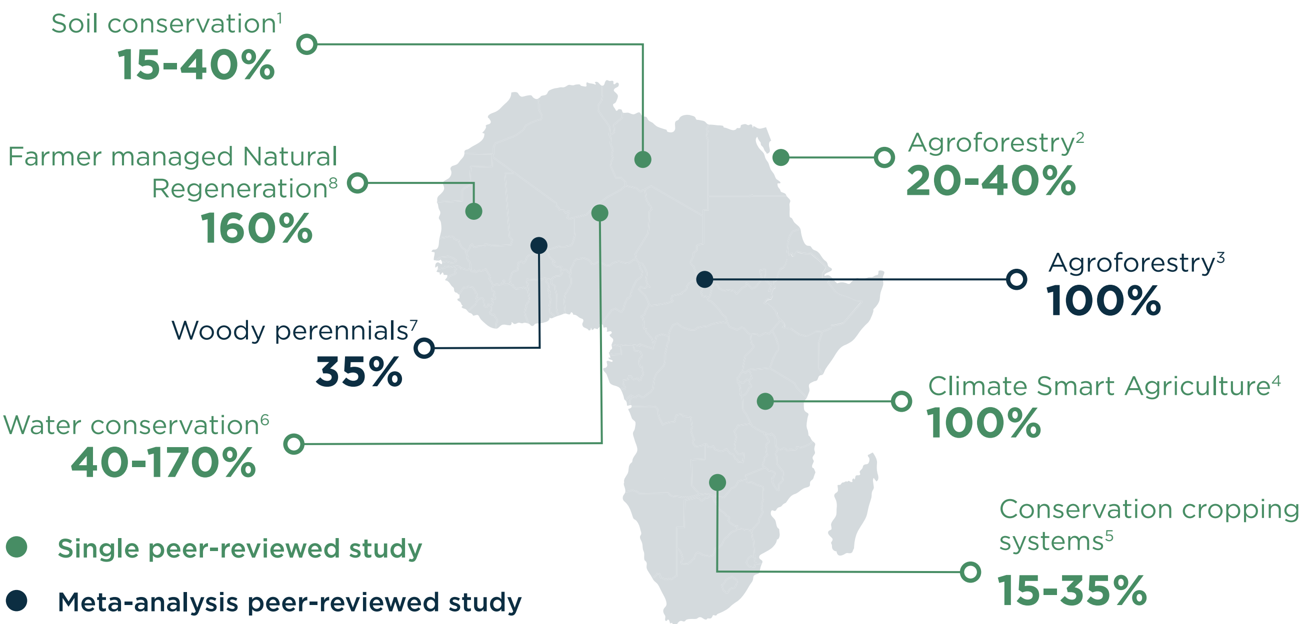
Source: Vivid Economics

3.1 Land restoration benefits for businesses and consumers

3.1.1 Farm production

Regenerative farming generates significant crop yield improvements in SSA. There is compelling evidence that the implementation of regenerative farming practices leads to substantial yield gains across SSA. Figure 7 illustrates the observed crop yield changes associated with a broad set of regenerative farming practices from a range of peer-reviewed academic articles. Farmers implementing agroforestry practices in East Africa have seen yields increase by 100% in comparison to non-regenerative practices (Amadu et al., 2020). Impacts are particularly strong in semi-arid regions of West Africa, which benefit especially because of the temperature and precipitation patterns they already face from climate change (Shem Kuyah et al., 2019). In the Sahel, the adoption of farmer managed natural regeneration (FMNR) was associated with increases in crop production ranging from 35% to 170% (Binam et al., 2017; Birch et al., 2016; Félix et al., 2018; Mcgahuey, 2020). As examples, FMNR adoption in Senegal is associated with millet production increase from 300 to about 770 kg of millet per hectare (Birch et al., 2016). In East Africa, agroforestry initiatives produced significant crop yield increases compared to non-regenerative monocultures, as shown in Figure 7 (Amadu et al., 2020; Fahmi et al., 2018). In Malawi, maize production increased from 320 to about 550 kg per hectare with climate smart agroforestry (Amadu et al., 2020).

Figure 7 : Crop yield increase observed in several regenerative agriculture initiatives across sub-Saharan Africa



Note: Values in the figure are rounded values. 1. Ibrahim et al. (2015), 2. Fahmi et al. (2018), 3. Shem Kuyah et al. (2019), 4. Amadu et al. (2020), 3. Shem Kuyah et al. (2019)5. Thierfelder et al. (2015)., 6. Reij et al. (2010), 7. Félix et al. (2018), 8. Birch et al. (2016) Reij et al. (2010). Thierfelder et al. (2015).

Source: Vivid Economics

Regenerative agriculture enables farmers to adapt to a variable climate and extreme weather events by enhancing crop yield stability and resilience. Regenerative systems are key to building crop resilience, particularly in vulnerable regions. Droughts and floods cause enormous economic losses[14] in the SSA region, which has a risk of drought[15] three times higher than the global average (Shiferaw et al., 2014). Soil conservation practices such as no-tillage, cover crops and crop diversification increase soil fertility, improve water retention and soil erosion protection, reduce soil temperatures and improve infiltration rates (S. Kuyah et al., 2017; Muchane et al., 2020). This overall increase in soil health has a stabilising effect that mitigates the impacts of climate change by increasing crop as well as farm system resilience, helping crops to deal with more intense rainstorms, increased daily temperature ranges and frequency of droughts (Anderson et al., 2020; Page et al., 2020; Williams et al., 2016). The combination and diversity of crops and products that is typical of regenerative systems provides additional benefits during these events. For example, trees planted among annual crops can maintain their own production during drier years because their deep root systems obtain water and nutrients from deeper in the soil (Quandt et al., 2019).

[14] 70% of the economic losses in SSA, and frequent drought conditions have reduced the GDP growth of many African countries (Shiferaw et al., 2014).

[15] Data on droughts is sourced from the international disasters database EM-DAT, which defines droughts as “an extended period of unusually low precipitation that produces a shortage of water for people, animals and plants. Operational definitions of drought, meaning the degree of precipitation reduction that constitutes a drought, vary by locality, climate and environmental sector”. Data is provided to EM-DAT from FAO and WFP. More information at: Guidelines | EM-DAT (emdat.be)

Box 2: What are the costs?

The initial costs of implementing land restoration practices may discourage adoption. Regenerative agriculture requires farmers and agribusinesses to choose the long-term increase in productivity over the short-term cost of forgone yields or capital expenditure to introduce new crops or practices. While some techniques such as reduced tillage result in lower workloads, other practices such as mulching may require greater labour inputs at certain times of the year. Labour related to managing weeds may be up to 30% higher, as pesticides are frequently unavailable to smallholder farmers (Pannell et al., 2014).

It can take time for investments to show returns. Timeframes for yield results from implementation span a significant range. While studies show that some yield increases can emerge within a single cropping season, others can take from two to five years. This is particularly relevant where land is taken out of use for one or more years during soil health improvement practices such as improved fallow, stumping or cover cropping. Production may also be delayed, with perennial tree products taking extended time to build harvest volumes, when initial restoration costs are at their highest (Dagar, 2020; IRP, 2019).

The overall economic benefits of restoration projects have been shown to exceed the cost. Long-term yields of restored land in Africa can exceed those without restoration by between 3 and 26 times (IRP, 2019).

Farmers are able to produce alternative and higher value crops which reduces crop failure risks and increases revenues all year-round. High crop diversity and biodiversity within the farming system is one of the key principles of regenerative agriculture. By introducing a diversity of crops and trees in combination with annual crops, a farmer can produce a range of annual and perennial and higher value food and non-food products (Lehmann et al., 2020). For instance, in agroforestry and forest farming, high-value and shade-tolerant speciality products such as fruits, botanicals, resins, medicinal and high-grade timber can be grown in the favourable microclimate (Elevitch et al., 2018; Sanchez, 2010). Forest products such as fruit, seeds and nuts usually have a higher value in comparison to heavily cultivated annual crops such as grains, and growing them can help mitigate income shocks and diversify revenue streams (Elevitch et al., 2018; Quandt et al., 2019).

Regenerative systems enhance agricultural synergies and lower input costs by increasing livestock fodder sources. Regenerative practices such as cover cropping and fodder banks yield supplementary products that can be used as fodder for livestock. Animal nutrition is a core aspect of animal husbandry and animal feed can account for up to 70% of total dairy farm expenditure (Mathukia et al., 2016). Green fodder and leguminous crops are low-cost sources of nutrients and protein, and cultivating fodder on the farm can lower feeding costs while minimising the need to outsource livestock feed and increasing resilience to price changes (Dawson et al., 2014). As regions become drier in coming decades, the introduction of fodder by means of cover crops, can also improve animal welfare (Chakeredza et al., 2007).

3.1.2 Food and beverage production

Food processors benefit from increased and more stable supply and reduced counterparty risk. If agricultural output increased from higher adoption of regenerative practices from farmers, local food processors would benefit from higher and more secure supply. Increases in agricultural production drive downstream activities, such as grain refining and other types of food processing, particularly of fruit and vegetables (Schaffnit-Chatterjee, 2014). Increased farmer yields also improve utilisation and efficiency in local processor facilities. Food and beverage processors therefore benefit from increased business activity and increased profit margins. Finally, regenerative agriculture practices also increase supply stability, driven by climate adaptation benefits (Lunn-Rockliffe et al., 2020; Pannell et al., 2014). This creates less likelihood of supply disruptions and lowers counterparty risk since farmers are more likely to meet their supply obligations.

Agribusiness and retail companies benefit from improved brand reputation and being able to meet demand for sustainable products. Companies are increasing benefit from value associated with their corporate social responsibility and sustainability strategy, and companies which do not pursue sustainable strategies risk reputational damage on the international scene. There are signs that middle class consumers in the African continent are also becoming aware and concerned over intensive pesticide inputs and effects on their health, companies which pivot to this new and emerging market signal could do well in the future. The agribusiness sector is especially sensitive to reputational issues as it responds to consumer preferences, environmental awareness and legislation (Rim et al., 2019). Companies increasing their CSR and sustainability performance have been seen to benefit from improved brand reputation (FAO, 2014; Gazzola, 2014), perhaps because consumers are paying increasing attention to sustainability attributes of products (Aflac, 2019). It is no surprise then, that some commentators expect sustainably marketed products to increase market share as consumers increasingly align spending with their values (Kronthal-Sacco et al., 2020), with consumers willing to pay a premium for products with environmentally-friendly attributes (McKinsey, 2012).

3.1.3 Consumers

Consumers may benefit from more stable and secure food supply, as well as from greater product diversity. Shocks in food production and pricing, especially for Africa's low-income population, can have a significant impact on households' ability to afford food and, as a result, food security (Haggblade et al., 2017). As regenerative agriculture can mitigate crop failure risks and provide more secure supply, consumers may benefit from more secure supply as well as from greater products diversity. In the event of price shocks, low-income households can potentially shift their food consumption to alternative food commodities, such as roots and tubers, whose prices are not closely associated with global prices (Haggblade et al., 2017). Regardless of price dynamics, consumers can benefit from a wider range of products, which contributes to more diverse diets (Binam et al., 2017) and allows them to select items with their desired characteristics.

3.2 Benefits for local livelihoods and societies

The evidence in this section shows how regenerative practices improve income and employment opportunities for individuals, empowering and benefiting local communities. Regenerative agriculture improves the livelihoods of smallholder farmers and local communities who rely on the production of crops. Regenerative practices deliver higher and diversified incomes and promote employment opportunities both off-farm and non-farm, as shown in Figure 8.[16] Improved revenue streams help farmers to expand their production from subsistence agriculture to commercial farming and enable households to increase their savings. Agricultural land restoration initiatives may also support individual and community empowerment when local knowledge and gender-focused actions are promoted.

Figure 8 : Regenerative agriculture's benefits on local livelihoods

Source: Vivid Economics

[16]Off-farm employment encompasses all agriculture-related activities that occur off the farm but are still part of the agricultural value chain. Off-farm employment refers to the labour required to move products up the agricultural value chain, and include extension services, processing, packaging, storage, transportation distribution, and retail sale. Non-farm employment refers to non-agricultural labour, including non-farm wage employment (e.g. employment in the private sector and outside agricultural market, such as in construction, health care, education, mining, tourism, etc.), non-farm self-employment or property income (rents, etc.)(Kassie, 2018; Lambert, 2019).

Household annual income can increase by up to USD 150 per year through crop diversification. Farming households using regenerative agriculture may supplement their income through diversification, such as agroforestry, crop diversification, rotation, cover cropping, crop-livestock integration or milling and log production. These practices generate income from products such as fuel wood, fodder, timber, fruit and livestock (Adams et al., 2016; Thorlakson & Neufeldt, 2012). Estimates of the additional revenues are wide-ranging. The sale of tree products from FMNR and agroforestry systems can increase revenues up to USD 45[17] per hectare per year (Binam et al., 2017; Thorlakson & Neufeldt, 2012). Other studies report higher income impacts, ranging between USD 130-150 per household per year from the revenues of tree based products, such as firewood (Chomba et al., 2020). Given that approximately 40% of the population in SSA lives below the poverty line of USD 1.9 per capita per day, although in rural areas this percentage can rise as high as 90% in some countries,[18] this may boost significantly the incomes of the poorest households.[19]

Regenerative systems stabilise household incomes, allow greater savings and improve access to finance. As farmers adopting regenerative agriculture can benefit from higher and diversified revenues streams, they may generate financial capital beyond subsistence levels alone, thereby aiding capital accumulation and re-investment at the farm level (Mbow et al., 2014). Capital accumulation may help increase the ability of households to respond to shocks (Quandt et al., 2019). Stable incomes also promote easier access to credit and savings, and households are more able to participate in non-farm wage labour and self-employment (Davis et al., 2017).

Regenerative practices can increase employment opportunities further down the agricultural value chain and the broader economy. Off-farm employment increases alongside yields, as larger harvests require more labour inputs to transport, process, transform and sell products. Non-farm employment increases across the economy, such as increased employment in sectors that produce farm inputs, and the use of services (Davis et al., 2017). As farmers feel more secure about their land, they also become more inclined to hire out land and shift towards non-farm types of employment (Kassie, 2018).

Higher agricultural productivity provides potential for scale and new business opportunities. The adoption of regenerative practices will lead to increased supply of agricultural products at both the local and regional level. The increased agricultural productivity derived from regenerative practices enables farmers to transition from subsistence to commercial farming. The higher income associated from increased yields allows farmers to invest in additional seeds and inputs for expanded production, improving both direct and indirect business opportunities for farmers and local communities (Gassner et al., 2019).

Agricultural land restoration initiatives have been linked to individual and community empowerment and social cohesion. Higher skills and incomes from regenerative agriculture programs enhance community self-sufficiency, especially through participatory and education processes (Asaah et al., 2011). Individuals and communities may be empowered from increased revenues from agricultural production, as farmers may be better able to afford to send their children to school, improve their housing, and better access health services (Kassie, 2018).

[17] Ranging between ~27 USD and ~74 USD per hectare across regions.

[18] In the Democratic Republic of Congo, rural poor (living with less than USD 1.90 per capita per day) are 89%, 65% in Guinea Bissau, 81% in Malawi (World Bank Group, 2020)

[19] Data calculated based on the average farm size and on average household size.

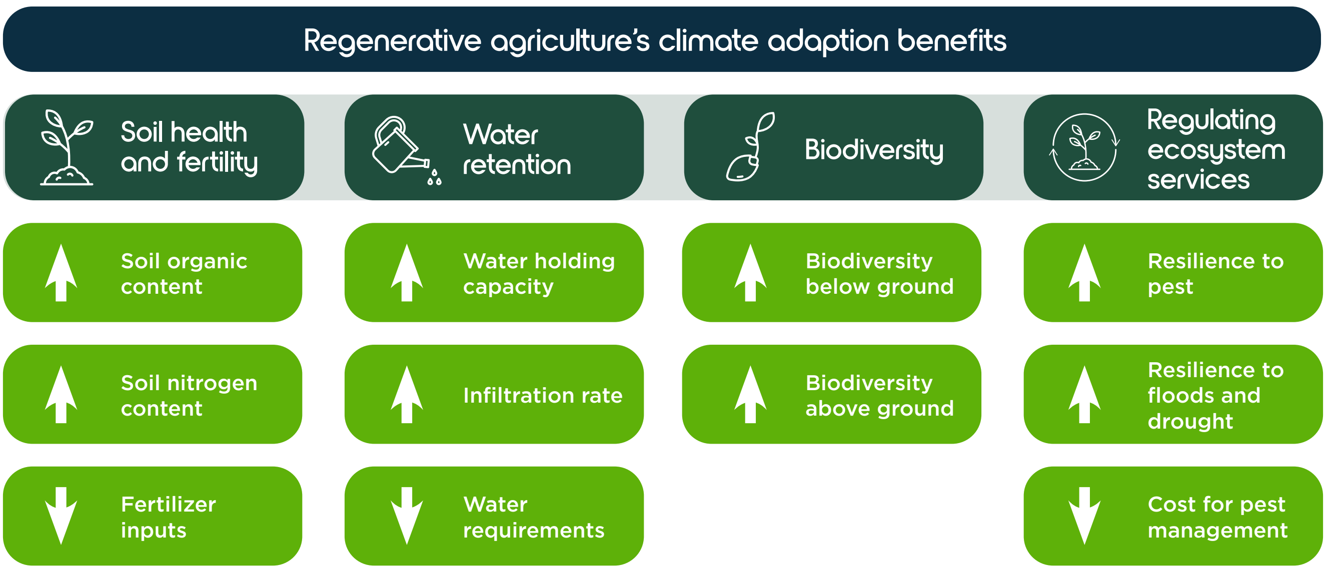
Regenerative agriculture initiatives can contribute to gender equity. Because engaging with regenerative practices does not typically require specialised technology or access to capital to achieve favourable results, regenerative agriculture could have the potential to contribute to gender equity improvements for smallholder farmers. By addressing gender equity issues associated with the lack of access to capital for costly inputs, engagement of both men and women can increase (Jones, 2020a). Furthermore, equitable gender participation in the decision-making process of land management has been shown in academic literature to have a positive impact on the efficiency and effectiveness of restoration programs (Broeckhoven & Cliquet, 2015; Chomba et al., 2020; Westerberg et al., 2019).

3.3 Climate adaptation and input cost impacts

3.3.1 Adaptation Benefits

Regenerative practices make farming systems more resilient to variation in climate. As climate change is expected to exacerbate climate variability, drought and flood and pest incidence, regenerative systems can improve resilience by delivering key environmental benefits, explained below in Figure 9.

Figure 9 : Regenerative agriculture average climate adaptation benefits



Source: Vivid Economics

Regenerative practices increase topsoil retention, nutrient retention and overall soil health. Regenerative practices increase soil nutrients, not only soil organic carbon, but also nitrogen, phosphorus and micronutrients (Shem Kuyah et al., 2019; Bayala et al., 2020; Sida et al., 2018). Soil organic carbon is estimated to increase by 20% and nitrogen 24% if regenerative practices are deployed. This increases not only in the top layer but also in subsoil to 50 cm depth or more, which has implications for both crop and tree growth, as well as for ecosystem services (Lal, 2015). Organic carbon and other nutrients in the topsoil are important for supporting, regulatory and provisional ecosystem services (such as increasing soil fertility, nutrient retention and ultimately yields).

Regenerative agricultural practices can improve conditions for vegetation growth and decrease water requirements by improving soil water holding capacity. As regenerative agriculture practices increase organic matter and cover soil, more water can be stored and retained in the soil, as rainwater infiltration is enhanced and runoff reduced (Bot & Benites, 2005; Shem Kuyah et al., 2019; Bargués-Tobella et al., 2019; Ilsted et al., 2016). As organic matter increases in the soil, soil moisture increases as well, improving the availability of water to plants: a 1% increase in organic matter in the soil profile can store up to an additional 150 m3 of water per hectare. In addition, soil cover and the avoidance of mechanical soil tillage reduce water loss. Soil moisture can increase up to 17-60% and water infiltration rate by 110-170% over a project implementation period of 20 years.[20] All these factors reduce water requirements for crops by up to 30% (Bot & Benites, 2005). This is particularly important for rain-fed crops and grazing land in dryland areas, which require moisture to be stored for long periods without rain.

Restoring soils can reduce soil erosion by 30%, avoiding the loss of essential nutrient-rich top-soil. When soil is restored and healthy, soil erosion caused by water and wind is substantially reduced. Covering and protecting soil with mulch also greatly lowers soil erosion. While precipitation runoffs can be up as high as 45% on some soil types, adding soil cover can completely eliminate soil erosion (Bot & Benites, 2005). Agroforestry reduced runoff by 57% in comparison to crop monoculture and infiltration rates are 75% higher under agroforestry systems (Shem Kuyah et al., 2019).

Regenerative practices increase biodiversity, which is fundamental to enhance ecosystem functionality and resilience. Regenerative systems conserve ecosystem biodiversity by providing habitat for species, reducing rates of conversion of natural habitat, conserving biological diversity below and above ground and preventing the degradation and loss of surrounding habitat (Garrity et al., 2010; Shibu, 2012). Biodiversity is fundamental to the delivery and stability of ecosystem services, which is fundamental for resilient farming systems (Erisman et al., 2016). Climate and water regulation, pest and diseases regulation and pollination are all necessary for agricultural systems to prosper.

Functional ecosystems make farming systems more resilient to pest outbreaks, which are expected to increase due to climate change. Crop pests are already a major factor influencing farm productivity at global scale, as about one-sixth of field production is lost to pests, with further losses occurring in storage (Dinesh et al., 2015). Crops grown in genetically uniform monocultures are more vulnerable to diseases, pests and nutrient deficiencies, and insect pest populations on insecticide-treated farms are up to ten times larger than on insecticide-free regenerative farms (LaCanne & Lundgren, 2018). Pest numbers are lower in fields with greater insect diversity, enhanced biological network strength and greater community evenness (LaCanne & Lundgren, 2018). Biological diversity increases when combining different crops or varieties, reducing pest prevalence, making the whole farming system more resilient to fungal diseases and pests, stabilising yield, while also improving the sustainability of the system as a whole (Erisman et al., 2016). As climate change and high temperatures are expected to increase the prevalence of crop pests, the frequency of new pest introductions and major pest outbreaks, Sub-Saharan countries are at great risk. Resilient systems are urgently needed to avoid increasing crop losses due to pest attacks.

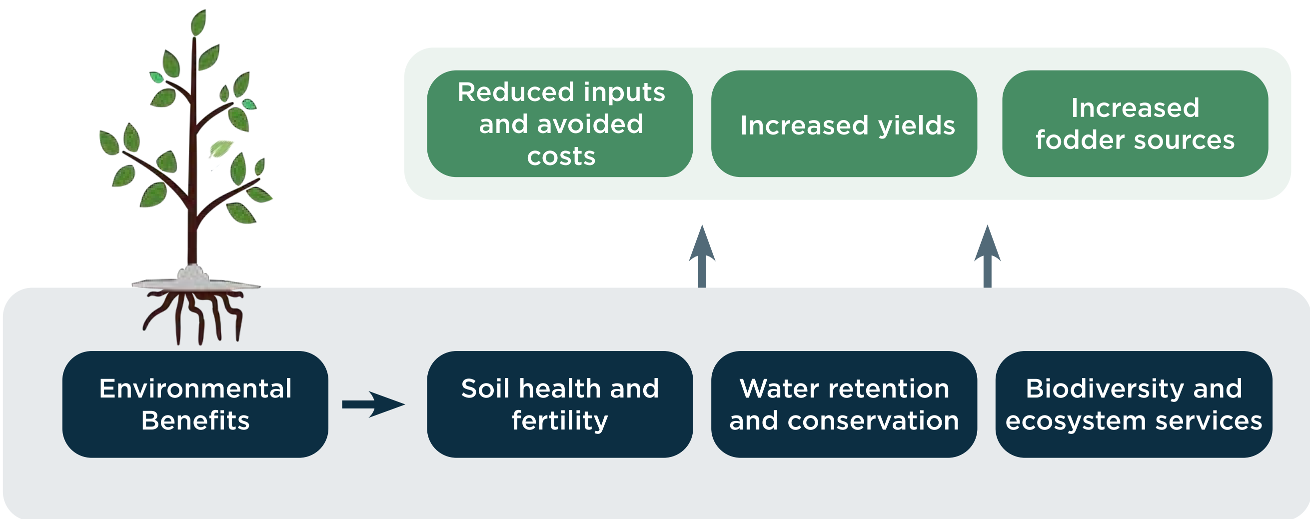
Regenerative practices mitigate the impacts of climate variability, by increasing system resilience to droughts and floods. Regenerative practices increase farm resilience to droughts and floods. Trees as well as perennial crops in intercropping systems can survive prolonged and seasonal droughts, as the roots abundance at soil depths, that are below the feeding zone of most annual crops, can transfer deeper resources to the surface, enabling better survival during long periods of drought or water stress (Dagar, 2020). Trees also increase resilience to droughts, as farmers may benefit from tree products when other crops are under water (Quandt et al., 2017). Increased soil water holding capacity helps crops resist drier seasons, and higher infiltration of water into soils reduces flooding,

[20]Source: Vivid Economics. See Appendix for details on the methodology.

also increasing water storage in soil and slow release to streams (Bot & Benites, 2005). Increased infiltration also improves groundwater recharge, thus increasing well supplies (Bot & Benites, 2005; Ilsted et al., 2016).

This range of environmental benefits from regenerative practices can directly lower farmer input requirements over time for costs such as irrigation, fertiliser and pest management. Regenerative agriculture increases the soil content of organic carbon, nitrogen and phosphorus, and hence soil fertility. Fertiliser requirements reduce significantly as crops absorb nutrients more efficiently from the soil, which translates into lower costs for farmers (Diallo et al., 2019; Shem Kuyah et al., 2019; Muchane et al., 2020). The increase in soil water holding capacity also reduces irrigation requirements, substantially cutting irrigation costs (Bot & Benites, 2005). Regenerative systems can also lead to lower pest prevalence, especially for perennial crops such as coffee, cocoa and plantain, reducing costs for pesticide use (Pumari et al., 2015) as well as the negative farmer health effects associated with pesticides (Elahi et al., 2019; Maumbe & Swinton, 2003).

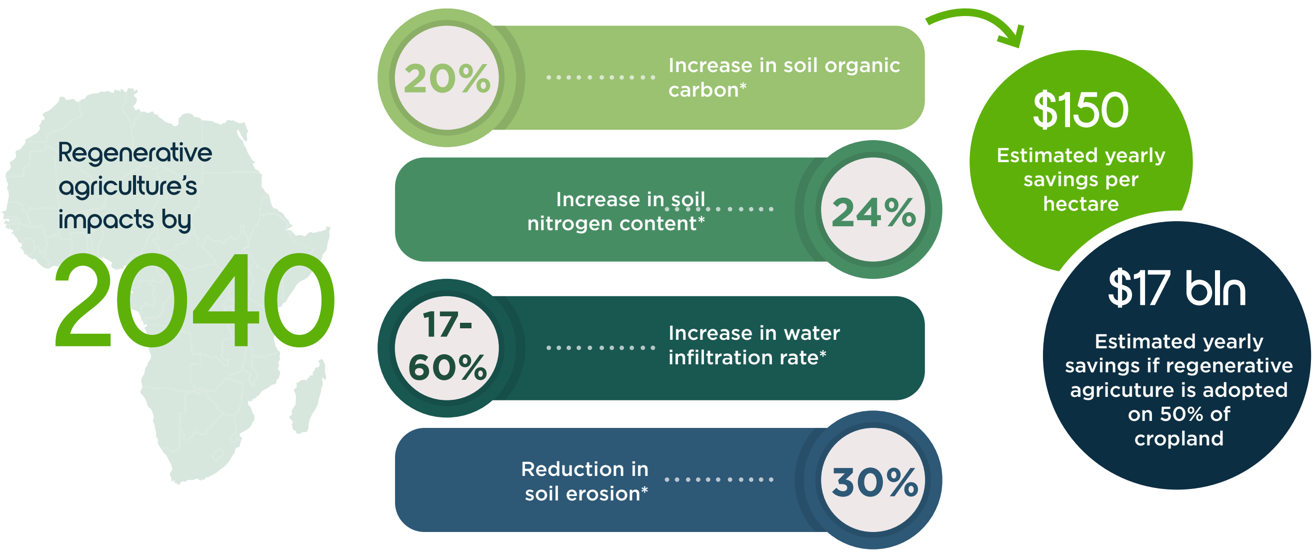
Figure 10 : Benefits of regenerative agriculture at the farmer level



Source: Vivid Economics

Reduced costs could equate up to USD 150 per hectare per year, which may translate into savings of USD 17 billion per year in SSA if regenerative practices are adopted at scale. The environmental benefits generated through regenerative agricultural practices can substantially reduce the farm inputs requirements, as well as the associated costs. As soil becomes healthier and soil erosion reduces, the soil is rich of essential nutrients, thus reducing the inputs and costs of fertiliser. Increased soil water retention reduces irrigation requirements, and increased biodiversity below and above ground increases ecosystem functionality, hence reducing pest management costs or disaster related costs. Overall, estimated USD 150 per hectare can be saved every year thanks to regenerative practices. This overall creates avoided costs for up to USD 150 per hectare.[21] If regenerative practices were adopted on half of the cropland of sub-Saharan Africa, savings would be up to USD 17 billion per year (see Figure 11).

Figure 11 : The impacts of regenerative agriculture on climate adaptation and input costs



Note: Data refer to changes over the project implementation period, which is assumed to be 20 years. Therefore, length of intervention of 20 years.

Source: Vivid Economics

[21]Source: Vivid Economics. See Appendix for details on the methodology.

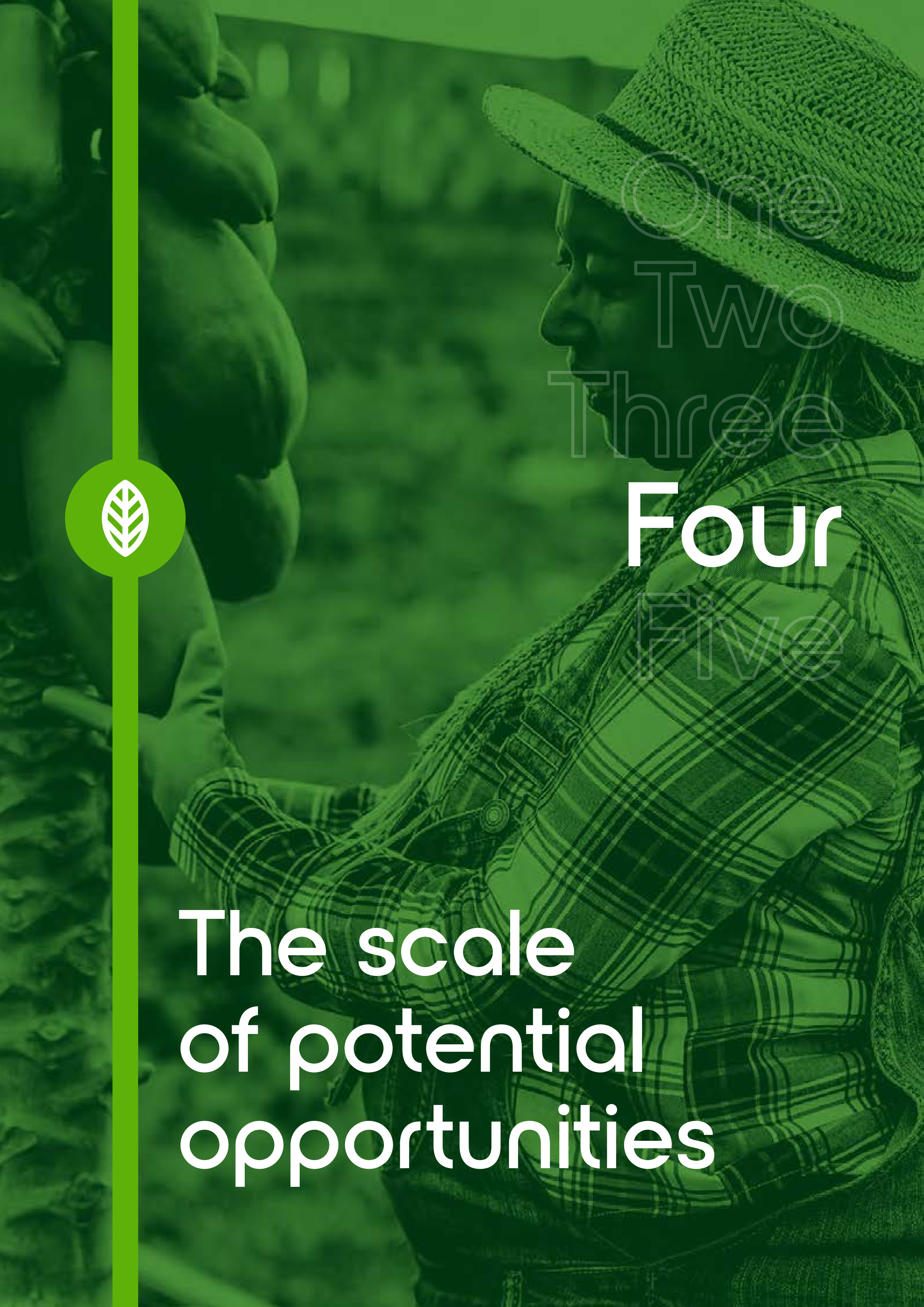
3.3.2 Climate Mitigation Benefits

In addition to adaptation benefits, regenerative agriculture has mitigation benefits making it a low-cost and effective solution to combat climate change. Regenerative agriculture can sequester large amounts of carbon dioxide. Carbon can be sequestered via soil organic carbon, increased vegetation coverage, and reduced input emissions. Agroforestry, soil management and pasture management solutions implemented on a global scale are estimated to be able to mitigate upwards of 8.4 $GtCO_2e$ per year globally, corresponding approximately to 12% of current global emissions (Jones, 2020b; Olivier & Peters, 2020).

Regenerative systems increase soil organic carbon content by an average of 20%. Soil carbon accounts for one third of global carbon stock, the second largest storage after the oceans (ELD Initiative & UNEP, 2015). Practices such as reduced tillage, mulching and shade tree planting lead to increased retention of organic carbon in deeper subsoil. This is critical for carbon sequestration, as soils at greater depths have the capacity to store more carbon for longer periods than topsoil (Drayton Chandler, 2016; Gross & Harrison, 2019). Organic management techniques have been shown to increase soil organic carbon by 20% over a project implementation period.[22] Soil organic carbon can increase further through implementing specific practices, such as mulching (40% increase), introduction of shrubs (39%) and agroforestry in general (57%).[23] As such, regenerative practices have potential to become an important solution in combating carbon emissions.

[22]The project implementation period is assumed to be 20 years.

[23]Data refer to a timeframe of 20 years. Source: Vivid Economics. See Appendix for details on the methodology



The scale of potential opportunities

4 : The scale of potential opportunities

This chapter of the report highlights the potential opportunities of scaling up regenerative agriculture across sub-Saharan Africa. The section presents and discusses estimates of the long-term socio-economic impacts of adopting regenerative agriculture at scale. The framework used for categorising these benefits is shown in Figure 12.

Section 4.1 outlines the modelling approach and some scenarios.

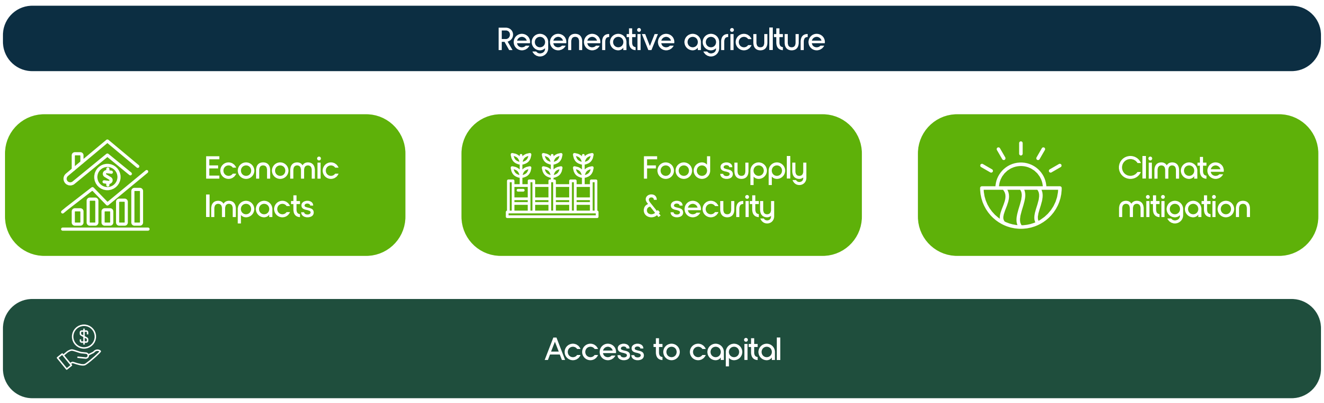
Section 4.2 sets out potential production and economic impacts.

Section 4.3 assesses the impacts on food supply and food security in sub-Saharan Africa.

Section 4.4 quantifies the climate mitigation potential.

Section 4.5 adds a brief consideration of how regenerative agriculture might enable access to capital for businesses.

Figure 12 : Categories of impact of regenerative agriculture in the long-term



Source: Vivid Economics

4.1 Modelling approach

Land use scenarios were developed to illustrate increased uptake of regenerative agriculture practices over time. Cropland area was held constant at 2020 levels, while two future yield scenarios for crops were considered. In the business-as-usual scenario (BAU), SSA continues on its current path with non-regenerative agriculture. In the regenerative scenario, yield enhancing technological progress was combined with levers that proxied regenerative practices, such as higher nitrogen uptake efficiency in soil[24] (which automatically generates lower fertiliser use per kg of crop production), better irrigation capacity, and sustainable animal waste management.

The results may be considered a conservative picture of the potential for regenerative agriculture under full implementation across SSA. The scenario reports 4% higher crop production above the BAU scenario by 2030, and 13% higher crop production by 2040. A comprehensive analysis on regenerative studies and literature review showed yield increases compared to baseline practices could average around 40% in SSA under full implementation. The modelled 13% increase in crop production by 2040 may therefore be seen as conservative, but gives insight into the consequent outcomes through the economy and labour market.

Higher production of crops generate economic and food security impacts. As agricultural production grows, this creates economic activity in the supply chain, which can be measured by increases in gross value added (GVA) and jobs supported. It can also change per capita food consumption, reduce food prices and improve households' economic vulnerability to price shocks. Furthermore, nutritional dimensions of food security are assessed, such as the calorie contribution to diet from various crop types (such as fruits, vegetables, nuts, and cereals).

[24]Directly leading to less fertiliser being required per kg of crop production

4.2 Economic and production impacts

The illustrative regenerative scenario has been chosen to give 13% higher crop production in 2040 than the BAU scenario. Innovation in agricultural technology and crop breeding continues to increase crop yields in the baseline scenario. However, the changes to innovation costs, nitrogen take-up efficiency, water availability and other aspects of regenerative practices would accelerate these yield increases and take them further. By 2030, sub-Saharan crop yields increase by 17% (an extra 4%) in the regenerative scenario. By 2040, the uptake of regenerative agriculture practices might increase yields by 65%, a 13% higher yield relative to the BAU result in 2040. This yield is equivalent to an additional 62 million tons of dry matter tonnes of production per year across SSA.

+13%

Agricultural production in 2040 under regenerative practices compared to BAU

Higher yields translate into higher GVA per year and stimulate job creation, measured in full time equivalent (FTE) employment supported. Higher agricultural yields increase crop production, leading to direct additional agricultural GVA. Higher output raises income for farmers that is spent in the local economy, inducing demand for labour and output in other sectors and creating additional GVA. The processing of these crops for consumption indirectly requires use of labour and capital in food processing, which supports GVA and employment expansion in this sector as well. There will be a similar effect in food distribution and retailing. In addition, use of intermediate inputs expands the supply of goods and services to farmers (including machinery manufacture, fuel, transport and agrochemicals). Finally, additional income in food processing and its supply chain induces jobs and GVA throughout the economy.

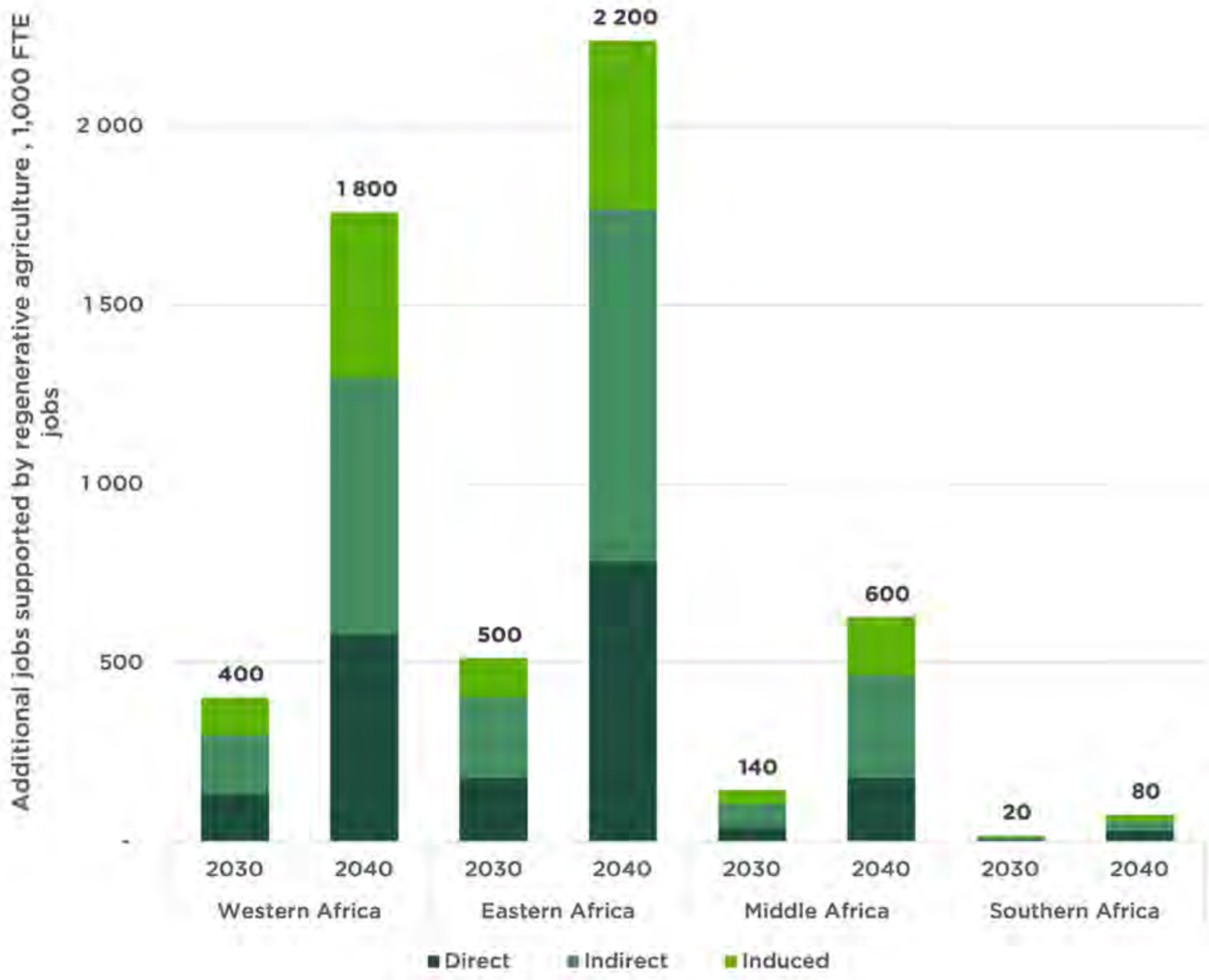
In the conservative scenario described above, regenerative practices might support upwards of 1 million FTE jobs across sub-Saharan Africa by 2030, and nearly 5 million FTE jobs by 2040. Figure 13 illustrates the absolute increase in annual jobs[25] in 2030 and 2040 if regenerative agriculture were to be adopted at scale, compared to non-regenerative practices. By 2030, more than 1 million additional FTE jobs could be supported across SSA if regenerative practices are used. By 2040, this number could reach nearly 5 million FTE jobs.

The long-term figures to 2040 show variability in employment impact across regions. Western and Eastern Africa have the largest increased employment opportunities, with an overall increase of nearly 1.8 and 2.2 million additional FTE jobs respectively by 2040. The reason Western and Eastern Africa are predicted a greater impact on employment compared to other SSA regions could be that they rely more heavily on the agricultural sector.

[25] Jobs can be those created, displaced or safeguarded

Agriculture makes up around 25% of GDP in these countries, compared to 17% in Middle Africa and only 4% in Southern Africa. Eastern and Western Africa also have a higher share of SSA's population, with 420 million and 380 million respectively, relative to 160 million and 64 million for Middle and Southern Africa, hence more jobs are expected to be created in these regions (FAO, 2021).

Figure 13 : Additional jobs that would be supported by regenerative agriculture in 2030 and 2040 in SSA compared to non-regenerative practices, thousands of jobs



Note: Direct and indirect jobs are only modelled in the processing sector. Induced jobs cover all sectors. Supported jobs include those created, displaced and safeguarded.

Source: Vivid Economics

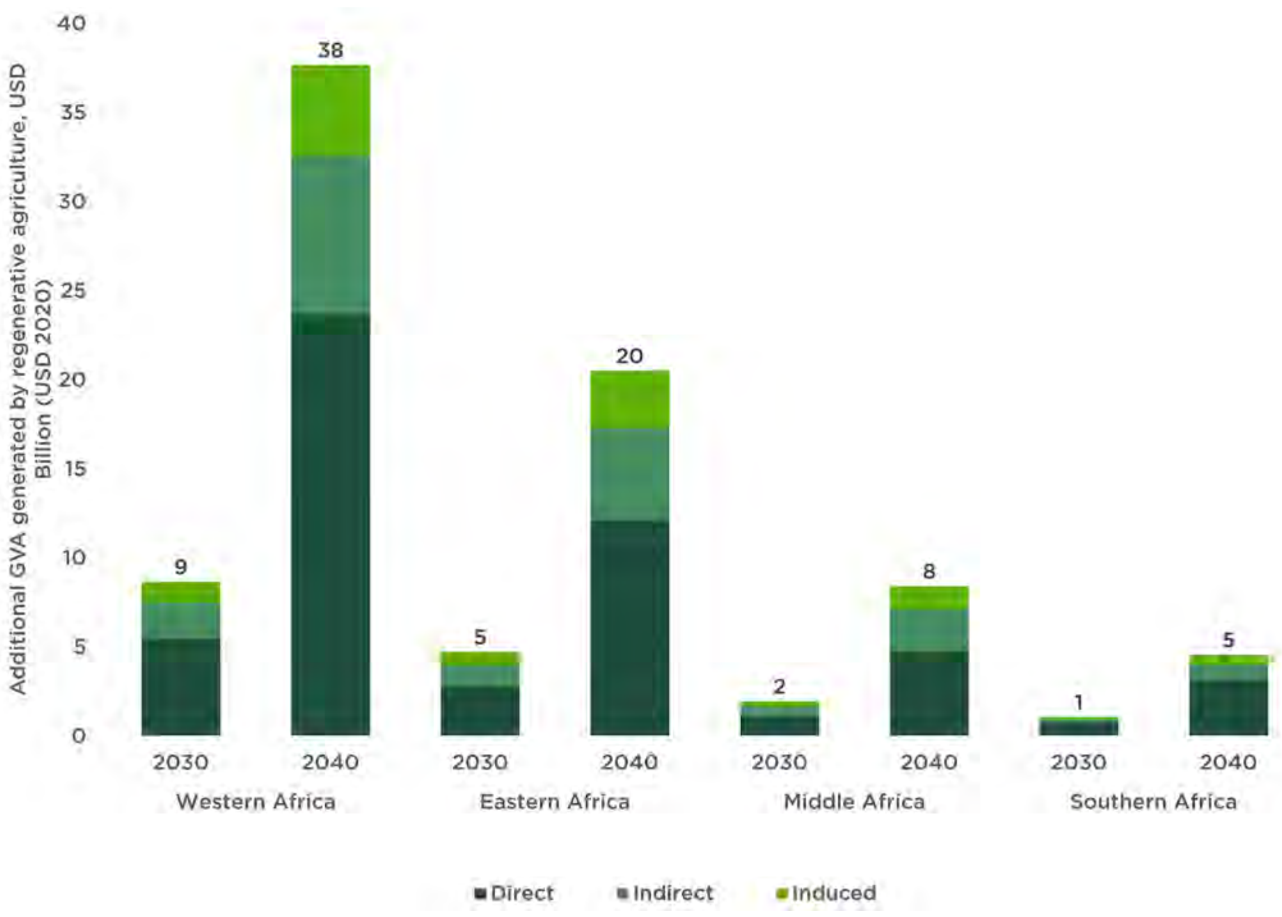
Regenerative practices could support more than USD 15 billion in Gross Value Added per year by 2030, jumping to about USD 70 billion per year by 2040. Figure 14 illustrates the impacts of regenerative farming adoption in sub-Saharan Africa on GVA creation in 2030 and 2040 across the four regions. By 2040, this conservative scenario indicates that the adoption of regenerative practices could produce direct GVA of over USD 30 billion per year in agriculture, and nearly USD 40 billion per year in indirect and induced GVA from food processing and other sectors. Agriculture is currently a large sector in the SSA economy, accounting for 22% of SSA's GDP.

Western and Eastern Africa are expected to see most of the GVA benefits. GVA created by 2040 in Eastern Africa could be USD 20 billion, while in Western Africa this could reach nearly USD 40 billion. Compared to other regions, Eastern Africa and Western Africa are characterised by high population and the highest total GDP. Middle Africa and Southern Africa see smaller GVA increases by 2040 as a result, accounting for nearly USD 8 billion and USD 5 billion respectively. The much higher GVA increase in Western Africa is particularly driven by direct processing sector GVA, so this result is likely driven by the region using more intermediate inputs as a portion of overall processing production or relying less on imports compared to other regions.

Impacts on GVA come to the largest extent from direct impacts, but indirect impacts from throughout the economy are also material. Direct impacts from increased yield account for more than half of all GVA in the scenario model, about USD 45 billion per year by 2040.

The increase in yields drives immediate additional agricultural output in agriculture, as well as in the processing sector which processes these increased inputs. The indirect effects in other sectors (ranging from fertiliser producers to service providers) is also large, potentially accounting for nearly USD 20 billion GVA.

Figure 14 : Scenario of additional GVA generated by regenerative agriculture in 2030 and 2040 compared to non-regenerative practices, USD billions (USD 2020)



Note: GVA includes GVA created, displaced and safeguarded.

Source: Vivid Economics

4.3 Food supply and food security impacts

Agricultural productivity may alleviate poverty and raise domestic food security. SSA is currently a laggard globally in terms of crop productivity and most of the agricultural produce is grown by smallholders living below the official poverty line. Poverty may be alleviated and food security improved by catching-up yields towards international levels (Gassner et al., 2019). Regenerative agriculture offers a way to increase farm productivity, supplying greater output and more diverse food sources compared to non-regenerative systems.

Figure 15 : Regenerative agriculture's impacts on food supply and security compared to BAU by 2040

Source: Vivid Economics

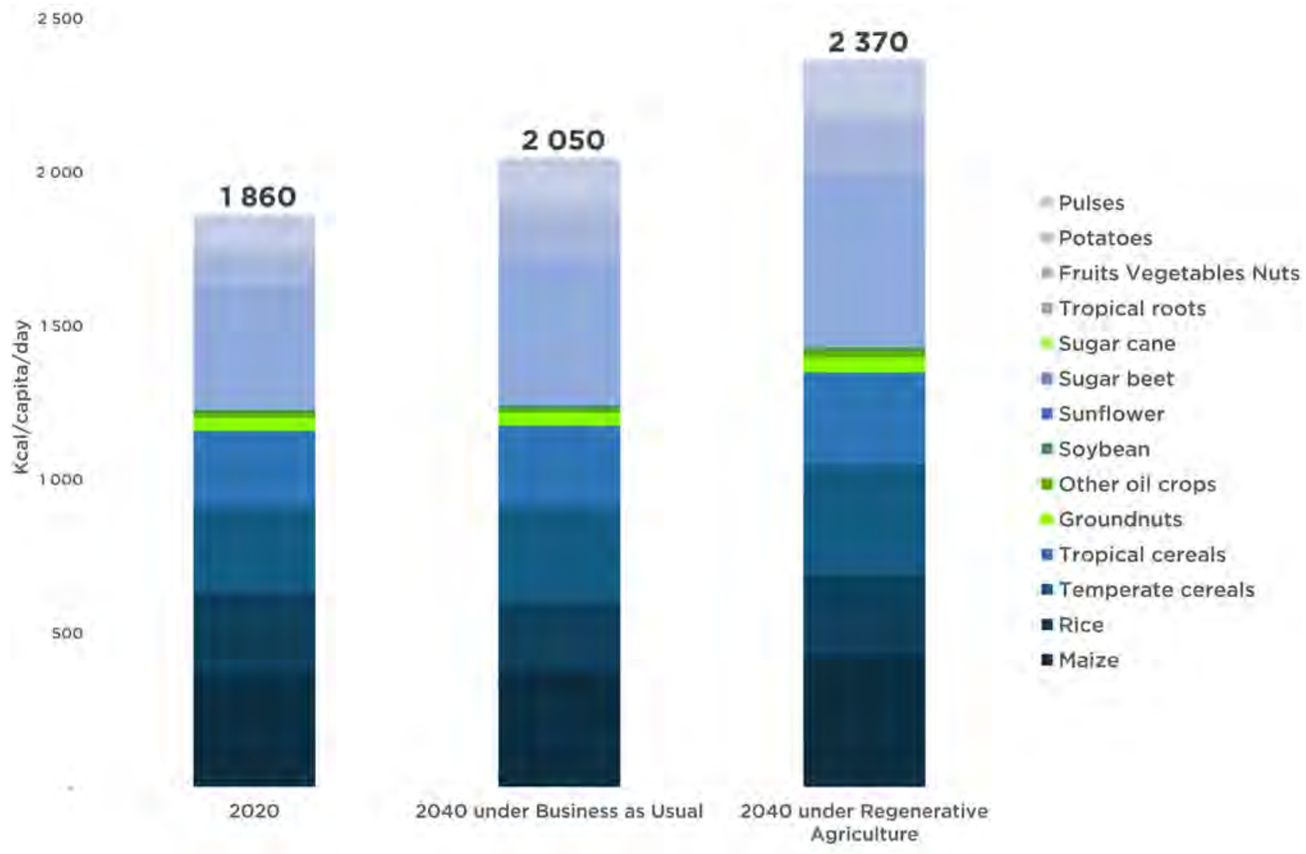
Regenerative farming systems are more resilient compared to non-regenerative agricultural systems. Resilience is gained both by providing more diverse agricultural products which can be harvested throughout the year and because of their tolerance of extreme weather events. This benefits societies at large and especially smallholder farmers and local communities in sub-Saharan Africa (Thorlakson & Neufeldt, 2012).

In the regenerative agriculture scenario, food prices may be lower by 16-24% by 2040. Food prices might be lower by about 20-30% compared to 2020, and 16-24% lower compared to food prices in BAU in 2040. Currently, households in sub-Saharan Africa spend on average about 50% of their income of food,[26] so households are vulnerable to shocks in food prices and are moderately food insecure (Rose et al., 2013; Smith & Subandoro, 2007). As food output increases it relieves pressure on food prices and households will spend a lower share of their income on food. In the regenerative agriculture scenario, households spend on average 41-47% of their income on food, which is 5-15% lower than in a BAU scenario, releasing income for spending on education, health, shelter and other goods and services.

[26]For reference, the average household food expenditure share in Europe is around 12%(Eurostat, 2019), 22% in China and 56% in Nigeria (World Economic Forum, 2016)

Regenerative systems increase per capita calorific intake by 16% and improve nutrition for society at large as well as for smallholder farmers. Daily calorific intake per capita may increase across sub-Saharan Africa by 2040 up to 16% more when agriculture is regenerative. As illustrated in Figure 16, calorific intake might increase from about 1,860 to almost 2,400 calories per person per day from 2020 to 2040 under regenerative agriculture. The results also indicate an improvement in diet. Calorific intake from more diverse crops (mainly pulses, fruits, vegetables, nuts and roots) is 16% higher compared to BAU, and 47% higher compared to 2020. The increase in cereals in 2040 is 15% higher in a regenerative scenario compared to a BAU scenario in 2040 and 16% higher than in 2020. Regenerative agriculture improves nutrition at the farm level as the food produced by the more diverse and stable crops and trees offers a diversity of nutrition to smallholder farmers and local communities. Farmers adopting agroforestry or FMNR for instance can not only harvest a wide range of on-farm forest products (fruits, nuts and pods) during the dry season when they otherwise would face food shortages, but also improve dietary diversity as trees and crops are simultaneously grown alongside other crops (Binam et al., 2015; Thorlakson & Neufeldt, 2012; Westerberg et al., 2019).

Figure 16 : Per capita daily calorie intake from the main crops' categories in 2020 and in two scenarios in 2040



Note: The 14 crops considered comprise the main four crop categories of i) cereals (maize, rice, temperate cereals, tropical cereals), ii) oil crops (groundnuts, soybean, sunflower, other oil crops), iii) sugar crops (sugar beet, sugar cane), iv) other crops (pulses, potatoes, fruits, vegetables and nuts, tropical roots). The consumption of sugar crops is too low to be easily visible in the chart.

Source: Vivid Economics

4.4 Climate mitigation impacts

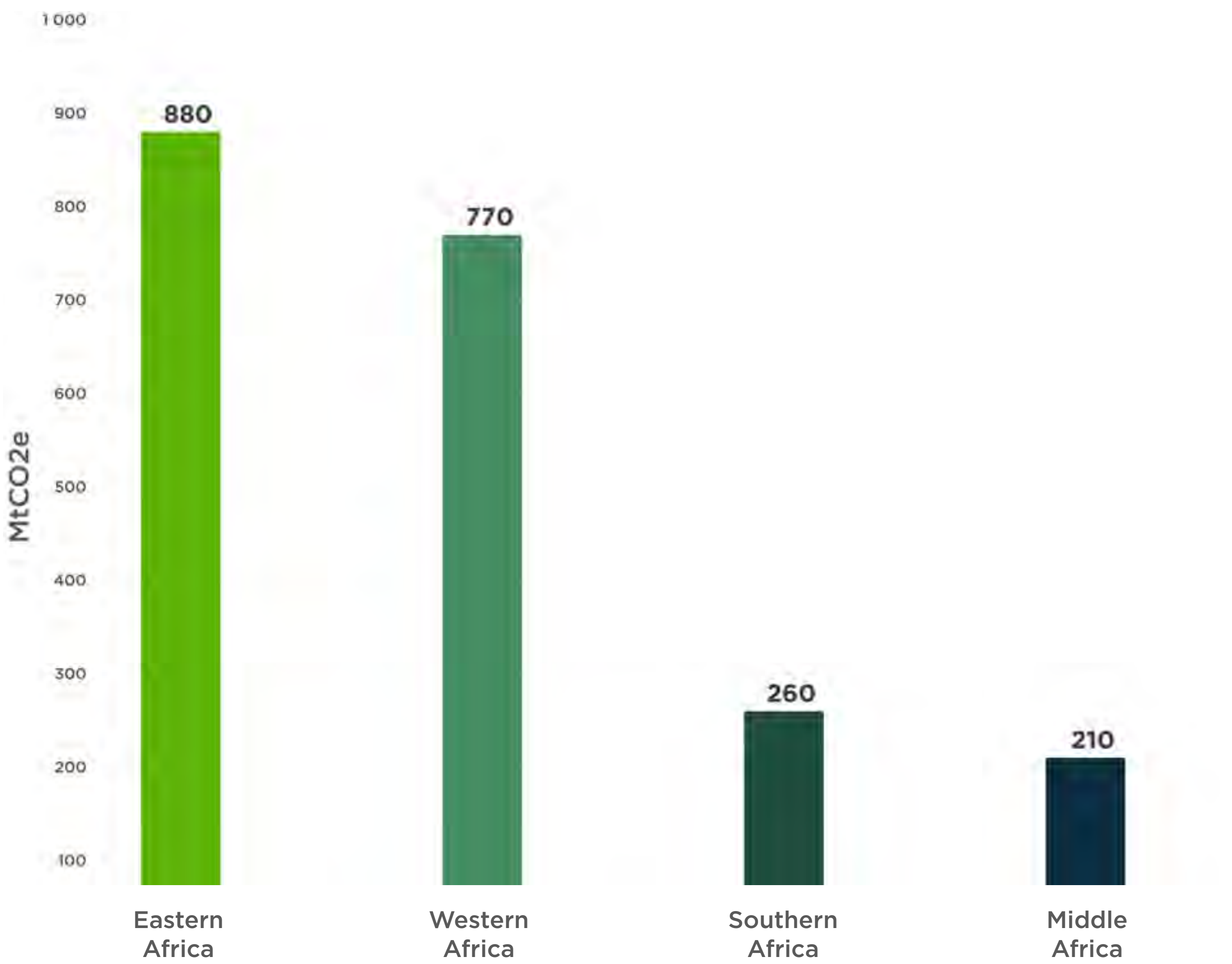
Regenerative agriculture can sequester large amounts of carbon dioxide, making it a low-cost and effective solution to combat climate change. Carbon is sequestered via soil organic carbon, increased vegetation coverage, and reduced input emissions. Regenerative systems are expected to increase soil organic carbon content by an average of 20%. This is important for carbon sequestration, as soil organic carbon is already extensive, accounting for one third of global carbon stock, and has the capacity to store carbon for long periods (Drayton Chandler, 2016; Gross & Harrison, 2019).

Increased uptake of organic cropland management in SSA might increase the soil carbon stock 4.4 $GtCO_2e$ by 2040. Sequestration rates for different crop practices vary, with reliable meta-analysis results showing between 1.1 tCO_2e/ha/y for cover cropping to 3.7 tCO_2e/ha/y for perennial grains switching (Paustian et al., 2019; Poeplau & Don, 2015). Estimates of annual soil carbon sequestration also vary substantially, with 4-5 $GtCO_2e$/y considered the upper limit for high adoption of best management agricultural practices (Paustian et al., 2019). The FAO (2011) found that a range of studies in developed economies showed an increase of soil carbon stock from nearly 100 tCO_2e to about 140 tCO_2e per hectare, a 40% increase. If 50% of cropland were to be managed through regenerative practices by 2040[27], the carbon stock in soil could increase in sub-Saharan Africa by 4.4 $GtCO_2e$ by 2040, or around 220 $MtCO_2e$ per year.

Agroforestry could sequester additional 106 $MtCO_2e$ every year across the sub-Saharan region, resulting in 2.1 $GtCO_2e$ sequestered over twenty years. If agroforestry is adopted at scale in sub-Saharan Africa, it could sequester up to 106 $MtCO_2e$ every year, corresponding to approximately 11% of sub-Saharan Africa's agricultural CO_2e emissions (Climate Watch, 2021). Figure 17 shows sub-Saharan African regions ranked by mitigation potential from agroforestry over twenty years. Eastern and Western Africa have the greatest potential, with about 878 $MtCO_2e$ sequestered in Eastern Africa and 773 $MtCO_2e$ in Western Africa. These regions are characterised by the coexistence of large areas of forest and pasturelands, which, when contiguous, can be turned into agroforestry areas. There is therefore a significant amount of untapped mitigation potential in these regions. Although middle and Southern Africa show lower potential for carbon sequestration through agroforestry, these regions can still significantly benefit from improved cropland management.

[27]Assumes no lag in implementation period

Figure 17 : Agroforestry carbon sequestration potential ($MtCO_2e$) over 20 years across sub-Saharan Africa



Note: GVA includes GVA created, displaced and safeguarded.

Source: Vivid Economics

Other aspects of regenerative agriculture also absorb carbon but have not been estimated here. Agroforestry and conservation techniques such as shade trees, cover-cropping and fallow pastures create higher levels of vegetation biomass. Most practices also involve reduced use of emissions intensive inputs. Chemical fertiliser production in particular is a highly emissions intensive. By reducing the use of these inputs, the potential emissions that would have been emitted under a BAU scenario would be avoided.

4.5 Access to capital

The flow of funds into sustainable solutions such as regenerative agriculture is growing rapidly. Public financing of nature-based solutions is estimated to be at least $115b per year globally, but private finance remains small in comparison and more is needed of both (United Nations Environment Program, 2021). Sources of funding include domestic government expenditure, overseas development aid or financing from development institutions. Private finance ought in the medium term offer a larger and more rapidly growing opportunity. A 2020 survey of $404 billion USD impact investing assets showed sub-Saharan Africa attracted 21% of funding, the largest individual region for investment globally (Hand et al., 2020). Food and agriculture was globally the most common sector for private investment, with 57% of respondents having some allocation and over half indicating plans to increase allocations.

Growing evidence for the ability of regenerative agriculture to meet climate targets creates the potential for increased access to funding. Access to finance can be a significant barrier for smallholder farmers (Varangis et al., 2014). This is particularly relevant given the identified upfront capital costs associated with switching to more sustainable practices. Businesses leveraging regenerative agriculture approaches could greatly enhance lending capacity as local banks and investors increasingly focus on green metrics and social outcomes. There is even the potential for additional revenue streams via carbon offsets, with groups such as RaboBank pioneering programs to enable smallholder farmers to receive carbon income for agroforestry and other regenerative practices (Rabobank, 2021).

One
Two
Three
Four

Five

Conclusion

5 : Conclusion

Businesses are already adopting regenerative agriculture in response to current and anticipated challenges, seeing yield impacts ranging from 68% up to 300%. Companies seeing changes to production as a result of degraded land are beginning to understand the potential impacts of inaction. Businesses such as AB InBev, LEAF Africa, Nespresso, Olam, Touton, and Twiga Foods have already implemented programs in the SSA region in programs reaching over 100,000 farmers. They are seeing success in the form of increased yields, greater output, and a more resilient and sustainable supply chain.

There is a clear business case for implementation in SSA farming at scale. Regenerative agriculture is an inexpensive way for agribusinesses to generate significant returns and build supply chain resilience. The long-term benefits far outweigh the costs for these practices, offering the agricultural and food processing sector both a substantial growth opportunity and an effective risk mitigation strategy. However, implementing new practices takes time and knowledge, and benefits are not always immediate. Responsive and timely access to training, investment incentives and capital is therefore critical for success.

Regenerative agriculture promotes business growth through direct production and cost benefits for the agricultural sector, and via indirect impacts on the supply chain. Farm production sees direct impacts through increased yield, improved production reliability and cost reduction. The benefits experienced by farmers and crop producers are then passed on to food processors through lower input costs and reduced supply disruption. These benefits flow through to the consumer who is able to purchase a greater variety of products at cheaper prices. Additional societal benefits

are seen throughout the value chain stemming from improved environment, food security and sustainable livelihoods.

Regenerative agriculture shows compelling long-term economic and food security potential. Under a conservative representative 2040 scenario, the uptake of regenerative practices in SSA could be generating upwards of USD 70 billion more GVA per year. Similarly, the scenario also shows these practices could be supporting 5 million additional jobs by 2040. Modelling also showed potential for food security impacts, with food prices decreasing by 16-24%, 13% higher food per capita consumption, and calorie intake increasing by 16% due to higher consumption of fruits, vegetables, nuts, roots, pulses and cereals.

Increased uptake of regenerative practices could have substantial climate mitigation and adaptation possibilities. Cropland management and agroforestry expansion were estimated to have sequestration potential of more than 6 $GtCO_2e$ by 2040. Adaptation benefits could also be generated, such as 20% increases in soil organic carbon, 30% less soil erosion and increased soil water retention. As adaptation benefits reduce inputs costs, it is estimated USD 17 billion can be saved every year if regenerative agriculture is adopted at scale.[28]

In conclusion, regenerative farming systems are profitable, while fulfilling a need for improvements in livelihood, nutrition, food security and environmental protection. Regenerative agriculture addresses all these challenges, improving returns from farming, food processing and retailing, restoring degraded land and securing future productivity, and creating economic benefits which ripple outwards through the economy. This report provides clear evidence for why regenerative agriculture deserves significant attention from both food supply chain businesses and public decision makers.

[28]Adaptation and soil carbon sequestration estimates based on regenerative agriculture being adopted on 50% of sub-Saharan Africa's cropland in 2040. Further information in Section 4.5 and Appendix A.

Appendix: Methodology of the scale of potential

Agricultural production

The land use modelling for the report was undertaken using the Model of Agricultural Production and its Impact on the Environment (MAgPIE). Developed by the Potsdam Institute for Climate Impact Research, MAgPIE is a spatially explicit, partial equilibrium model that solves for the least-cost way to meet future food demand. The model accounts for climate policies, socio-economic variables, such as GDP, income and population, and physical inputs, eg. biophysical constraints on water and yields. MAgPIE also calculates land use costs and patterns of future land use change. MAgPIE takes regional economic conditions1 as well as spatially explicit data on potential crop yields, carbon stocks and water constraints under current and future climatic conditions into account. Based on these, the model derives specific land use patterns, agricultural water use, greenhouse gas dynamics, yields and total costs of agricultural production for each grid cell.

MAgPIE was used to model two scenarios: business as usual and a regenerative agriculture future. MAgPIE includes a set of input parameters assumptions which can be modified to characterise the scenario required. For business as usual, default settings were kept reflecting current policies and agricultural methods. Regenerative agriculture at scale in SSA was modelled by changing several characteristics of agricultural systems at a global level. Assumptions on regenerative agriculture included the characterization of nitrogen efficiency in soil, irrigation requirements, crop residues management and animal waste management. In both scenarios, low carbon price trajectories consistent with >2°C warming were used in developing countries, and moderate carbon prices consistent with 2°C warming were used in industrialised countries. In practice, this means that SSA had a carbon price of 30USD/tCO_2e in 2040 in the scenario calculations.

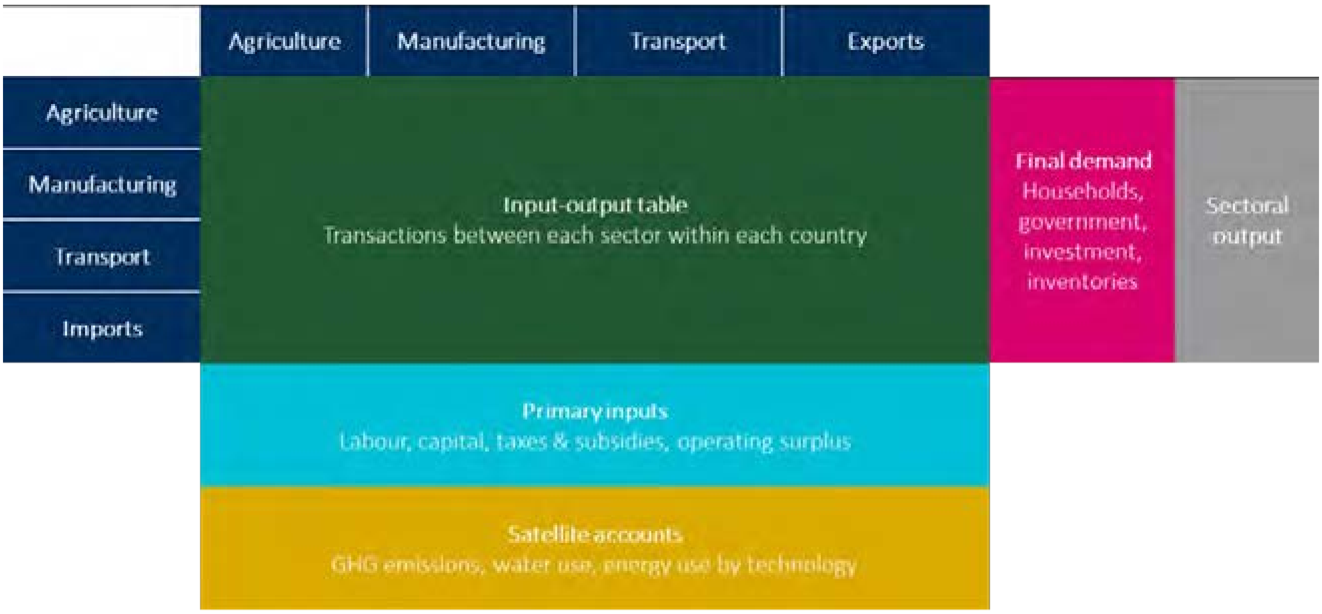
The key assumptions:

- Cropland is kept constant over time in SSA.

Economic impacts

The potential impacts of regenerative agriculture on GVA and supported employment are modelled using one of Vivid Economics' in-house macroeconomic models, I3M. I3M is an input-output modelling framework based on the Eora multi-region input-output table (MRIO). The MRIO is a square matrix that represents the intermediate transactions between all sectors in all countries. In addition, the final demand of households, government purchases and other agents within each country for the output of all sectors is represented in the Final Demand block. Correspondingly, the primary inputs to sectoral production (labour, capital etc.) are represented in the Primary Inputs block. A simplified version of the table is represented in Figure 18.

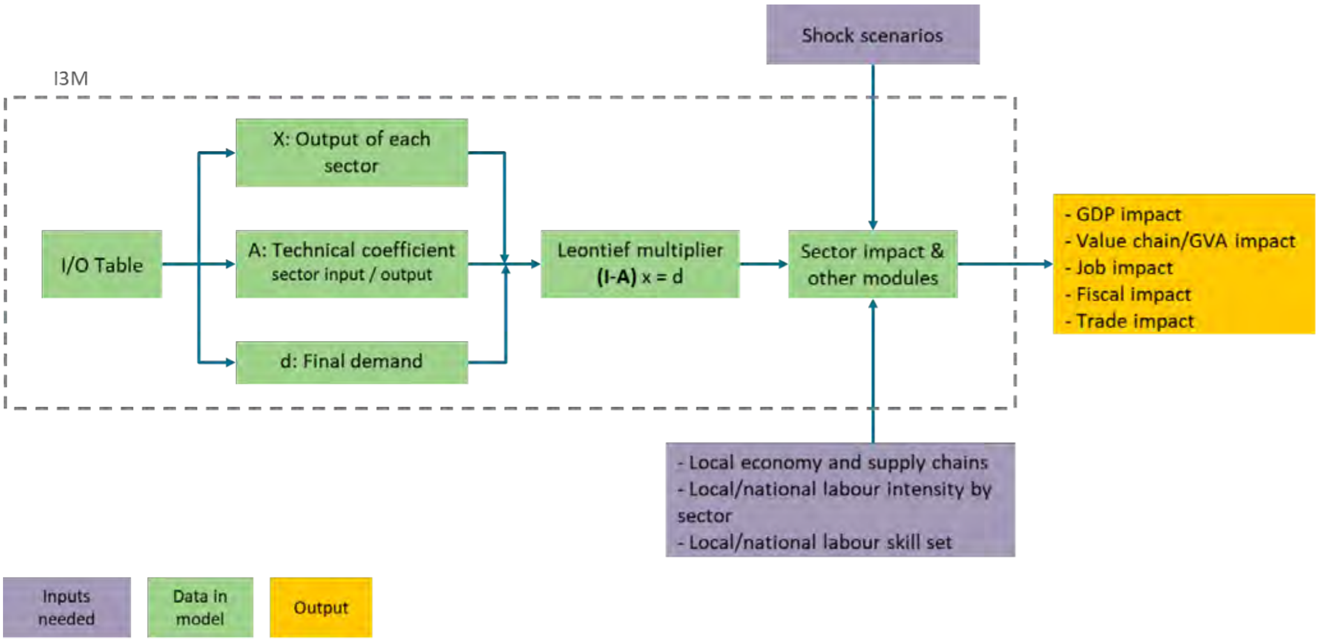
Figure 18 : Simplified representation of the Eora MRIO matrix



Source: Vivid Economics

I3M works by modelling the impacts of investments and other interventions as shocks to final demand in specific sectors. The flowchart in Figure 19 shows how the MRIO is used to calculate the matrix of Leontief multipliers. Multiplying a shock vector (a change in final demand for every sector) by the Leontief matrix produces the increase in sectoral output needed to satisfy the increase in final demand. Relationships between sectoral output and variables such as GVA, employment and GHG emissions (determined from the Satellite accounts of the Eora database) are used to calculate the impacts of the shock. The shock vector itself determines the 'direct' impacts, while the additional impacts on sectoral output are used to calculate the 'indirect' and 'induced' impacts. The 'short-term' impacts of interventions are defined as those that result from capital expenditure (CAPEX) associated with the intervention. The 'long-term' impacts result from the operation phase of the intervention i.e. the operating expenditure (OPEX). In this case, the long-term impacts are calculated on an annual basis.

Figure 19 : Representation of the I3M system



Source: Vivid Economics

I3M model is a demand-driven model, meaning that it assesses changes in the economic activities associated with changes in the final demand. Because the adoption of regenerative practices along the agricultural value chain in SSA would imply a shock in supply rather than in demand, I3M settings were adjusted in a bespoke manner for this work. This was done by solving the model 'backwards'. First, it was assumed an increase in agricultural productivity -achieved through regenerative agriculture in SSA. The yield increase was based on: Successively, given the increase in agricultural output, the changes in GVA and employment required to support this increased outcome in the agricultural sector are modelled.

Here the assumptions used to implement and apply the impact modelling are briefly outlined:

- The agricultural productivity increase associated with the supply shock was estimated at 13% by 2040. The yield increase (%) for SSA translates into the same yield increase (%) within each country.
- Cropland is assumed to be constant. There is no change in land use associated with increased agricultural production.
- Crop prices remain constant.
- Multipliers for livestock feed are the same as for all crops.
- Only 32% of all crops go into food processing, with the remainder 68% assumed to be either consumed/used directly or exported.
- Agricultural production is assumed to be 70% crop production and 30% other (eg livestock)
- Domestic processors are absorbing all local increases in supply, and processor do not prefer imports over exports when output increases.
- Increased agricultural output is assumed to have **no:**
    - » Direct and indirect impact on employment in the agricultural

sector. This is explained by the fact that regenerative agriculture is assumed to increase farm productivity ceteris paribus. Given the same amount of input (e.g. in terms of land, labour, etc.), regenerative agriculture is assumed to produce higher yields. This assumption is further justified by the fact that labour requirements associated with regenerative practices specifically are difficult to quantify, and there is no consensus whether they would require more or less labour on farm. This also applies to the indirect impacts. Given the debate is still ongoing, assuming no direct impacts on agriculture is cautious.

» Indirect impact on GVA in the processing sector.

Food security

The long-term impact of regenerative agriculture on food security are assessed using MAgPIE results in combination with literature review based off-model calculations. The potential impacts of regenerative agriculture on food security are described by means of impacts on per capita food consumption, food price, economic vulnerability to price shocks and calorie intake. All variables were assessed for the business-as-usual scenario and for the regenerative agriculture scenario in 2040. Data in the report are expressed as the percentual difference between the regenerative agriculture scenario and BAU. The methods used to calculate each impact are outlined below:

- Per capita food consumption. Per capita food consumption is calculated dividing the total agricultural production increase calculated by MAgPIE (see above), by the projected population increase until 2040.
- Food price change. The change in aggregate food price is calculated using data on the price elasticity of food demand in SSA. A literature review was performed estimating food price elasticity to range between -0.6 and -0.9 (Cornelsen et al., 2015; Dunne & Edkins, 2008; Haggblade et al., 2017; Magrini et al., 2017). The price elasticity of food demand is then used to back calculate the change in food prices required for demand to increase so that markets to clear given the increase in food supply.
- Food expenditure share. Food expenditure share is calculated from the estimates of per capita consumption, the initial food expenditure share in 2020, and the price change. Income is assumed to be constant from 2020 to 2040.
- Per capita daily calorie intake. To calculate the per capita daily caloric intake, data from MAgPIE are provided. The model provides estimates of daily per capita calorie intake in SSA in 2020 from different crop categories, namely i) cereals (maize, rice, temperate cereals, tropical cereals), ii) oil crops (groundnuts, soybean, sunflower, other oil crops), iii) sugar crops (sugar beet, sugar cane), iv) other crops (pulses, potatoes, fruits, vegetables and nuts, tropical roots). Based on information on the production of each crop in 2040 and population growth, the potential 2040 calorie intake from each crop is computed. Note that calorie intake only considers calorie intake from crops, while it does not account for calorie intake from animal products and animal derivatives.

Carbon sequestration potential for agroforestry

The mitigation potential of agroforestry was estimated using a combination of spatial analysis and literature review. First, spatial analysis is used to estimate the opportunity size of agroforestry across SSA countries. Estimation for intervention space builds on previous work conducted by Vivid Economics. The assessment was conducted by analysing spatial data on pastureland and forestland by country, and by identifying pastureland adjacent to forest. The areas within 5 km from forests were then considered as suitable for agroforestry interventions. Two sources of data were used, namely i) Ramankutty et al. (2008) which provides information on spatial estimates of the distribution of pastureland across the globe, and ii) data from Globcover (2009) on global forest cover. The result was a potential area (ha) that can be converted into agroforestry.

Previous work by Vivid Economics undertook this spatial analysis on 13 African countries[29] to assess the potential of agroforestry. For each of these, the potential agroforestry area was calculated as a percentage over the total country area. For the purposes of this report, the results from the spatial analysis were scaled up to all countries in sub-Saharan Africa. This was done by comparing each country in sub-Saharan Africa with the 13 countries, in terms of several characteristics, such as agricultural GDP share, agricultural land cover and forest cover. Each country was matched to the most similar of the countries as to each criterion. The potential for agroforestry for all countries was then calculated separately for each criterion by applying to the each country the agroforestry potential expressed as a percentage from the most similar country on the shortlist. An average across criteria was then calculated, resulting in the total agroforestry potential expressed as an area (ha).

The mitigation potential of agroforestry was then calculated by multiplying the CO_2e sequestration potential per hectare by the total agroforestry potential. The estimate on CO_2e sequestration potential of agroforestry per hectare builds upon previous work conducted by Vivid Economics and is estimated to range between 3.4 and 5.2 t per hectare per year.

Carbon sequestration potential for cropland management

The data to estimate carbon sequestration potential from cropland management are from FAO (2011). Data was multiplied by the MAgPIE estimated cropland in SSA, which is kept constant from 2020 onwards according to earlier assumptions. Then a factor of 0.5 was applied to represent the scenario of half of SSA cropland being managed with regenerative practices.

[29]Burundi, Central African Republic, Congo, Cote d'Ivoire, Gabon, Liberia, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Zambia, Zimbabwe.

Environmental impacts

Ecosystem benefits associated with regenerative agriculture were estimated and assessed by means of literature review. The key environmental benefits associated with regenerative agriculture related to soil health and soil water retention/infiltration.

Table 1 : Variables searched in literature and number of observations collected, in total and from meta-analysis studies

Environmental impact	Variable	Nr. Observations	Of which meta-analysis
Soil health	Soil organic carbon	23	12
	Nitrogen content	9	9
	Soil erosion	8	2
Soil water retention	Soil moisture	32	1
	Infiltration rate	26	1

Source: Vivid Economics

The literature review was performed on peer-reviewed articles, which varied in terms of study area, study type (e.g. experimental design, meta-analysis, etc.) and types of agricultural practice analysed (e.g. agroforestry, mulching, alley cropping, etc.). Observations of variables were collected from these papers in combination with databases. Data were then analysed, and observation were prioritized given certain characteristics, such as i) consistency of the study area with the project focus (i.e. observations on SSA were prioritized compared to global observations), ii) study design (observations from meta-analysis were prioritized compared to experimental designs), iii) consistency with the average (i.e. anomalies were excluded).

Savings and avoided costs from regenerative agriculture

Farm saving were assessed and estimated by means of literature review. The avoided costs considered are: i) the avoided costs of fertiliser usage and ii) the avoided costs for pest management. The fertiliser associated savings were calculated as the cost of fertiliser needed to amend the average yearly loss of NPK nutrient per hectare in SSA. The average cost of fertiliser (USD/kg) was assessed through a literature review, as well as the yearly NPK loss (NPK kg/ha) in sub-Saharan countries. The two were multiplied to obtain avoided costs of fertiliser per hectare (USD/ha). It is assumed that 1 kg of fertiliser amends 1 kg of NPK. The avoided costs for pest management are estimated as the avoided costs for pesticides, assuming that regenerative systems do not use pesticides. The average costs of pesticides per hectare (USD/ha) in sub-Saharan countries was estimated through a literature review. The avoided costs for fertiliser and for pest management are summed up to represent the avoided costs or saving per hectare. These are then multiplied by the total cropland area in SSA, and by a factor 0.5 to represent the scenario of half of SSA cropland being managed with regenerative practices.

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published with the support of the partner organisations of the ELD Initiative and Deutsche Gesellschaft fu?r Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Coop
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