Amaly

bridge between funders' hopes and an impactful legacy

Harvesting Impact:

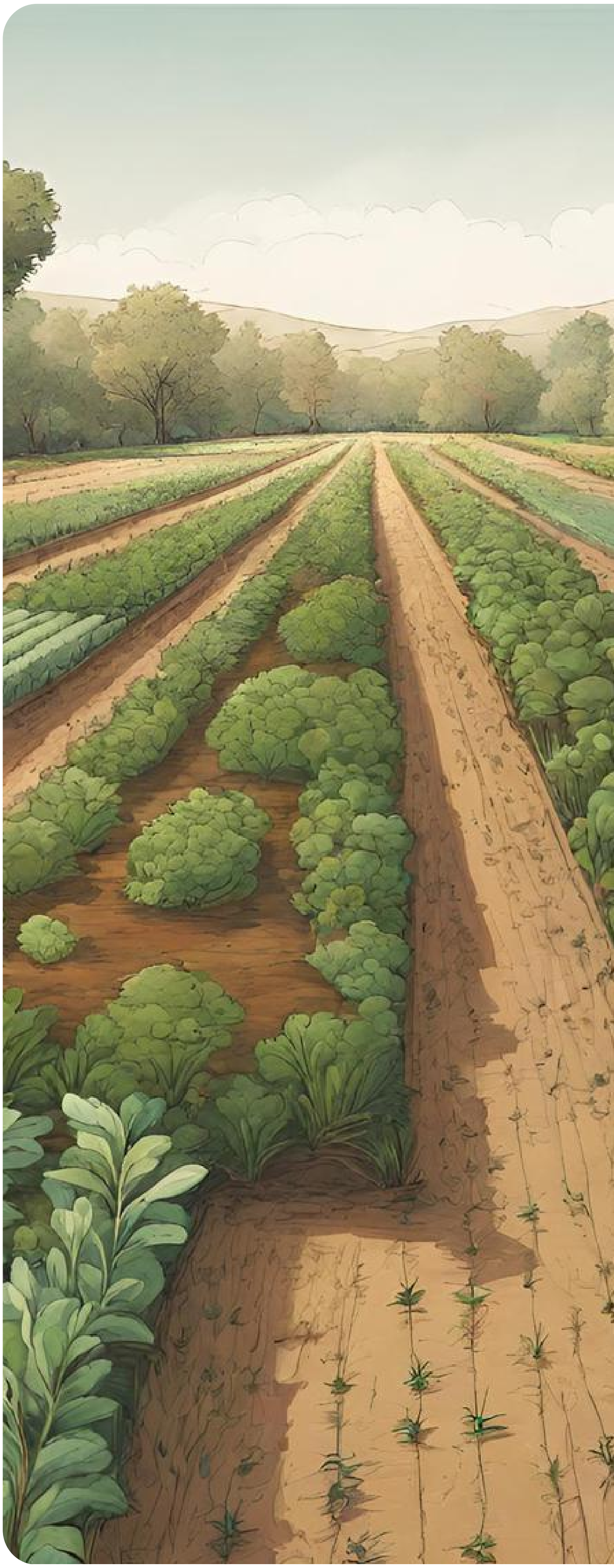
A Primer on Regenerating Degraded Farmland in East Africa for Farming NGOs & Institutional Investors

2024

With strategic insights of thought leaders from ...

European Bank for Reconstruction and Development · goodwell invest with impact · WATEREQUITY · GLOBAL RESILIENCE PARTNERSHIP · CATALYST 2030 Collaborating to achieve the SDGs · GREEN CLIMATE FUND · IFAD INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT · care EGYPT FOUNDATION · Emirates Nature · WWF · Save the Children · IUCN International Union for Conservation of Nature

TABLE OF CONTENTS



MESSAGE FROM MANAGING PARTNER

Amaly

We are committed to delivering farming asset management services that aid funders meet their financial, social and environmental goals through dedicated tax-efficient asset management vehicles and technical support.

Our mission is to unlock funding for NGOs and rural communities to ultimately impact ONE BILLION lives. We work with organisations that are fiscally responsible, have robust governance structures and are mission-aligned.

We are a nonpartisan organisation creating a better world by providing diverse, equitable and inclusive solutions for farmers in East Africa.
It is in our DNA!

FOREWORD

This report serves as a guide to NGOs, institutional funders and other stakeholders committed to creating a sustainable agricultural future for smallholder farmers in East Africa. It not only underscores the urgency and importance of regenerating degraded farmlands but also presents a roadmap to harnessing hidden value by reducing the productivity gap of degraded farmlands in East Africa. We hope the findings presented in this report will contribute to the development of environmentally conscious and economically fruitful agriculture projects in East Africa.

WAHID A KAMALIAN
Managing Partner
Amaly Asset Management &
Amaly Regen Ag Studio

EXECUTIVE SUMMARY

Introduction:
The global agricultural landscape is rapidly evolving, necessitating sustainable and impactful farming practices. This report explores the power of regenerative agriculture, emphasising its pivotal role in restoring soil health, ensuring water conservation and unlocking untapped value in value chains. Through this report, we will uncover the potential of regenerative agriculture to revitalise soil, conserve water, and create new opportunities within value chains, showcasing its significance in the modern agricultural paradigm.

Report Overview:
Chapter 1 delves into the negative effects of conventional agricultural methods and the potential solutions offered by regenerative agriculture principles and practices. Through this exploration, it aims to shed light on the transformative potential of regenerative agriculture in addressing environmental degradation and fostering sustainable farming practices. It examines the transformative potential of regenerative agriculture in breaking the vicious cycle of environmental degradation and poverty faced by smallholder farmers in the region. The case studies will identify intervention areas that can foster a virtuous cycle, benefiting both the environment and society.

Chapter 2 presents two insightful case studies on crop waste, focusing on the cashew and coffee value chains in East Africa. It also identifies potential areas where the waste can be converted to value-added byproducts.

Chapter 3 provides an in-depth exploration of the critical role of water in East Africa, focusing on innovative water conservation solutions and irrigation modules. It also examines current water challenges and dynamics of use in East Africa, while highlighting the policy framework governing water use in the region.

Chapter 4 delves into the policy considerations for asset managers, investors and financiers in East Africa. It aims to offer an understanding of the policy landscape in East Africa, enabling NGOs to navigate and engage with funders more effectively.

Notes: 1. Some of the countries considered in this publication are not technically part of East Africa however their inclusion was due to their geographical and cultural proximity, as well as their frequent inclusion in discussions and dialogues on East African agriculture.
2. Amaly value creation analysis is based on select crop value chains, market data and secondary research. Results may vary based on different crop types and environments.
Please reach out to Amaly Asset Management and Amaly Regen Ag Studio to discuss our findings and how we can design robust assumptions for your investment case in different crop value chains across different environments.

Conservative market metrics from application of regenerative agriculture and asset management practices.

10% to 30%
Reduction in waste at farmgate level

90+%
Conservative increase in revenue from yield increase due to farming practices

25%
Average reduction in cost of nutrients

Amaly Asset Management metrics
Applying select Amaly Asset Management's performance optimisation metrics on estimated degraded cashew farmland in East Africa.

750 k+
hectares of degraded cashew farmland in East Africa

2.2 MT mn+
missed production of raw cashew due to suboptimal crop yields

$1.8 bn+
estimated revenue from missed production of raw cashew nuts

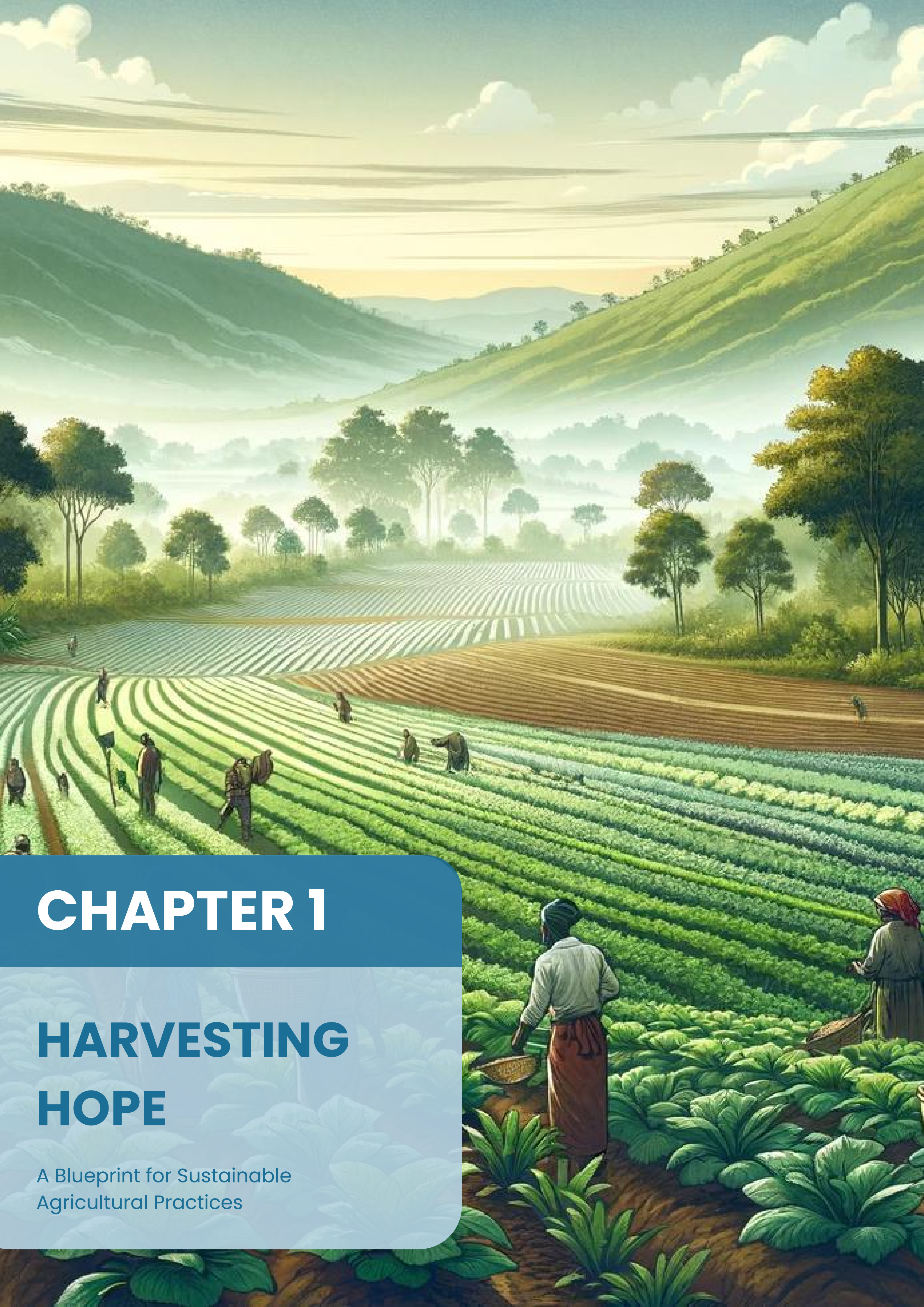
30%
wasted raw cashew nuts at farm level **p.a.**

$540 mn+
additional estimated revenue from raw cashew nuts not wasted

378 k+
smallholder cashew farmers in East Africa

$ 6,100+
increase in income of each smallholder cashew farmer in East Africa per annum

Sources: FAO[1], scientific publications, government data and Amaly Legacy analysis



CHAPTER 1

HARVESTING HOPE

A Blueprint for Sustainable Agricultural Practices

Introduction

The global population is rapidly rising, putting immense pressure on the world's agricultural system. As a result, there is an urgent need for sustainable and environmentally friendly farming practices that can help address the challenges of feeding the growing population while protecting the environment. One such solution is regenerative agriculture, a farming method that focuses on **repairing** soils damaged by excessive and repeated use of chemical pesticides and fertilisers, **optimising** the water cycle and nutrient retention, **repairing** topsoil, **expanding** biodiversity and **bolstering** the vitality and health of agricultural soil.

Regenerative agriculture addresses the challenges of feeding the growing population by focusing on long-term soil health, which in turn increases the soil's capacity to absorb and retain water and nutrients, thus improving the soil's ability to withstand the impacts of climate change. This farming method aims to repair topsoil, which is the layer of earth where most of the plant roots and soil biology reside, and expand biodiversity, which is crucial for a healthy ecosystem and fertile soil. This approach also reduces farmers' costs and improves their income through improved yields and quality which support premiums that can be obtained for their produce—ultimately improving their livelihoods.

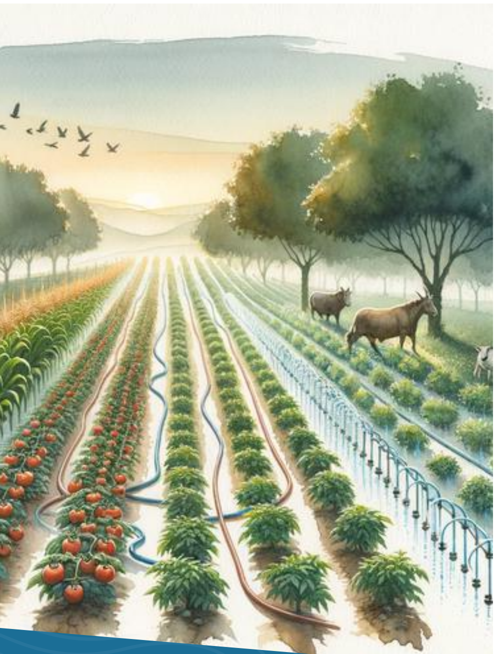
Regenerative agriculture can also be a catalytic agent that stimulates policies and actions that could improve smallholder farmers' livelihoods and financial security in the long term. In this context, investors and financiers who fund the transition to regenerative agriculture could stimulate the establishment of clear land tenure policies and encourage farmers to secure land rights documentation, especially in regions where customary rights are common without formal documentation. This solidification of land tenure documentation, usually a condition precedent in funding transitioning to regenerative agriculture, reduces financing risk and empowers risk-averse smallholder farmers to invest confidently in their land.

By intertwining regenerative agriculture with appropriate supportive policies concerning ownership and stewardship, farmers can help create a sustainable and resilient agricultural system that feeds a growing population while benefiting the environment and communities.

Why Definition Matters?

> "Defining regenerative agriculture operational policies, procedures and processes at the farm level not only impacts the soil health and crop yields, but also unlocks access to certifications that impact the liquidity and pricing of these crops, which is critical for sustainable adoption of these practices."

DR. CHARLES MORTON
Partner | Regen Ag
Amaly Regen Ag Studio



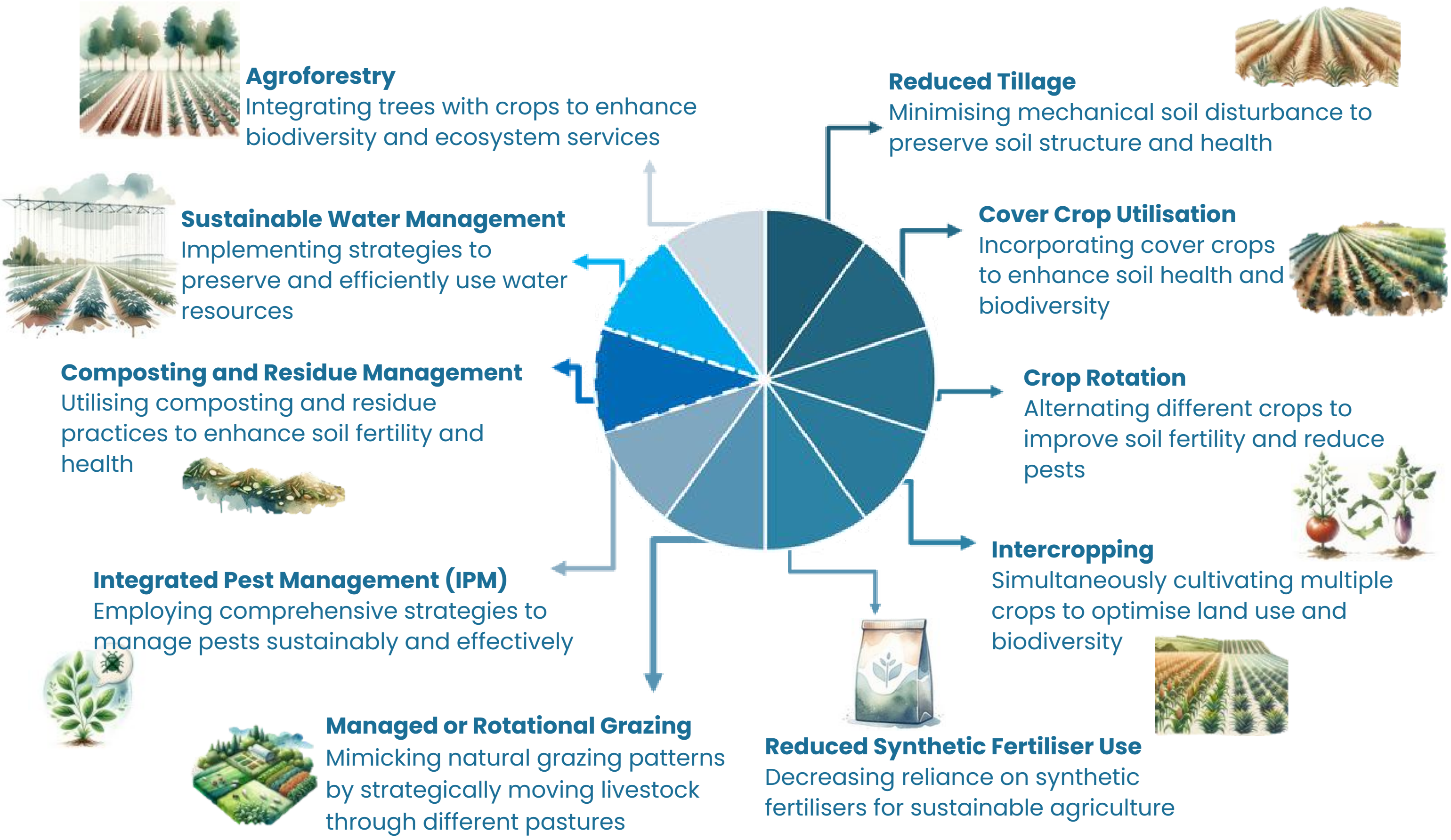
Defining regenerative agriculture:

Amaly defines regenerative agriculture as a holistic and sustainable approach to farming and land management that aims to restore and enhance the health of ecosystems, improve soil quality and promote biodiversity. The regenerative practices that Amaly considers have been presented on page 5.

Who is shaping the definition of regenerative agriculture?

1. Carbon credit standard setting bodies — VERRA, Gold Standard certified SDG impacts
2. Certification organisations — Regenerative Organic Certified™, Certified Regenerative by AGW, Savory, regenagri, Land to Market Verified
3. NGOs and other organisations who create their own frameworks and/or contribute to industry standards — SAI Platform, IUCN

Regenerative farming practices rejuvenate soil and enhance biodiversity that support a thriving and sustainable agricultural landscape.



Regenerative agriculture employs a variety of practices that work in harmony with nature to promote soil health, sequester carbon and enhance the resilience of agricultural systems.

Central to regenerative agriculture is the practice of reduced tillage, which minimises soil disturbance and helps preserve soil structure and organic matter. Additionally, cover crop utilisation involves planting a variety of crops to cover the soil, reduce erosion and enhance soil fertility. Crop rotation, another key practice, involves alternating the types of crops grown in a specific area to prevent the depletion of soil nutrients and reduce the buildup of pests and diseases. Intercropping, the practice of growing two or more crops together, promotes biodiversity and can help control pests and diseases.

Furthermore, regenerative agriculture emphasises the reduced use of synthetic fertilisers and instead encourages the use of natural fertilisers, such as composting and residue management, to improve soil fertility. Managed or rotational grazing is another critical practice that involves systematically moving livestock across pastures and fields. The movement of livestock aids in the control of invasive species and enhances soil fertility through the natural deposition of manure. Integrated pest management is also a key component, focusing on natural pest control methods to minimise the use of chemical pesticides. Sustainable water management is essential, aiming to conserve and efficiently use water resources. Finally, agroforestry, which involves integrating trees and shrubs into agricultural systems, helps enhance biodiversity, improve soil health, and provide additional income sources for farmers.

Regenerative agriculture encompasses a range of practices that prioritise soil health, biodiversity and ecosystem resilience. By implementing these practices, farmers can work towards building healthier, more sustainable agricultural systems that benefit both the long-term viability of their farms and the environment as a whole.

Regenerative Agriculture VS Traditional Agriculture

Regenerative Agriculture

- **Diverse Crops:** Emphasises diverse crop cultivation for enhanced biodiversity
- **Organic Inputs:** Favours organic inputs to reduce reliance on synthetic fertilisers and pesticides
- **Water and Nutrient Conservation:** Focuses on sustainable water management to optimise water use and reduce nutrient runoff
- **Minimal Soil Disturbance:** Preserves soil structure, enhancing soil health and promoting carbon capture

Traditional Agriculture

- **Mono-crops:** Single-crop cultivation limiting biodiversity and ecosystem resilience
- **Chemical Inputs:** Relies heavily on synthetic inputs, such as fertilisers and pesticides, for crop production
- **Inefficient Water Use:** Leads to environmental stress, reduced ecosystem resilience and nutrient runoff
- **Tillage (Soil Disturbance):** Contributes to soil erosion and degradation

Regenerative agriculture is a significant departure from conventional resource management practices. Water conservation is achieved through initiatives such as cover crop planting, natural drainage systems and irrigation methods designed to preserve soil moisture. Soil fertility is naturally enhanced through the promotion of biodiversity, avoiding the use of chemical fertilisers.

This is achieved by adopting practices such as rotational grazing of livestock and crops to replenish essential nutrients. Pests and disease management rely on introducing habitats for beneficial insects and the strategic use of crop diversity to disrupt pest cycles. The active introduction of multicropping, cover cropping and crop rotation fortifies soil, sequesters carbon and has been proven to elevate both the income and stability of farmers.

14% CAGR of Global Regenerative Agriculture Market 2018 to 2030

Source: Polaris Market Research[2]

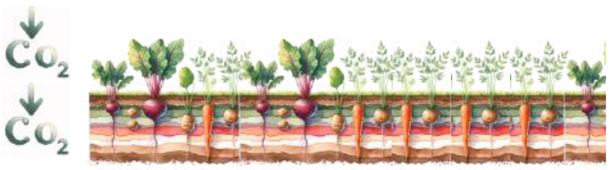
85-90% Plants nutrient acquisition is mediated by microbes

Source: California State University[3]

21% More nutrients in crops grown using regenerative agriculture practices

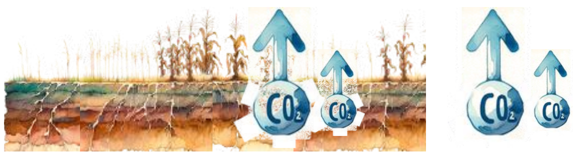
Source: Regenerative Farmers of America[4]

Regenerative farming practices can significantly increase the levels of important nutrients in foods compared to conventional farming methods. Crops grown using regenerative methods contain higher quantities of vitamins, minerals and phytonutrients due to the buildup of soil organic matter and microbial diversity. This allows plants to better uptake the required nutrients from the soil. Healthier soils also influence the nutrition profile of crops through their effects on the crop microbiome.



Summary: Regenerative agriculture practices increase biodiversity, enrich soils, improve watersheds and enhance ecosystem services.

VS



Summary: Degrades soil health, causes soil erosion, loss of biodiversity and contributes to climate change.

... at the heart of regenerative farming is soil health which is the foundation for productive and resilient agricultural systems, influencing crop yields, water quality and carbon sequestration ...

Healthy soils consist of clearly defined layers composed of the degradation of organic materials

Soil Layers

- Organic matter ▶ Decaying leaves and plant matter
- Surface soil ▶ Holds most organic matter, plant roots interact with biosphere in the soil food web
- Subsoil ▶ Full of clay soils that trickle down from above
- Parent rock
- Bedrock ▶ Supporting structure

When soil deteriorates, it loses its ability to support vital processes, resulting in reduced health, biodiversity and productivity. The minerals and microbes in healthy soil play a crucial role in purifying water and filtering out pollutants, while its natural regulation of water movement helps prevent flooding by managing the flow of rainfall and irrigation water.

How Healthy Soil is Degraded?

> "Healthy soil is not just the bedrock of agriculture; it's a dynamic ecosystem crucial for purifying water, sequestering carbon and ensuring biodiversity.
> Our commitment to regenerative farming is a commitment to nurturing this vital resource, safeguarding the future of our planet and its inhabitants."

DR. CHARLES MORTON
Partner | Regen Ag
Amaly Regen Ag Studio

Tilling Impact

Non-regenerative agriculture practices such as tilling can lead to soil compaction and erosion

Loose Porous Soils: Loose porous soils allow for the infiltration of water and for deep root growth.

Compacted Soils: Compacted soils reduce root depth and deny plants of nutrients. They also reduce water infiltration and increase runoff.

Tilling compacts soils, reducing porosity and water uptake and increases water runoff and erosion.

Raindrop Impact Damage

Covered Soils: Covered soils reduce erosion as organic cover absorbs and retains water pressure from rain.

Open Soils: Soil particles are dispersed due to splashing and are washed away.

1 

Soils with non cover crops leads to homogeneous soil structure, reducing water uptake and increasing erosion.

2 

Healthy soils with cover / mixed crops provide deep root soil porosity to maintain soil biodiversity.

Transitioning from traditional agriculture to regenerative methods requires strategic preparation and adaptation based on local conditions and agricultural practices.

Transitioning to Regenerative Agriculture

Challenges in Implementing Regenerative Agriculture Practices

Mindset Shift

Transitioning from traditional agriculture to regenerative practices requires a fundamental shift in mindset, as farmers need to embrace new approaches that prioritise soil health and ecosystem resilience.

Knowledge and Training Gaps

Access to information and education about regenerative agriculture practices and their benefits is crucial. Farmers may require training to effectively implement these practices.

Market Access and Demand

Aligning regenerative agricultural practices with market demands and consumer preferences can be challenging, requiring adjustments in production and marketing strategies to meet evolving market needs.

Labour Intensive Process

Regenerative agriculture practices, such as diverse crop cultivation and minimal soil disturbance, can be more labour-intensive initially, requiring adjustments in labour management.

Resource Constraint

The transition to regenerative agriculture may pose resource constraints, including initial investment in new equipment, infrastructure and training for regenerative practices, which can be financially challenging for farmers.

Key Considerations Prior to Implementing Regenerative Agriculture Practices

Soil Condition and Health

- Assessing soil structure and composition
- Understanding soil nutrient levels and pH balance
- Evaluating soil erosion and compaction

Biodiversity

- Surveying existing plant and animal species
- Assessing habitat diversity and ecosystem services
- Understanding the impact of regenerative practices on local flora and fauna

Topography

- Analysing landscape features and slope
- Assessing soil drainage and water retention
- Identifying erosion-prone areas

Water Resources

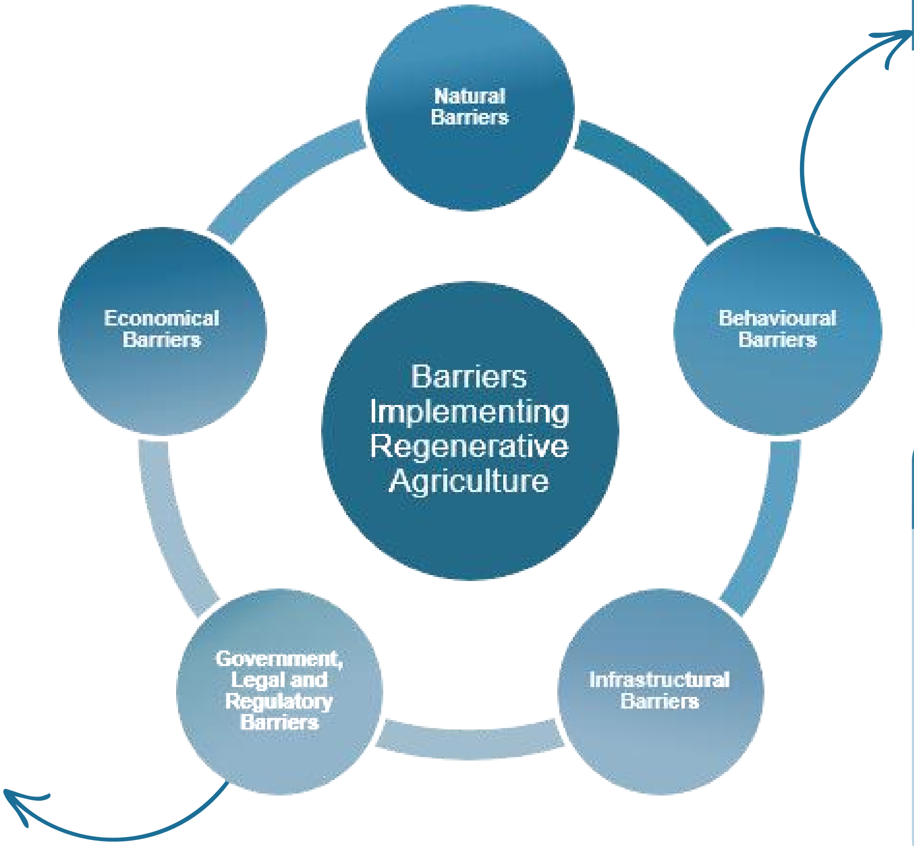
- Evaluating water availability and quality
- Identifying potential for water conservation and management
- Understanding the impact of regenerative practices on water resources

Climate and Microclimate

- Analysing regional climate patterns
- Assessing microclimate variations
- Understanding the influence of climate on agricultural practices

Identifying challenges and optimal solutions is crucial to facilitate an effective and lasting transition to regenerative agriculture, as potential barriers can risk failure and undermine future adoption. Economic uncertainties of transition, lack of tailored technical guidance and sociocultural resistance to divergence from norms, as major barriers preventing widespread adoption of regenerative agriculture practices.

Barriers to Implement Regenerative Agriculture



Risk Aversion & Intertia

Smallholder farmers' risk aversion and inertia pose a significant challenge to the adoption of regenerative farming, as they may be reluctant to invest in new practices without **assurance on financial returns and land ownership.**

Land Tenure

Investing in farmland in emerging markets is a significant challenge for smallholder farmers and institutional asset managers due to the lack of legal certainty on land tenure and ownership.

Supply Chain

Building regional infrastructure and partnerships between farmers and the market could help "close the loop" so that regenerative farmers have a **viable way to scale up while maintaining their stewardship practices.**

Diverse Industry Insights

CHARLES KARANGWA
Global Head of Nature-based Solutions, International Union for Conservation of Nature (IUCN)

“There is a knowledge gap to substantiate what is Sustainable Agriculture which negatively impact on funding allocation.
It is important to know that farms are modified ecosystems that depend on nature in many ways, for nutrient supply, water supply, pest control, pollination and other services.
Soil biodiversity conservation is at the heart of most sustainable farming practices and this is what fully represent Nature-based Solutions and should be prioritised for investments and financing.”

YUAN-TING MENG
Angel Investor; Agribusiness and Finance Specialist, Food and Agriculture, Organisation (FAO)

Food and Agriculture Organization of the United Nations

“To spur regenerative agriculture practice amongst smallholder farmers requires an ecosystem approach to shift the paradigm. Beyond the public sector’s policy to support R&D and incentivise investment to lower such transition cost, a clear business case for both farmers and corporations will stand as the strongest push, leveraging market dynamics to emancipate the upside of regenerative practice for all, specifically on farming profitability and environment sustainability. From risk mitigation, patient capital, and extension services to farmers, to operation and cost efficiency across stakeholders, a market that demands and value for regenerative harvest, while taking time to evolve, is nevertheless an imperative for sustainable prosperity.”

MARWA HUSSEIN

Programme Director,
Agriculture and Natural Resources,
Care Foundation

❝ No authority or entity can work alone anymore! All partners involved must share the same knowledge, full picture and let go some of our own ego to unite efforts. Small farmers representing 70-80% of the agriculture power in the Middle East need the proper knowledge delivered in a simple and informative way. Starting by what's in it for them and how much would any practice cost and what is the return. Without their buying in, it will all be just unfinished prototypes and wasted efforts. ❞

JULIE CHENG

Member of Investment Committee,
Water Equity

❝ The beauty of approaches like climate-smart agriculture [regenerative agriculture] practices like agroforestry, to creating sustainable food systems, is that they generate multiple co-benefits, e.g. they create carbon mitigation and adaptation benefits, while also improving the food security and livelihoods of rural communities and improving soil health. But today, the critical bottleneck is the lack of catalytic funding needed to help de-risk investments in these practices as well as in technologies which can improve the cost of implementation and monitoring, particularly for smallholder farmers in developing countries. Catalytic investing of course can also help scale investments by attracting investors who might otherwise not invest. ❞

ANDREW GARDNER

Associate Director, Biodiversity Conservation,
Emirates Nature-WWF

❝ At least in the context of traditional mountain and oasis farming in the UAE, the barriers to implementing regenerative farming methods are both social and financial. Most farmers are conservative in nature, and need to have good reason to move away from old and tried methods. The farms are typically small, use flood irrigation, and generally grow dates, some fruit trees, vegetables and fodder crops. Much of the produce is used locally. However over extraction of ground water, unregulated grazing and use of agrochemicals have taken their toll. These farmers are generally less aware of more circular and sustainable practices such as modern irrigation methods, local waste water treatment for irrigation, composting and mulching and introduction of water wise and higher value crops. However, when such methods are demonstrated so that farmers can see the benefits, and especially if finance is available, the farmers are happy to adopt new methods. ❞

DINA SALEH

Regional Director,
Near East, North Africa,
Europe & Central Asia,
International Fund for Agricultural Development

❝ Accelerating regenerative agriculture and sustainably enhancing the livelihoods of smallholder farmers require dismantling systemic barriers, such as limited access to markets, finance, and technology and inadequate policy. For high value commodities like coffee and cashew, which are crucial for sustaining the livelihoods of smallholder farmers, the disparity in value distribution along the supply chain undermines their socio-economic sustainability. To foster inclusivity, it's crucial to build equitable and fair-trade practices, invest in pro-poor research and innovation and community-led knowledge exchange, and promote climate smart agriculture and infrastructure that supports sustainable practices. This inclusive approach ensures that the benefits of regenerative agriculture - improved soil health, biodiversity, and climate resilience but also increased incomes - reach those at the heart of our food systems. ❞

MARYAM FAROOQI

Senior Advisor
Gulf,
Save the Children

❝ The importance of philanthropic funding is vital for farming practices across the world; even more so for countries experiencing the devastating effects of the climate crisis. The enhancement of soil fertility means we can enhance the growth of crops and create transformational impact for livelihoods. ❞

What is the role of social innovation to remove some of the implementation barriers of regenerative agriculture and help drive system transformation?

CATALYST 2030
Collaborating to achieve the SDGs

Social innovators are the connecting tissue along the continuum of local to national to global levels, interspersing the spectrum of policymakers, private sector and development actors. Social innovators, by working closely with local communities, can identify and address specific barriers to regenerative agriculture, ensuring that solutions are tailored to local environmental and socio-economic contexts. They take on unique entrepreneurial risk by working alongside communities and bridging implementation gaps to transition to regenerative agriculture by facilitating collaboration between farmers, scientists and finance providers, thereby overcoming knowledge and resource barriers to realise social impact.

Social innovation enables the co-creation of solutions, testing and scaling into sustainable and viable products that are critical links between the disenfranchised and formal institutions of state and market at apex levels of leadership and governance. Social innovation requires tenacity, patience and a deep commitment to work for the vulnerable whose scaling of success depends on encouraging collaboration, creativity and experimentation - ingredients that are essential for developing innovative solutions to complex challenges such as climate change. The experimentation and learning must ensure it connects diverse actors to drive meaningful changes, test innovations and launch with a strong proof of concept. Yet, scaling within limited geographical locations is no longer enough. Creating access to a wide range of possible strategies, innovating for specific contexts, or even general elements of solutions must now transcend boundaries due to the urgent change needed to save the planet for people to thrive.

New alternatives need new actors exploring innovations for old, wicked problems. There has been an inability to produce an impact in the face of intergenerational poverty, unequal access to financing and even developments in technology. Opportunists who have explored possibilities have produced a further neglect of the masses such that attaining sustainable development goals has hardly been possible. Social innovation creates long-lasting outcomes that aim to address societal needs by fundamentally changing the relationships and power dynamics through localisation efforts and advocating for redistribution of financing. Social innovation can change the exclusionary mechanism that traps vulnerable people in poverty cycles and instead create pathways for them to access and transform climate finance through engagement with innovative funding models. This would lead to a redirection of resources to local levels, thus increasing transparency, accountability, equity and inclusivity. It would facilitate a localised just transition into a low-carbon economy led by the enterprises of social innovators.

In the end, change has to be embraced by all at all levels in all geographies, in all spheres of needs, and for all kinds of challenges. The more each horizon expands the more resilient the response. Increased volumes of resilience responses will produce a scale that attracts resources technology, and finance and ultimately a population that demands change. This would be the pinnacle of exponential growth and development that we all strive to attain.

Catalyst 2030 is an emerging network of disparate networks already working on a range of issues operating in different geographies on different scales. Within that network lies an emerging urgency to deepen, sharpen and widen accessibility of all innovation into proven possibilities that address development change that is critical for vulnerable communities which is founded on evidence-based science and technology to produce alternatives.

Amaly's examination of a large body of literature showcases the transformative impact of regenerative agriculture on carbon sequestration, agriculture yield increase and artificial input reduction, using studies conducted in diverse environments (soil types, crop types, topographies etc.,) serve as evidence of these practices' potential.

Impact of Regenerative Agriculture

Practices	↑ Carbon Sequestration[A]	↑ Yield[B]	↓ Fertiliser Requirement[C]	↓ Water Requirement[D]
No Tillage	11%	29%	15%	28%
Cover Cropping	9.8%	19%	53%	7%
Intercropping	19%	25%	32%	31%
Crop Rotation	9.7%	15%	33%	21%
Composting	32%	42%	23%	32%
Agroforestry	34%	48%	69%	40%
IPM	NA	25%	64%	NA
No Synthetic Fertiliser	21%	4%	32%	45%
Water Conservation	5.4%	31%	49%	43%

Source: See Chapter 1 Notes section

Impact on Yield

Our analysis based on very conservative and base case estimates indicate a yield increase of 90% to 180%+ on degraded farmland.

~90%

180+%

Our analysis indicates that regenerative agriculture practices can increase crop yields and quality by over 960% for select crops and regions, highlighting to institutional investors the transformative impact of these practices.

Reduction in Fertiliser Requirement

25+%

Conservative estimates indicate that regenerative farming practices can achieve a fertiliser savings of 25% or more.

~90%

Amaly's team has developed a proprietary solution to reduce the cost of nutrients and fertilisers by circa 90%.

Source: Amaly Legacy analysis

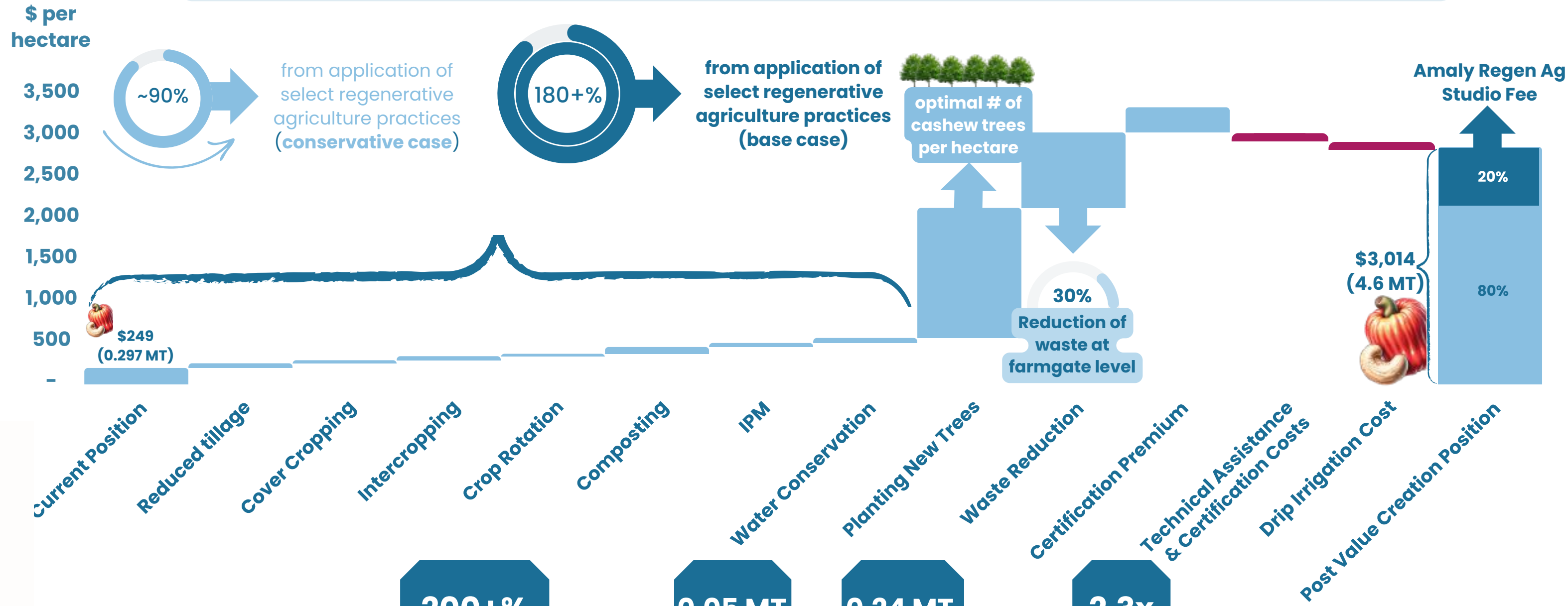
Inference: Regenerative agricultural practices offer a multifaceted solution by increasing crop yields, reducing the need for fertilisers and water, and actively sequestering carbon, demonstrating their potential to revolutionise farming while addressing critical sustainability challenges.

Note: Average percentage from various studies conducted for different crop varieties in different trial environments. Amaly's analysis is based on various crop value chains, market data and secondary research. Results may vary based on different crop types and environments.

Please reach out to Amaly Asset Management and Amaly Regen Ag Studio to discuss our findings and how we can design robust assumptions for your investment case in different crop value chains across different environments.

Below is an analysis on the impact of regenerative agriculture practices along with our series of asset management value creation initiatives on a sample cashew farmland in an East African country demonstrating with a reasonable investment a strong increase in yield, income and profitability

Illustrative Base Case: Impact of Amaly Asset Management's Intervention on Performance of a Degraded Cashew Farmland in Tanzania ($ per Hectare)



200+%

increase in $ value from added processing raw cashew nuts to kernels with relevant certifications for international exports

Source: Amaly Legacy Analysis

0.05 MT ~ 0.24 MT

estimate increase in CO_{2e} sequestration per hectare per annum

Source: Amaly Legacy Analysis

2.3x

irrigated crop yields are 2.3 times higher than those from rainfed ground

Source: Netafim[5]

Notes: 1. Our case study assumes optimal yield levels which take a few years to develop. **2.** Our case study only considered select regenerative agriculture practices. **3.** We excluded the impact of carbon credit revenue and enhanced profitability through value-added processing, all of which are activities that Amaly incorporates as part of its business plans. **4.** Our sample degraded farmland assumes optimisation of current suboptimal irrigation system to drip irrigation with effective rain harvesting and water conservation system. **5.** Amaly Regen Ag Studio's fees cover cost of nutrients. **6.** Cost of irrigation assumes a 20 year life value. **7.** Scale of project is critical to achieve some of the key cost and profitability assumptions. **8.** We assume a very conservative assumption of 60% survival rate of planted trees **however Amaly has developed a series of germplasm controlled trials to create resilient cashew tree strains which result in higher yields, nutritional value and survival rate**

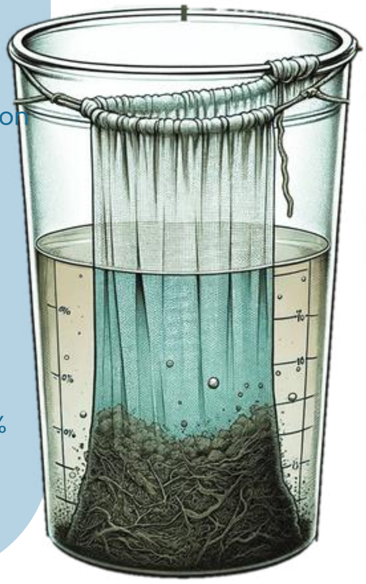
Impact on Yield

Our analysis based on very conservative and base case estimates indicate a yield increase of 90% to 180%+ on application of regen practices on degraded farmland.

~90%

180+%

Our analysis indicates that regenerative agriculture practices can increase crop yields and quality by over 960% for select crops and regions, highlighting to institutional investors the transformative impact of these practices.



Please refer to **page 24** for further information

Reduction in Fertiliser Requirement

25+%

Conservative estimates indicate that regenerative farming practices can achieve a fertiliser savings of 25% or more.

~90%

Amaly's team has developed a proprietary solution to reduce the cost of nutrients and fertilisers by circa 90%.

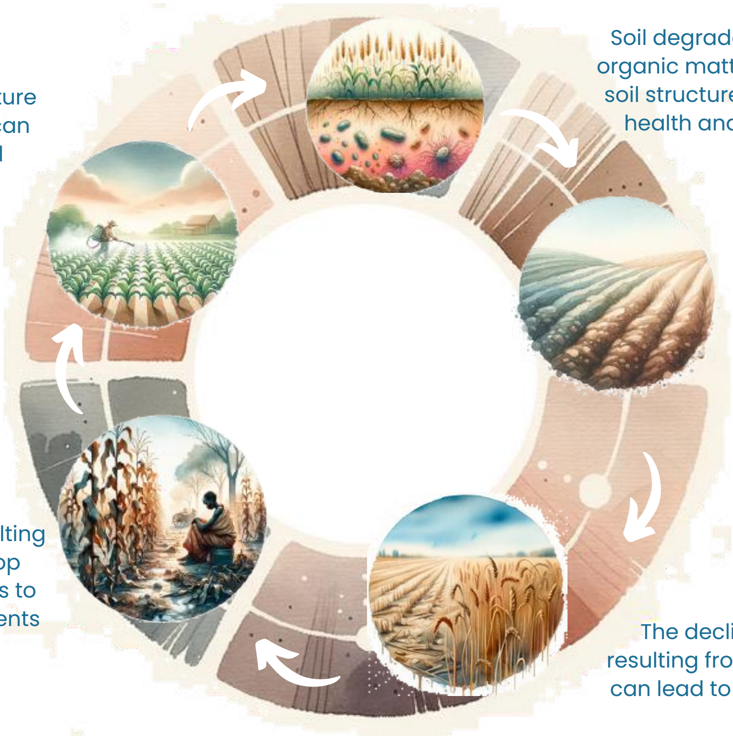
Source: See Chapter 1 Notes section

Source: Amaly Legacy analysis

Please reach out to Amaly Asset Management and Amaly Regen Ag Studio to discuss our findings and how we can design robust assumptions for your investment case in different crop value chains across different environments.

The transformative potential of regenerative agriculture lies in its ability to break the vicious cycle of soil degradation, declining yields and environmental harm perpetuated by traditional farming that ultimately leads to the decline of once-fertile fields. In contrast, regenerative agriculture offers the promise of a virtuous cycle that rejuvenates and nourishes the land, resulting in flourishing fields, improved sustainability and enhanced ecosystem health.

Vicious Cycle of Traditional Farming: The Downward Spiral



70% less pollinators in areas of intensive traditional cropping system[6]

Agriculture is responsible for **80%** of the soil degradation in Europe[7]

Traditional farming practices are ensnared in a self-perpetuating cycle that perpetuates environmental degradation, economic instability and reduced resilience. It is characterised by a series of interconnected factors that collectively undermine the sustainability of conventional agricultural systems.

One of the primary contributors to the downward spiral is soil degradation. Continuous monoculture, excessive use of synthetic fertilisers and reliance on chemical pesticides deplete the soil of essential nutrients and beneficial microorganisms. Consequently, soil health deteriorates, leading to decreased fertility and increased susceptibility to erosion. The loss of topsoil, rich in organic matter, increases the decline in fertility and reduces the land's capacity to support required healthy plant growth. Erosion also contributes to sedimentation in water bodies.

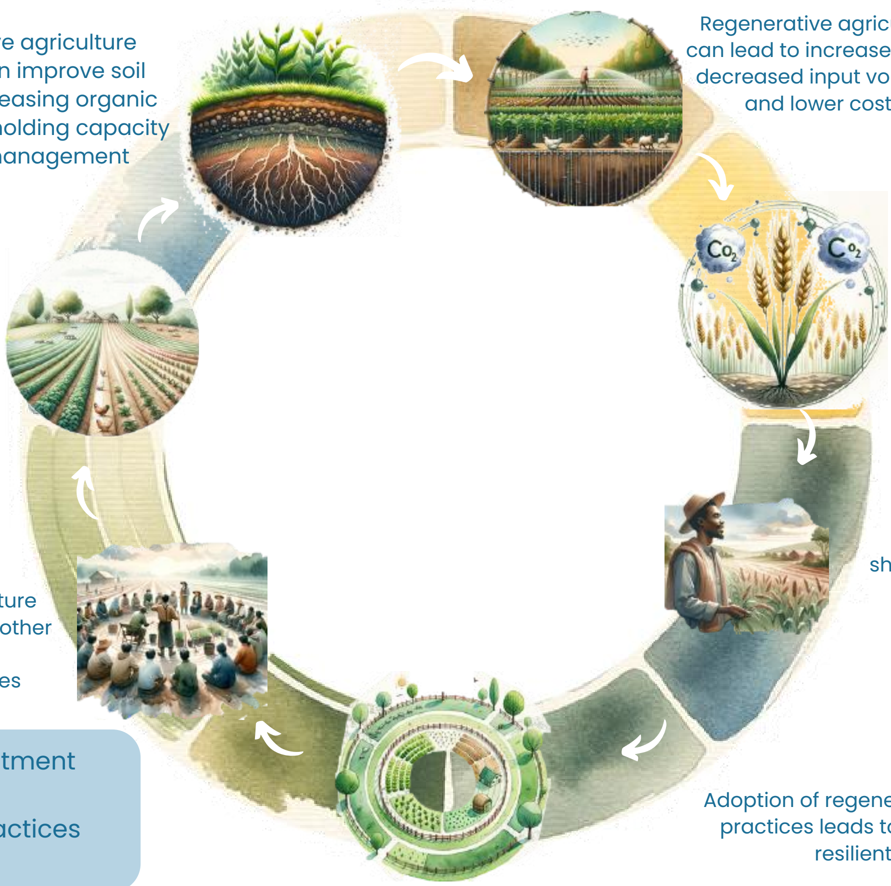
While synthetic fertilisers initially boost crop yields, this dependence creates a feedback loop. Continuous application of these chemicals disrupts natural ecological balance leading to the development of resistant pests and weeds. Farmers find themselves trapped in a costly cycle of escalating chemical use to combat diminishing returns.

The financial burden associated with purchasing expensive chemical inputs and coping with declining yield contributes to the economic instability of traditional farmers. As the cost of production rises and market prices fluctuate, farmers face increased debt and economic uncertainty. This vulnerability makes it challenging for them to invest in more sustainable practices or adapt to changing environmental conditions. As climate change intensifies, traditional farming systems become more susceptible to extreme weather events, disrupting planting seasons and intensifying existing challenges.

Breaking the vicious cycle of such farming practices requires a paradigm shift towards sustainable farming practices. By prioritising soil health, biodiversity and sustainable practices, regenerative agriculture offers a transformative approach that can restore ecosystems, enhance agricultural resilience and promote long-term environmental and economic sustainability.

Regenerative agriculture operates on the principles of interconnectedness and mutualistic relationships, forming a virtuous cycle that transcends traditional farming practices. At the heart of this cycle is a harmonious synergy between soil health, biodiversity and carbon sequestration.

Virtuous Cycle of Regenerative Practices: The Flourishing Fields



15%–25% return on investment for farmers adopting regenerative farming practices at scale[8]

Regenerative farming commences with a focus on soil health. Through practices like cover cropping, reduced tillage and crop rotation, the soil becomes a thriving ecosystem teeming with beneficial microorganisms.

Healthy soil attracts a spectrum of beneficial insects, birds and microbes. This biodiversity acts as a natural pest control mechanism, reducing the need for synthetic inputs.

Enhanced soil structure and increased plant diversity facilitate greater carbon sequestration. Plants absorb atmospheric carbon dioxide during photosynthesis and transfer a portion of it into the soil, contributing to the mitigation of greenhouse gas emissions.
Such farming practices promote resilience against environmental stressors, minimising crop failure risks. Efficient nutrient cycling and reduced reliance on external inputs further underscore the sustainability of the farming system.

A transformative approach, fostering compatible relationships between agriculture, ecology and communities.

Environmental Impact

Regenerative agriculture practices play a crucial role in combating climate change by reducing greenhouse gas emissions and increasing soil carbon sequestration.

Economic Impact

Regenerative agriculture practices can significantly enhance farmers' income by improving crop yields, product quality and eligibility for carbon credits.

Social Impact

Regenerative agriculture practices can positively impact communities by empowering them through economic growth, environmental sustainability and improved quality of life.

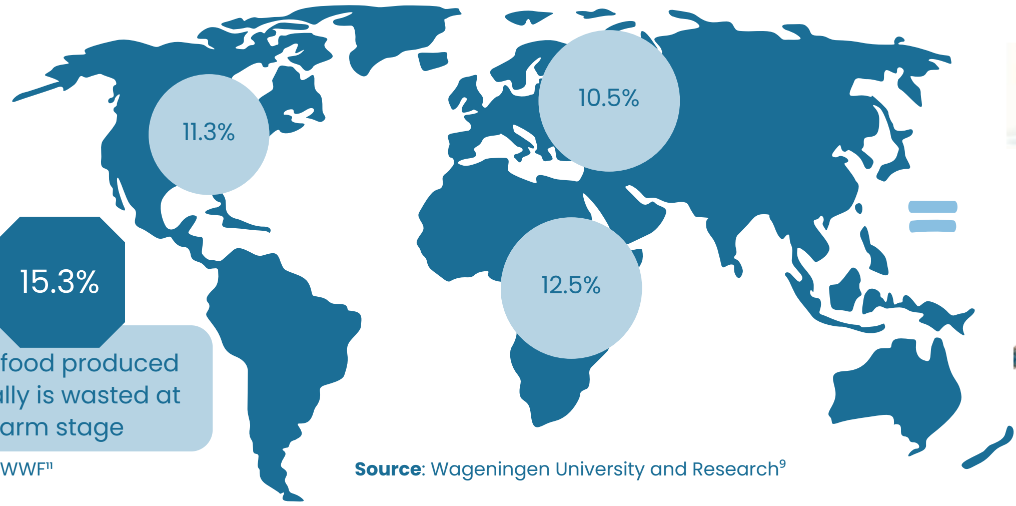
CHAPTER 2

TRANSFORMING AGRICULTURAL WASTE

A Blueprint for Value Creation and Sustainable Development

Pre-harvest food waste is a pressing global concern, as crops lost before reaching the market gate contribute to economic losses for small farmers and have broader implications for food security and resource conservation.

Global Farm Level Waste



15.3%

of all food produced globally is wasted at farm stage

Source: WWF[11]

Source: Wageningen University and Research[9]

Global Impact

1/4 of fresh water used for farming is wasted

1/4 of fertiliser used in farming

~8-10% of GHG emission

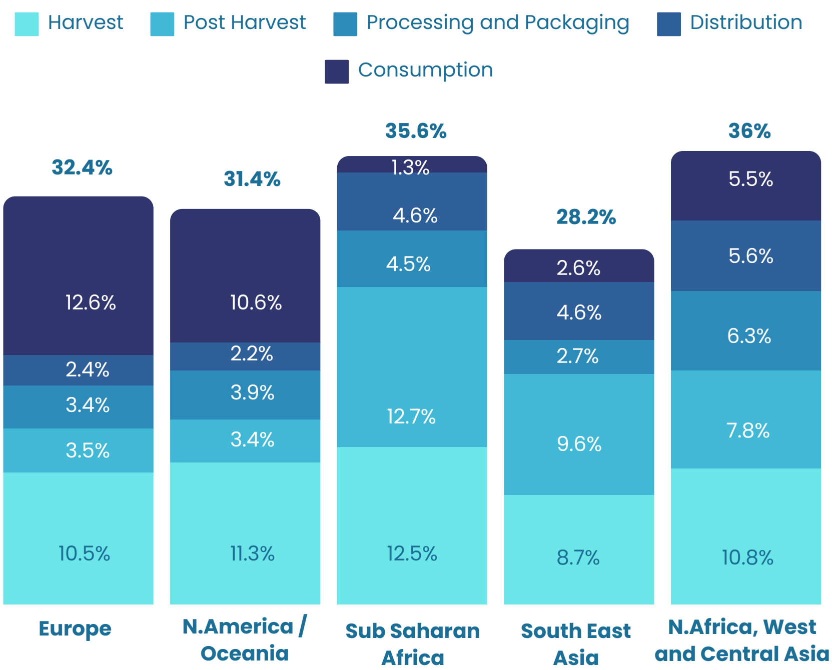
Source: WRI[10]

Impact of Waste on Water, Fertiliser and GHG Emissions

"Curtailing crop waste at the farm stage can lead to significant environmental benefits and resource management, resulting in decrease in water and fertiliser usage, and reduction in greenhouse gas emissions from these farms. This underscores the critical role of efficient crop management in combatting climate change."

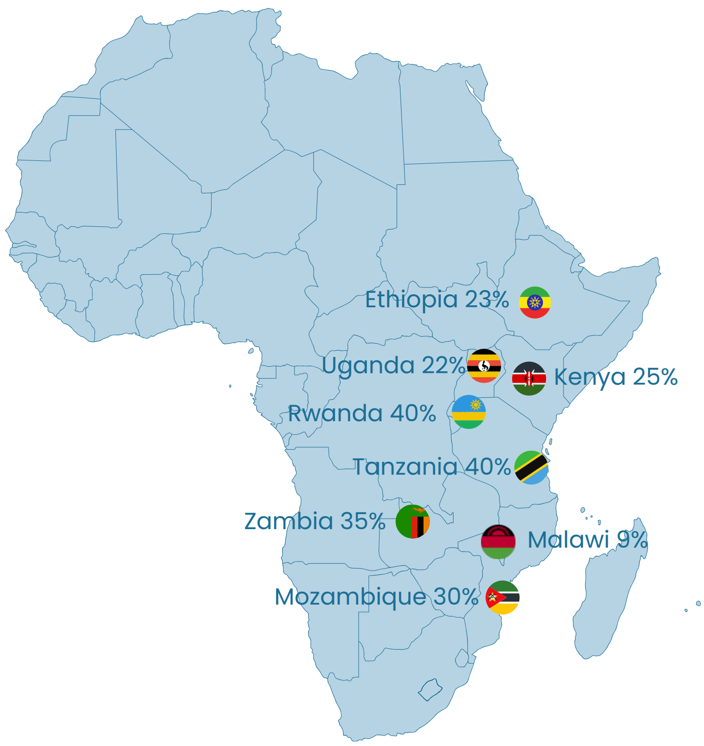
DR. CHARLES MORTON
Partner | Regen Ag
Amaly Regen Ag Studio

Crop Loss Across The Value Chain



Source: Wageningen University and Research[9]

Farm Level Crop Loss in East Africa



Sources: Government data and scientific publications[12-19]

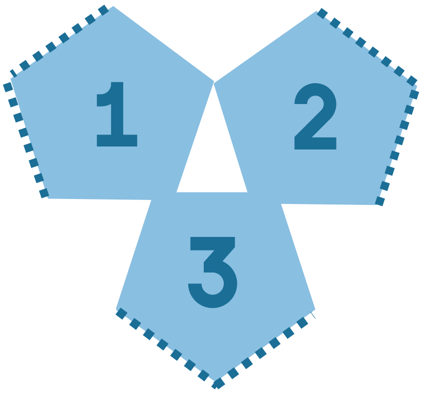
Crop waste is a pervasive issue that symbolises both lost resources and missed opportunities. Innovating in crop waste utilisation could offer creative solutions to this challenge and extract value from these materials for a more sustainable future.

Introduction

Farm waste encompasses the secondary outputs of agricultural activities, commonly referred to as "agricultural waste" due to their non-primary nature. These by-products mainly manifest as crop residues, including residual stalks, straws, leaves, roots, husks, shells and animal waste like manure. Remarkably, agricultural wastes are abundant, renewable and cost-free, rendering them a valuable resource with the potential for various applications. The environmental repercussions of agricultural waste hinge not only on the quantity produced but also on the methods employed for disposal which can contaminate and pollute the environment.

Extracting Value from Crop Waste

Farmers can reduce on-farm losses and create new revenue streams by implementing effective residue management practices, such as composting or repurposing crop waste into nutrient-rich soil amendments or valuable byproducts.



Residue Management
involves the sustainable management of crop residues after harvest, which can include leaving crop leftovers in the field to enrich the soil.

Composting
entails the decomposition of organic matter to produce a nutrient-rich soil amendment.

Byproducts
Using crop residues to create byproducts

Pulp and Paper
cereal straws, bagasse and corn stalks, can be used to produce pulp and paper products.

Chemicals Extraction
involves obtaining plant nutrients, waxes, oils and other chemicals.

Animal Feed
produce animal feed, either as roughage or in the form of feed pellets or blocks.

Biogas
offers a sustainable energy solution for heating and power generation.

Bio-materials
Source of raw materials for bioplastics and bio-composites.

Fibres
extract cellulose fibres, which are used in the production of textile.

Biofuel
converted ethanol and biodiesel, which serve as sustainable transportation fuels.

Residue management is crucial for soil regeneration and composting is increasingly recognised as a valuable approach for managing farm residues and addressing agricultural waste challenges.

1 Managing Crop Residues for Soil Replenishment

Residue management is crucial for soil regeneration, involving the handling of crop remains, such as stalks and leaves, after harvest. Farmers decide whether to leave residues on the field, incorporate them into the soil, or remove them, based on factors like soil health, pest control and erosion prevention.

The global crop residues was more than **5 billion metric tons** in 2020–2021.

Source: Economics of Crop Residue Management[20]

2 Composting

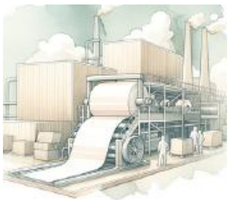
Composting transforms organic farm waste into a nutrient-rich soil amendment through biological decomposition. This process involves aerobic microorganisms breaking down the waste material, with aeration controlling moisture levels and temperature to sustain the composting microbes. The resulting finished compost is dark, crumbly and earthy-smelling, improving soil structure and providing nutrients when applied in fields.

Innovative companies are exploring diverse methods to convert agricultural byproducts into valuable commodities, moving beyond traditional composting. Entrepreneurs are creating a range of useful products from crop waste, including biomaterials and biochemicals.

3 Byproducts

Residue Revolutionaries

Paper



Paddy straw, wheat straw, and sugarcane bagasse can be used to obtain paper through a process that involves collecting and pulping these agricultural residues, separating the fibres, and then forming them into paper sheets.

Paperwise
Tensei
Craste

Animal Feed

Residual parts of harvested crops, such as leaves, stems, unmarketable produce can be used as livestock feed. This provides supplementary nutrition and is an eco-friendly alternative to traditional feed sources.

Biomilitus
Veolia Group
Entio

Bio-material

Agricultural residues or plant-based feedstocks are used to create environment friendly and sustainable alternatives to traditional plastics. Also, offers renewable source for various other applications.

Traceless
Plantswitch

Textile

Fibres sourced from agricultural residues diverts waste materials from landfills. Utilises the cellulosic portions of plants typically discarded after harvest through novel processing.

Altmat
Ananas-anam
Bananatex
ADRIANO DI MARTI

Bio-gas

Biogas technologies capture farm residue, and using anaerobic digesters stimulate methane-producing microbes that transform the biodegradable biomass into a green gas that can fuel cookstoves, machinery etc.

Anaergia
EnTech
Sistemabio

Biofuel

By extracting oils from residual plant materials after harvest or fermenting sugars from stalks and leaves, crop waste can be converted into liquid biofuels like biodiesel and ethanol.

Woodland Biofuels
Green Plains
POET

Chemicals Extraction

A wide array of biochemicals used in industrial manufacturing processes and commercial products can be extracted from farm residues, including organic acids, alcohols, waxes and resin compounds found in plant cell structures.

Cannare
Pyrotech energy
Novapangaea

Note: This is not an exhaustive list.

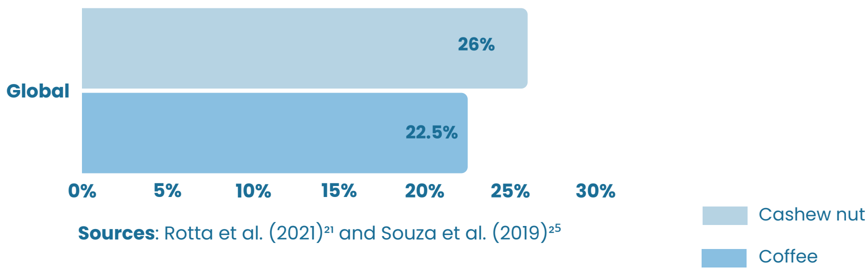
Unlocking Value: A Comprehensive Look at the Cashew and Coffee Value Chain

The agricultural fabric of developing countries in **Asia, Africa and South America, especially** East Africa is intricately woven with the cashew and coffee value chains, profoundly shaping rural livelihoods and regional economies. Nevertheless, persistent inefficiencies in crop waste management continue to impact farmers and the wider industry. Therefore, unravelling the intricate dynamics of crop waste within these value chains is essential for overcoming challenges and unlocking untapped opportunities.

The findings presented in this report can guide stakeholders, policymakers and industry players in developing practical solutions to mitigate waste, improve sustainability and promote economic growth in the cashew and coffee value chains. By addressing the challenge of crop waste, East Africa can strengthen its position in the global market while supporting the livelihoods of its farming communities.

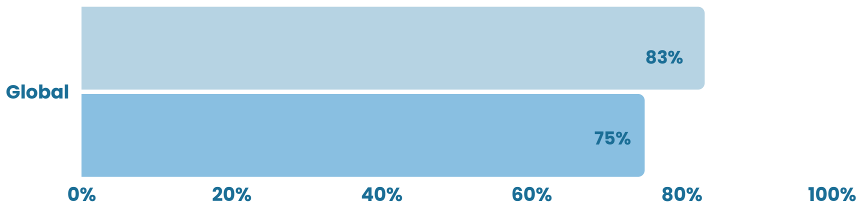
Considerable amounts of cashew nuts and coffee are lost from pre-harvest to market. This analysis provides valuable insights into the rates of wastage occurring at both the pre-harvest and post-harvest stages of the cashew and coffee value chain.

% of Preharvest Wastage



Sources: Rotta et al. (2021)[21] and Souza et al. (2019)[25]

% of Postharvest Wastage



Sources: Rotta et al. (2021)[21] and TechnoServe[24]

Preharvest losses persist due to multiple factors viz., pest infestations, diseases, adverse weather conditions and inadequate farm management. By fostering agroecosystem balance through practices like integrated pest management, cover cropping, farmers can naturally mitigate pest and disease pressures.

A sustainable value chain offers a comprehensive approach to mitigating post-harvest losses. By prioritising the entire ecosystem, from farm to table, this approach integrates innovative solutions throughout the supply chain. Implementing controlled atmosphere storage ensures optimal conditions for maintaining product freshness, reducing reliance on chemical preservatives.

Energy-efficient cold chain management can preserve quality during transit, complemented by the waste-to-resource transformation in modern processing facilities, where byproducts like cashew shells and coffee pulp are repurposed. Community-based initiatives empower local stakeholders and traceability systems enhance transparency, accountability and product quality assurance. Such practices not only minimise waste but also foster a resilient, environmentally conscious and economically viable cashew and coffee value chain.

SALONI GOYAL

Sustainability Manager (Corporate)
Agri Value Chain
Arise IIP

ARISE
INTEGRATED INDUSTRIAL PLATFORMS

“Prioritising the development of a sustainable and low-carbon value chain, centered on the triple bottom line, requires fostering partnerships, government support, sourcing directly from farmers, implementing end-to-end processing, and promoting finished goods directly from Africa to international markets.”

80% of the coffee production is by smallholder farmers at the bottom of the pyramid.

Source: Fairtrade Foundation[23]

Only **6.7%** of the global coffee cropland is organic.

Source: Union Coffee[22]

20% of the coffee sourced by Nescafe of Nestle to be regeneratively grown by 2025.

Source: The Investor Vafie Magazine[26]

Cultivating Sustainability: Transforming Cashew Nut Supply Chain into a Circular Economy

Sowing and Cultivation

Flowering, Fruit Formation and Ripening

Harvesting and Drying

90% Cashew Apple not utilised[29]

Cleaning, Roasting, Shelling

75-95% Cashew Shells are disposed[24]

Drying and Peeling

Grading and Sorting

Packaging

Storage

13% Cashew lost due to lack of good storage conditions[30]

Distribution and Logistics

Retail and Consumption

After harvesting and separating the cashew apple, cashews with the shell undergo drying (sun drying or machine). Then heat treatment —steam cooking, oil bath roasting, drum roasting—is employed to soften the shell. De-shelling is the removal and separation of kernels from their outer shell, which is followed by oven drying and humidification of shelled cashews. Post that is peeling, where testa is removed from the kernel. Kernels then undergo grading, a process that classifies them into different quality grades before packaging for storage and shipment.[27]

	Residue Waste	Potential Usage
 **Fruit Formation & Ripening**	Cashew leaves, cashew timber and gum from timber	Fodder, mulch, biomass, furniture, construction, and resin (varnish, adhesive)
 **Harvesting**	Cashew apple	Beverages, jam, jelly, vinegar, animal feed, traditional medicine, pigments and dyes
 **Processing**	Shell liquid, kernels and Testa	Resins, varnishes, coatings, adhesives, lubricants and rust Inhibitors
 **Storage**	Cashew nuts	Cashew nut oil, butter, flour, animal feed or compost
 **Grading & sorting**	Discarded cashew kernels	Animal feed, cashew infused products such as oil, snack mix

Sources: Igbinadolor, et al. (2017)[29], TechnoServe[24], Lucia and Garry (2017)[30] and Brito de Figueirêdo (2016)[31]

BITTA WYCLIFFE

Senior Investment Manager

goodwell
invest with impact

" I recognize the intricate challenges and immense potential within the cashew nuts value chain. Investors must balance the pursuit of environmental stewardship and economic returns, acknowledging that the transition to sustainable practices involves navigating complex dynamics of land tenure security, access to innovative technologies, and market linkages. However, the journey is not without its hurdles. Smallholder farmers, who are central to the cashew value chain, often grapple with uncertain land rights, limited access to capital, and a lack of technical know-how, impeding their shift towards more sustainable practices. Additionally, the fragmented nature of the value chain presents challenges in achieving scale and securing fair value distribution. The publication serves as a beacon, showcasing how strategic investments in regenerative practices, coupled with robust policy frameworks and targeted financial instruments, can address these challenges. By illustrating successful case studies and presenting actionable data, it underscores the role of investors in fostering an ecosystem that not only enhances the sustainability of the cashew value chain but also propels smallholder farmers towards greater economic resilience. In essence, our role as investors extends beyond mere capital provision. It's about nurturing an environment where sustainable practices thrive, ensuring equitable growth and resilience in the cashew nuts value chain. The insights from this report should reinforce our commitment to this vision, guiding our strategies towards impactful investments. "

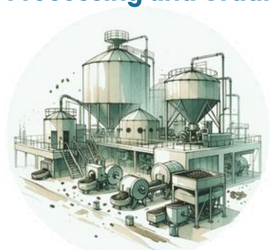
Coffee Supply Chain: Transforming Waste into Opportunities for a Circular Economy

Sowing and Planting

Flowering and Fruit Formation

Harvesting

Processing and Grading



Coffee sludge is the most common residue, which makes up 45% during the processing of coffee beans[33]

Storage

Export

Import, Roasting, and Grinding

Coffee pulp rich in nitrogen (N), phosphorus (P), potassium (K) and other trace elements can significantly enhance coffee yields by **15-33%** when used as a soil amendment.[28]

Packaging, Branding, and Distribution

Retail

90% of spent coffee grounds is wasted[34]

Coffee seeds are sown in expansive, shaded nurseries and after about 3 to 4 year gestation period, the coffee plant yields fruit. Upon harvest, the coffee cherries go through the processing phase. Beans are then dry or wet-processed. Wet processing involves the removal of pulp and mucilage from cherries through water immersion, while dry processing involves natural sun drying or machine assistance.

After wet processing, the pulped and fermented beans are dried, next hulling of the parchment layer and in the case of dry processing entire dry husk is removed during the hulling stage. Followed by grading and sorting where beans are meticulously separated based on factors such as colour, density, and size, culminating in a final step of precise manual selection, particularly crucial when the beans are for export.[32]

	Residue or Waste	Potential Usage
 **Harvesting**	Damaged and over ripen cherries	Compost, animal feed, cascara, natural dyes, cosmetics and skincare products
 **Processing**	Skin, pulp, mucilage, defective coffee beans, Parchment and hulls	Biogas production, pectin, mushroom substrate
 **Roasting**	Silverskin a.k.a chaff	Culinary purposes, fertiliser, briquettes
 **Retail and Consumption**	Coffee grounds	Odor neutraliser, natural pest repellent, fertiliser, natural de-icer

GABRIELA CHANG VALDOVINOS

CSO and Co-Founder, EthicHub

EthicHub

“Coffee is one of the most traded commodities in the world and 80% of coffee is sourced from smallholder farmers at the bottom of the pyramid. Despite well intended people working with them, these smallholder farmers are at an unfair disadvantage and there is an imbalanced allocation of benefits. In order to change this, the question we need to do is what is the cost and impact of our purchase on people and planet, socially and environmentally?”

Sources: Murphy, M. and T. Dowding[32], International Scientific Conference “Biologisation”[33], Otieno, et al. (2019)[28] and Kourmentza, et. al. (2018)[34]

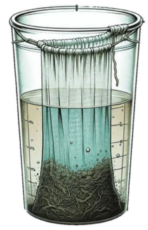
From Crop Waste to Nutrient-Rich Compost

The transformation of crop waste, such as husk, pod skins and coffee shells, into compost results in a high nutrient content compost offers substantial benefits for soil health and plant growth. Amaly has taken a progressive approach by delving into microbial mixes to further enhance the potency of its compost.

Cost Reduction

Fertilisers and nutrients represent a major cost for farmers, and while government subsidies help make these products more accessible, they can still be out of reach for many. Innovative, cost-effective solutions like compost tea are transforming the way farmers provide nutrients for their crops, offering a more affordable and sustainable option






	NPK Synthetic Fertiliser	Animal Manure	Amaly's Magic Compost Tea (Proprietary Formula)
Impact on yield	★★★	★★★	★★★
Sustainability	–	–	★★★
Scalability	★½	★	★★★
Cost	½	★½	★★★
Innovation	★	–	★★★
Overall ranking	★	★½	★★★

Source: Amaly Legacy analysis

★ Rating
– No rating

What's so special about compost tea?
Compost tea is revolutionising agriculture by providing a cost-effective, accessible, and innovative soil health and crop yield enhancement solution, surpassing traditional methods in affordability, accessibility and advancement with its tailored microbial blends.

DR. HECTOR HERNANDEZ
Biochemistry and Molecular Biology, MIT

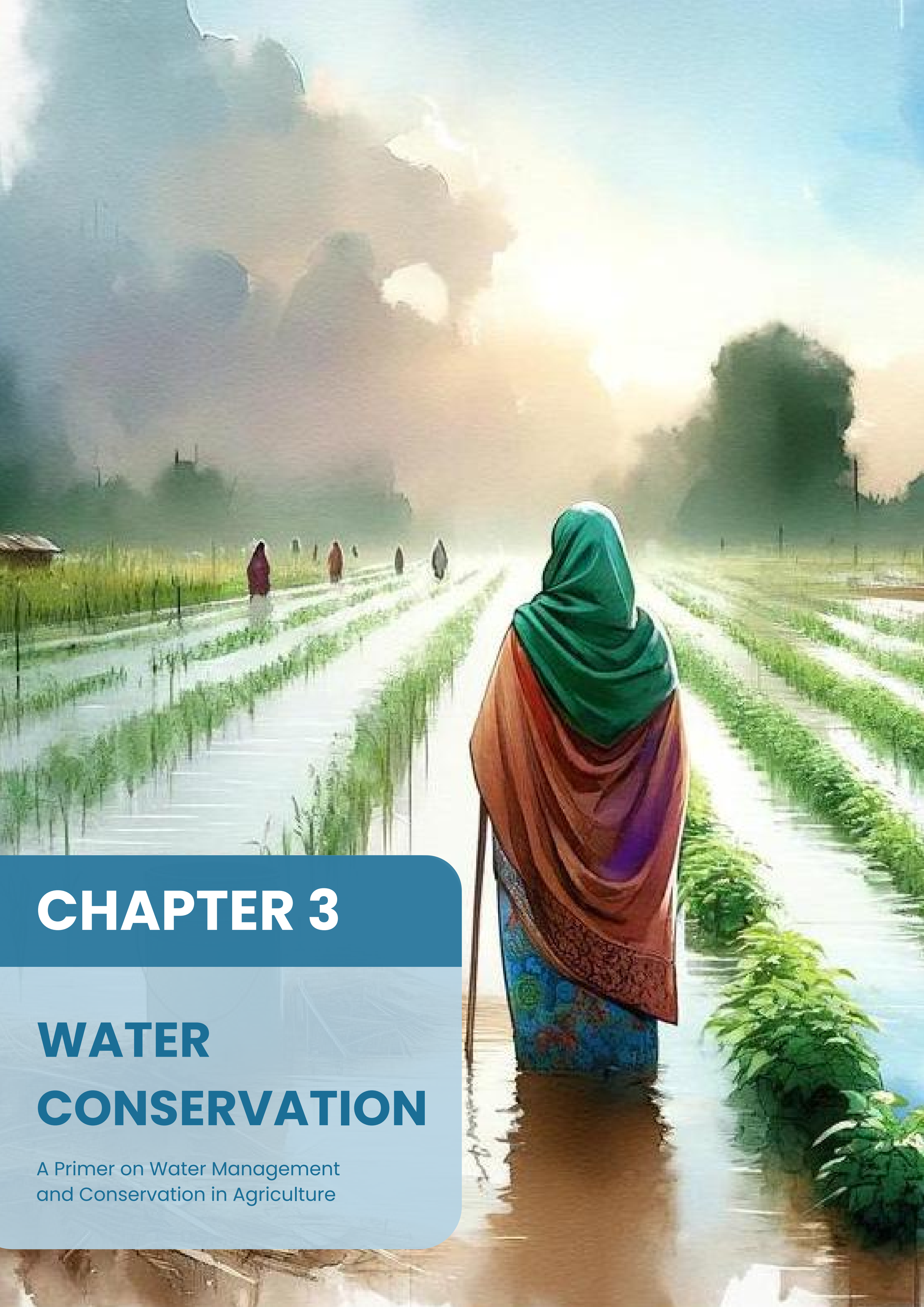
Partner, Amaly Regen Ag Studio

"Fertilisers and nutrients remain the largest cost for smallholder farmers despite government subsidies in some countries ... innovation in compost tea formulations, especially around microbial ecology, is presenting viable, highly effective and scalable alternatives that ease the transition to regenerative agriculture."

DR. OTTO X. CORDERO
Associate Professor, Department of Civil and Environmental Engineering, MIT

Massachusetts Institute of Technology

"As the second most consumed beverage in the world, tea leaf compositing can be a highly scalable strategy to circularize the use of resources in agriculture. When added to soils, fermented tea leaves provide nitrogen and trace metals to plants, reducing demand for synthetic fertilizers, while increasing the growth of beneficial microbes and contributing more stable forms of carbon to soil – thus reducing GH emissions."



CHAPTER 3

WATER CONSERVATION

A Primer on Water Management and Conservation in Agriculture

As agriculture grapples with increasing water scarcity, it is essential for farmers to adopt water conservation strategies to ensure sustainable food production and ecosystem preservation. This chapter explores innovative approaches such as drip irrigation, water sourcing and storage techniques, water-efficient crops, and regenerative practices to increase soil moisture, providing practical solutions for farmers to overcome water challenges and secure their future operations.

Introduction

The growing global population's demand for agricultural output is placing extreme pressure on the limited freshwater sources available for crop cultivation. Agriculture's current water management approaches are steering the sector towards surpassing available supply levels, as overexploitation and pollution progressively diminish viable water resources.

The sustainable management of water resources in agriculture involves minimising water wastage and optimising water use through various strategies and techniques, such as drip irrigation, crop rotation and water-efficient crops, to maintain or improve crop yields and overall agricultural productivity.

65%	Average rainwater lost and not available to crops in rain-fed agriculture
~60%	Wastage of irrigation water due to inefficient irrigation systems

Source: FAO/IAEA[35]

Source: WWF[36]

Amaly recognises the importance of water conservation in agriculture and advocates for the adoption of innovative techniques such as drip irrigation, water sourcing and storage techniques, water-efficient crops and the adoption of regenerative agricultural practices to enhance water management and ensure sustainable food production.

Key Water Conservation Approaches and Solutions

Approaches to Water Conservation

1. Drip irrigation and micro-sprinklers to minimise water wastage.

2. Smart irrigation systems and sensors for efficient water management.

3. Innovative techniques to store and source water for irrigation, including rain harvesting systems, dams and water catchments, half moon / semi-circular bunds.

4. Optimising water use by integrated pest management.

5. Water-efficient crop varieties, intercropping, crop rotation.

6. Mulching and cover cropping to reduce evaporation.

7. Other regenerative farming practices and improved soil management techniques for water retention.

- Mulching and cover cropping to reduce evaporation
- Sustainably manage water resources
- Techniques to minimise water consumption needs

Amaly highlights the importance of efficient water allocation, which depends on understanding the main water use on the farm and available water sources. This chapter profiles traditional irrigation needs as well as common water inputs that supply agriculture's diverse requirements

Key Water Uses in Farming

Irrigation

Harvesting and Post-Harvest Processing

Livestock Watering

Frost Protection

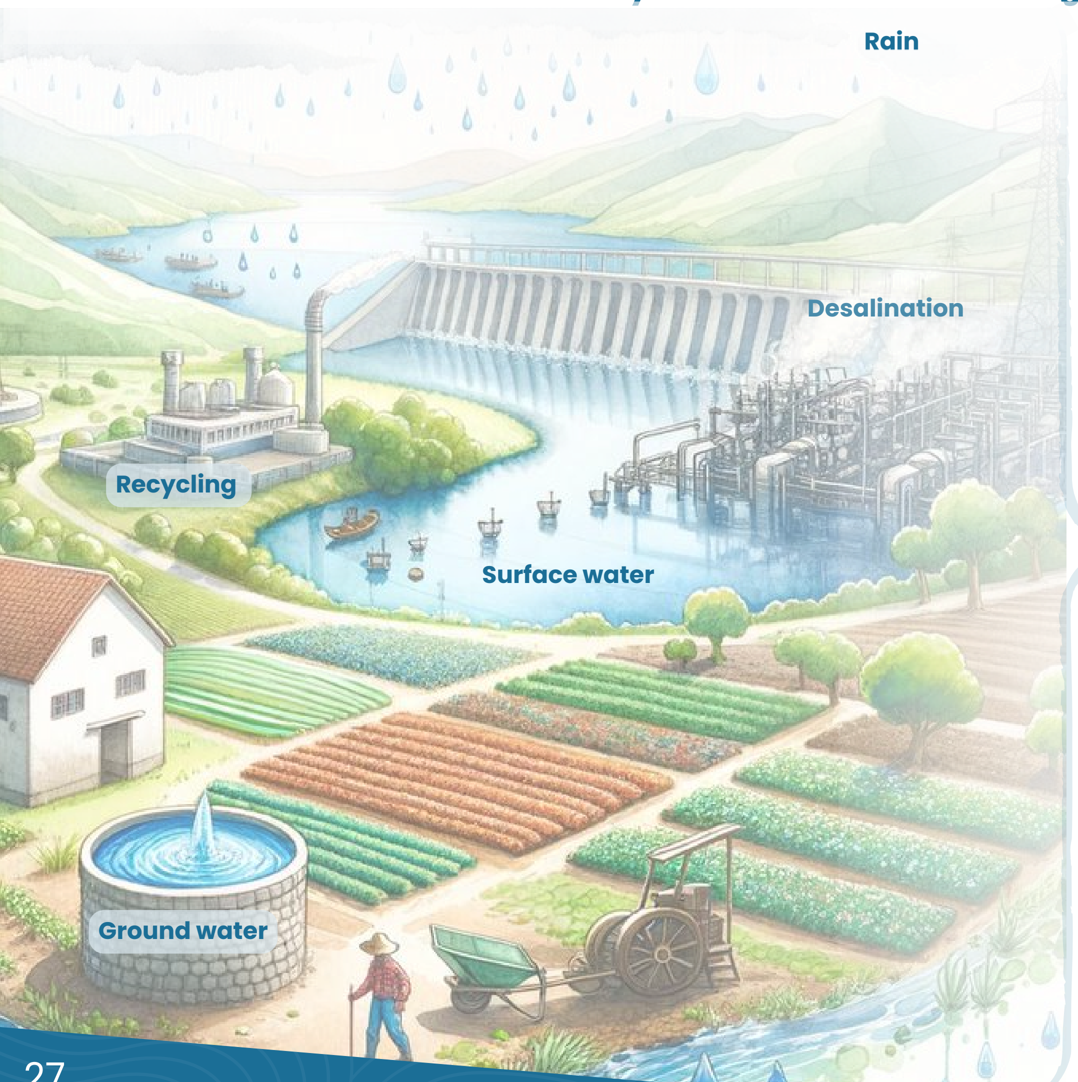
Soil Preparation and Seed Germination

Aquaculture

Composting

Crop Cooling

Key Water Sources in Farming



Rain

Surface Water

Ground Water

Desalination

Recycled Water

Irrigation technology plays a crucial role in determining water distribution and productivity on farms. Here we offer an overview of the primary types of irrigation systems used in agriculture.

Overview of Irrigation Systems

We conducted an analysis of irrigation systems, water sources and uses in Tanzania to uncover an option with different costs, water usage rates, energy sources, suppliers, applications and advantages or drawbacks available to smallholder farmers. This in-depth understanding enables us to identify and recommend the most suitable, cost-effective and sustainable irrigation solutions that are well-suited to the unique needs of smallholder farmers, advancing our goal of promoting efficient water use and enhancing crop yields.

Types of Irrigation Systems

Natural Rain Irrigation

- **Definition:** precipitation that occurs when water vapour in the atmosphere condenses into water droplets that become heavy enough to fall under gravity.
- **Usage:** 1mm of rainfall supplies 1 litre of water per square metre.
- **Pro:** Low maintenance and water can be harvested through rainwater harvesting.
- **Con:** Climate change has made rainfall prediction challenging.

Flood Irrigation

- **Definition:** Irrigation method that sources water from lakes, streams, rain etc.
- **Usage:** Average water usage is 4-7 tonnes per hectare (dry season), and 6-9 tonnes per hectare (growing season).
- **Pro:** Ineffective in sandy soils, and requires graded and level land.
- **Con:** Lack of precision leads to water waste, thus not sustainable or efficient, and labour-intensive process.

Basin irrigation

- **Definition:** Use of river water to leach salts from soil to groundwater.
- **Usage:** Used for crops that need to be submerged during growth, such as rice paddies
- **Pro:** Low cost, easy to maintain, and controlled flooding and irrigation.
- **Con:** Not suitable for all crop types, prone to water wastage, and long-standing water can lead to increased pests, diseases, and water salinity.

Border Irrigation

- **Definition:** Pre-prepared embankments or small earth structures across a field through which water flows.
- **Usage:** crop water use of 0.20cm to 2.5cm per hour, averaging 30-60mm per crop application.
- **Pro:** Allows for soil to become saturated while excess water drains away from the field.
- **Cons:** Not suitable for sloped fields.

Furrow Irrigation

- **Definition:** Shallow trenches made along the slope of the field between raised beds or ridges get their water sources from groundwater.
- **Usage:** Most suitable for growing tree crops.
- **Pro:** Cost-effective, individual control of flooding.
- **Con:** High potential for erosion, and the amount of water wasted is high (~40%).

Fixed Irrigation

- **Definition:** This irrigation setup has components like pipes, sprinklers/emitters, pumps etc., permanently installed in fields, sourcing water from the surface and groundwater.
- **Usage:** Used to irrigate large agricultural fields.
- **Pro:** It is efficient since water can be applied at low rates and works well on medium and coarse-textured soils. May lead to clogging.
- **Con:** The System cannot be readily reconfigured to account for new farming layouts.

Lateral Movement Irrigation

- **Definition:** This system sources water from surface or groundwater.
- **Usage:** Can be used to grow all field crop types.
- **Pro:** Highly efficient due to precise application and has opportunities for fertigation thus saving water and labour.
- **Con:** High initial capital cost involved.

Surface Drip Irrigation

- **Definition:** This type of micro-irrigation system is where low-volume water emitters or drippers are placed on the soil surface to slowly water the crop root.
- **Usage:** Used to deliver irrigation directly to plants at the base of the stem.
- **Pro:** Recommended for areas with waterlogging problems.
- **Con:** Initial installation cost is high, high operation cost, and needs trained staff to maintain.

Subsurface Drip Irrigation

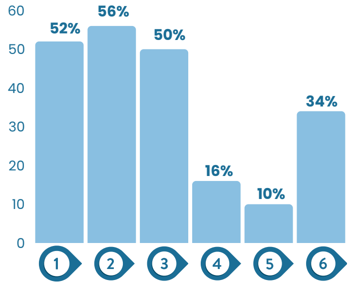
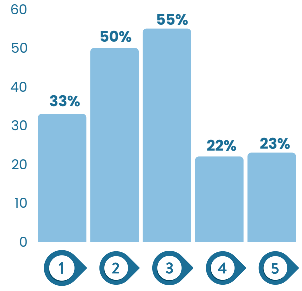
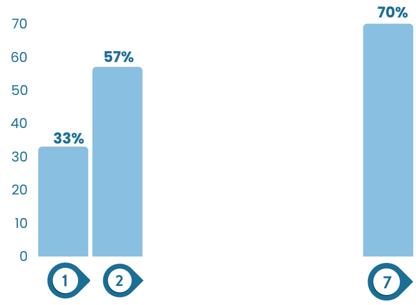
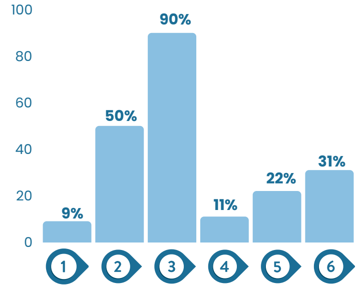
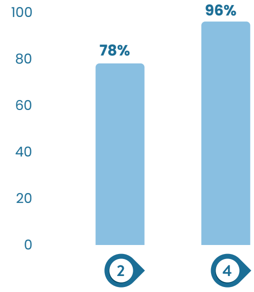
- **Definition:** In this system, plastic drip lines containing water emitters are buried just below the soil surface providing an accurate amount of water.
- **Usage:** Reduction in weed growth, highly efficient and uniform.
- **Pro:** Highly beneficial since no water is lost to evaporation, no soil erosion, reduction in pests and weeds.
- **Con:** Initial installation cost is high, high operation cost and need trained staff to maintain.

Sources: Brouwer (1985)[37], Wikifarmer[38], Tiwari and Raghuwanshi[39] and Kuchta (2022)[40]

The type of irrigation system employed has a considerable impact on on-farm resource usage and the environment.

Impact of Water Conservation Solution

Amaly conducted an analysis of various water conservation solutions to assess their quantitative impact on reducing water use, increasing long-term water availability, minimising nutrient runoff and reducing soil erosion, among other factors. The purpose of this analysis is to provide decision-makers with the necessary information to make informed decisions regarding the most effective water conservation solution for agricultural practices.

Water Conservation Solutions		Metrics Illustrating Efficiency of these Solutions
	Drip irrigation delivers water directly to the roots in a controlled and precise manner.[A]	
	Microsprinklers apply water uniformly over a small area, which provides localised watering around individual plants.[B]	
	Smart irrigation sensor, technology-based devices that optimise irrigation by collecting real-time data on soil moisture levels.[C]	
	With cover crop and mulching, evaporation is reduced as the soil surface is shaded by cover crop foliage. These crops intercept raindrops which are absorbed rather than running off.[D]	
	Half moon/Semi circular bunds are curved earthen ridges constructed across farms. Their semicircular shape slows and spreads water flow.[E]	

27% **Water reduction with water efficient crops**

1. Reduction in water use
2. Reduction in nutrient runoff
3. Reduction in soil erosion
4. Increase in soil moisture
5. Reduction in evaporation
6. Reduction in soil salinity
7. Increase in long term water availability

Sources: Amaly Legacy analysis and Samiha, et al. (2020)[41]

CHAPTER 4

TRANSITIONING TO REGENERATIVE AGRICULTURE: POLICY ENABLERS

Exploring Agricultural Policy Considerations in East Africa

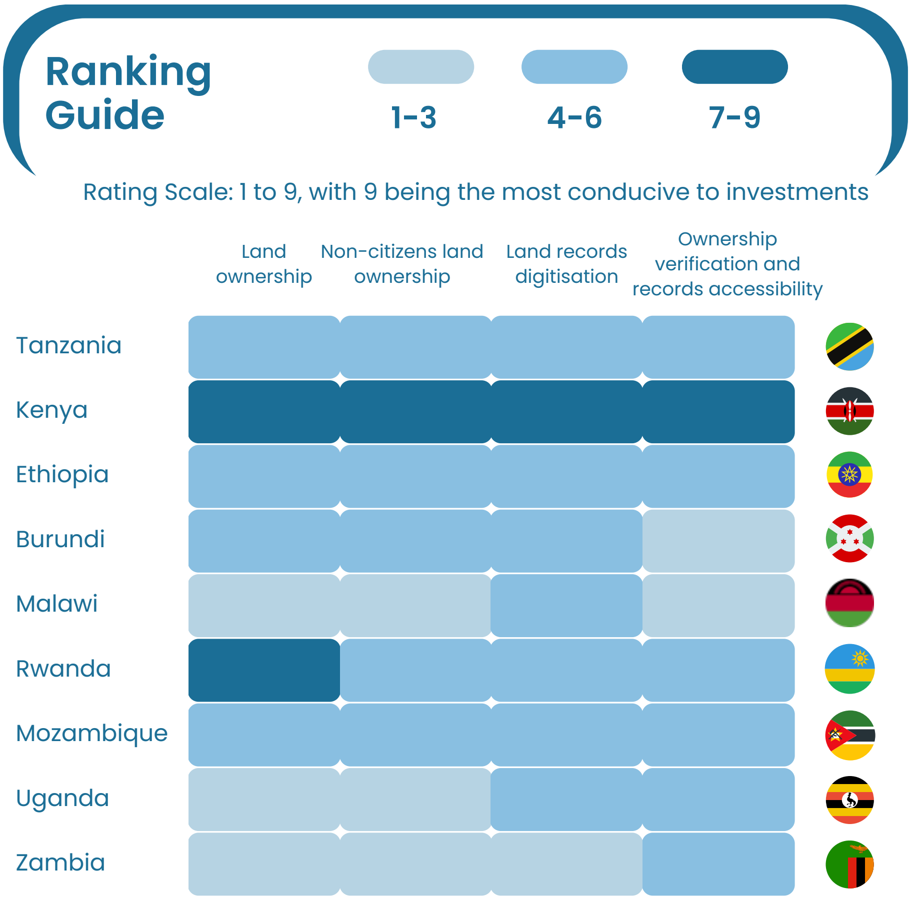
Note: Policy initiatives in the context of enabling the transition to regenerative agriculture are measures or actions undertaken by governments, international organisations, or other entities to support regenerative agricultural practices that restore and enhance natural ecosystems. These initiatives can include regulations, programmes and projects that create favourable conditions to transition to regenerative agricultural practices.

Land rights and trading and investment policies play a significant role in shaping the agricultural sector. This chapter delves into these policies and their impact on the development of the agriculture sector in East Africa.

Land ownership increases productivity by **10.2%**

Source: Olagunju, et al. (2023)[42]

Land Regulations[A]



The rankings on land policies underscores the potential for agricultural investment and development in East African nations. By considering factors such as the ease of land acquisition, investment thresholds, digital accessibility of land records, and efficiency of land verification processes, the guide aims to illuminate the diverse regulatory environments and their respective approaches to facilitating land-related transactions. It is important to recognise that each ranking is not an absolute measure of policy effectiveness but rather a relative indicator designed to understand the spectrum of opportunities and operational dynamics within the region. The intent is to foster dialogue and encourage the sharing of best practices among nations to collectively enhance investment attractiveness and development outcomes.

Kenya launched the National Land Information Management System (NLIMS) in 2021 to digitise land records and enhance transparency and access to land information.[43]

Responsible and Innovative Land Administration (REILA) project in Ethiopia establishing an efficient and transparent system for rural land registration. Over its two phases, REILA registered over 1.1 million land parcels in targeted regions.[44]

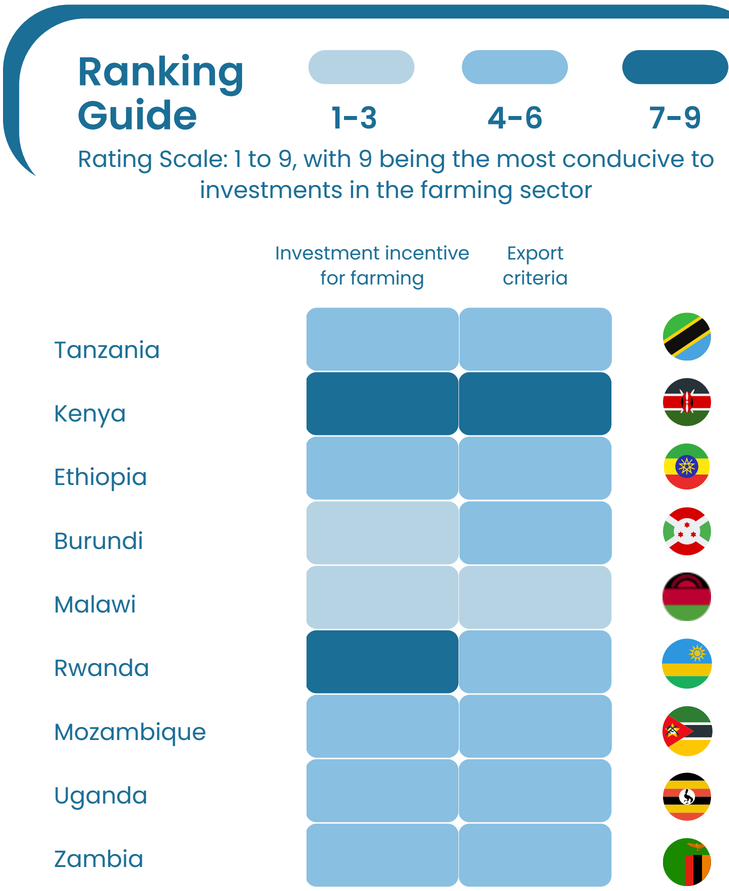
The Land Tenure Regularisation process in Rwanda registered all the land in the country for the first time, demarcating and adjudicating over 10.3 million land parcels between 2010 and 2013 to provide land titles to rightful claimants nationwide. This represented a major achievement in securing land tenure for rural communities.[45]

Notes: 1. The information is derived from a combination of primary and secondary sources. Some government authorities proved challenging to contact, hindering the process of obtaining additional information beyond what is publicly available. **2.** Some of the countries considered in this publication are not technically part of East Africa however their inclusion was due to their geographical and cultural proximity, as well as their frequent inclusion in discussions and dialogues on East African agriculture.

This is a comparison of incentives and export requirements across East African nations to assess their competitiveness in attracting agricultural businesses.

Investment and Trading Policy Considerations[B]

Policies and regulations of the agriculture sector in East Africa



The rankings are intended to serve as an informative baseline for assessing the agricultural policy landscape in East Africa, highlighting the various ways in which each country fosters an environment conducive farming investments and trade. Recognising the unique circumstances and policy-making processes of each nation, the rankings aim to gently underscore areas where policies are well-aligned with international best practices, as well as areas with potential for policy optimisation, all with the spirit of constructive engagement and the shared goal of enhancing the agri-sector's vibrancy and global competitiveness.

The new Agricultural Policy launched in 2021 aims to transform Kenya's agriculture into a modern, profitable and competitive sector by promoting commercial agriculture and strengthening food and nutrition security.[47]

Zambia's National Agricultural Policy 2012-2030 aims to make the agriculture sector more productive and sustainable by promoting sustainable farming and increasing access to resources for small-scale farmers.[48]

United Nations Development Programme and the Common Market for Eastern and Southern Africa have launched the Climate Smart Agriculture initiative in Uganda in 2022 to sustainably increase agricultural productivity and incomes; adapting and building resilience to climate change.[49]

Technologies for African Agricultural Transformation (TAAT) Programme

TAAT provides access to smallholder farmers in Africa to implement technologies that improve agricultural productivity targeting select crop value chains. Currently active in over 30 countries addressing food and nutritional security challenges through agricultural transformation in Africa.

Source: African Development Bank Group[46]

MASSIMILIANO RIVA

Sustainability Lead for Equity Funds and Corporate Bonds, Principal, Green Climate Fund, EBRD

European Bank for Reconstruction and Development

GREEN CLIMATE FUND

The diverse landscapes of East Africa are true gems, from world-known parks to pristine mountain volcanos, forests to gorgeous hilly farmlands. These landscapes need to be protected, buffered from pollution and agriculture, and where damaged, to be regenerated. Regenerative agriculture and nature-based solutions, provide options that can deliver environmentally, socially and commercially viable solutions. In a recent exercise, we identified and profiled over forty nature-positive business solutions for agribusiness, from retailers to producers and traders. From gradual implementation and transition in traditional commercial agriculture companies to completely new efforts by start-ups, technical solutions and markets are there. These theoretical and technical solutions face, yet, long-standing barriers, such as lack of financial access and affordability of capital, cultural resistance to change, market access and logistics. Everyone can do its part. From impact investors and forerunners entrepreneurs taking the initial risks to local communities and organizations providing the required training to farmers and intermediaries and governments in extending extension services. Dedicated financial vehicles already exist, including a growing number of thematic equity funds that can help scale companies and build the track record for other investors

This is a comparison of key policies in East Africa governing irrigation, water access and solar energy incentives.

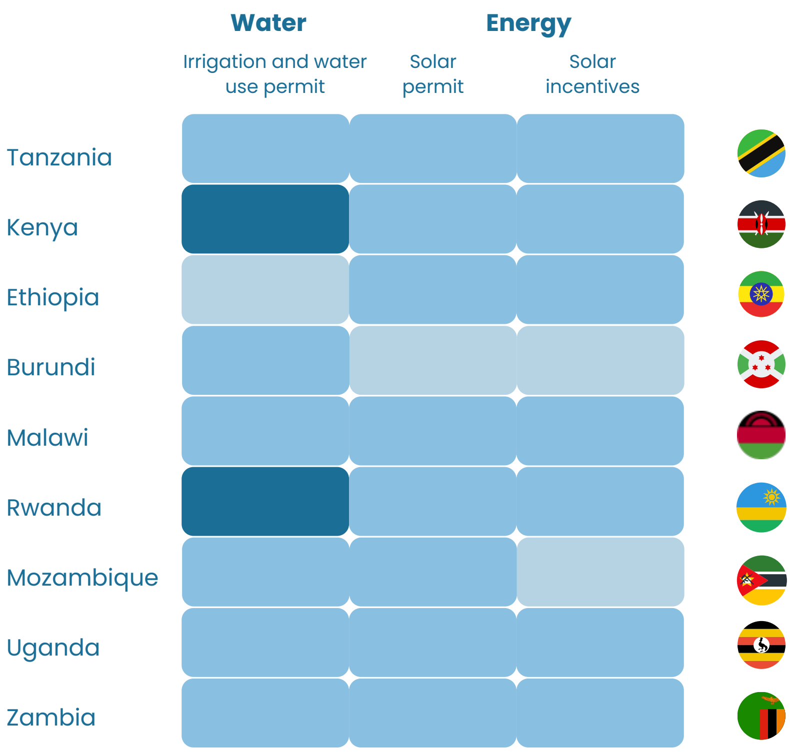
Water and Energy Regulations[c]

Policies and regulations for water and energy management in East Africa

Ranking Guide

1-3 | 4-6 | 7-9

Rating Scale: 1 to 9, with 9 being the most conducive to investments



About **85%** of farms in Africa lack energy access, only **5%** of cropland is equipped with irrigation.

Source: Power For All[50]

NATHANIAL MATTHEWS

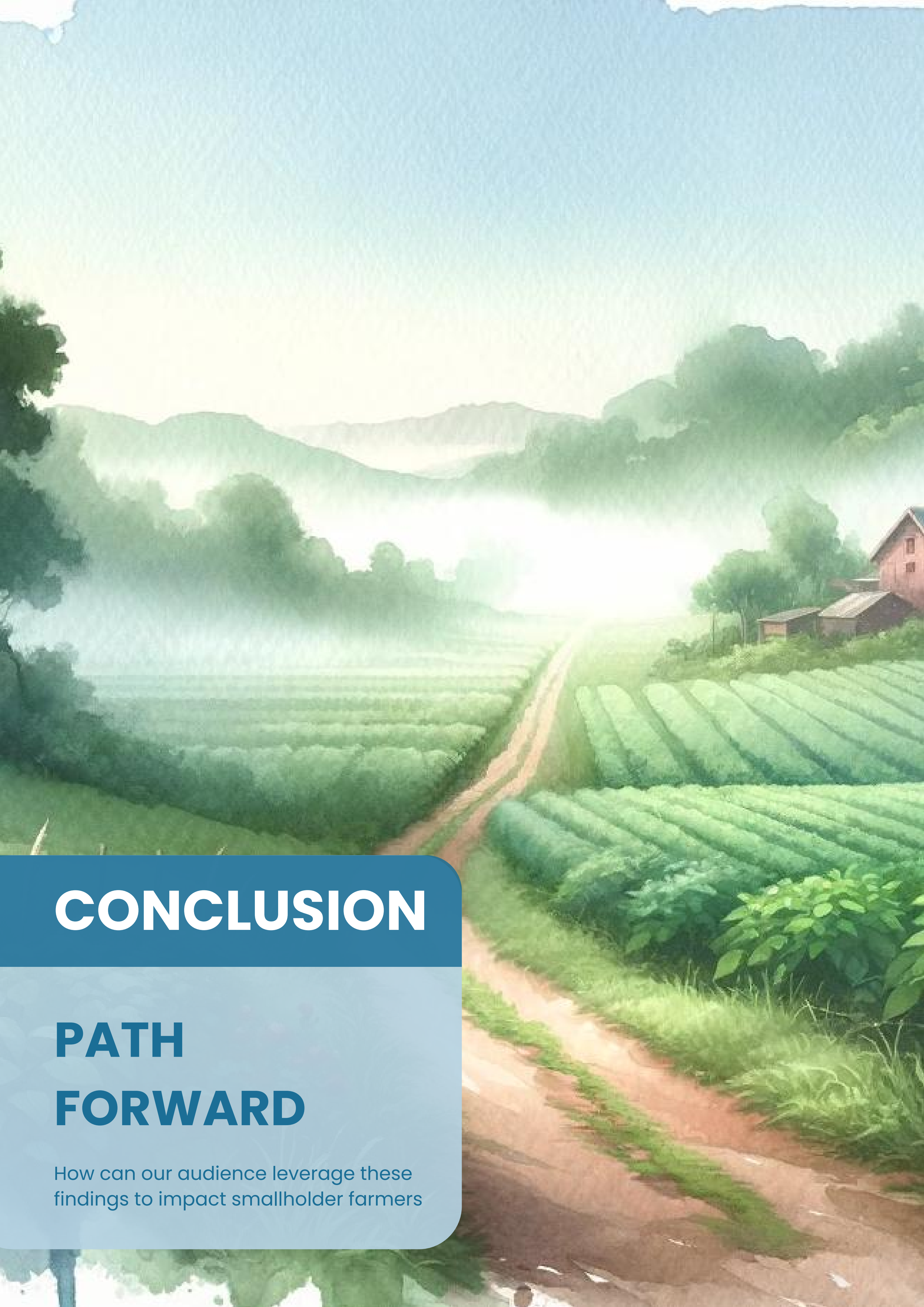
CEO, Global Resilience Partnership

“Globally, effective regenerative agriculture depends critically on clear land tenure policies that ensure long-term land security for farmers, fostering investment and sustainable land use. Equally vital are incentives that promote regenerative practices, which not only improve soil health, protect biodiversity which agriculture depends on, and enhance agricultural productivity but also support climate resilience. Access to reliable energy and water resources is indispensable, as it enables the implementation of sustainable agricultural technologies and practices essential for regenerative agriculture to thrive.”

The rankings are a reflection of the current policy frameworks governing water and solar energy across East African countries, with an emphasis on the ease of permit acquisition and the availability of solar incentives. These measures are indicative of each country's commitment to sustainable practices and investment potential in these sectors, offering a constructive overview that encourages continued progress and cooperative efforts to optimise policy environments in support of regional growth and environmental stewardship.

Kenya Off-Grid Solar Access Project (KOSAP) to increase electricity access in underserved areas through the construction of mini-grids, standalone solar home systems and installation of solar water pumps. KOSAP is part of Kenya's efforts to accelerate renewable energy deployment in Africa.[51]

The Distributed Renewable Energy-Agriculture Modalities (DREAM) programme in Ethiopia in collaboration with the Ministry of Water and Energy, Ministry of Irrigation and Lowlands and Ministry of Agriculture, focuses on building solar mini-grid powered irrigation systems, offering a sustainable energy source for agriculture. This initiative to enhance irrigation efficiency and reliability for smallholder farmers, aiming to boost crop yields, incomes and food security. It marks a significant step in integrating renewable energy into the agricultural sector in Ethiopia.[52]



CONCLUSION

PATH FORWARD

How can our audience leverage these findings to impact smallholder farmers

PATH FORWARD ...

Abundance of Untapped Value

Today East Africa presents a wealth of opportunities for investors and asset managers, with an estimated annual missed revenue of $34 billion from 872 million hectares of degraded farmland from merely 5 crop value chains with the potential to impact, notwithstanding the missed revenue from waste to value opportunities, which together can impact 3 million smallholder farmers, adding ~$552 to the livelihoods of each smallholder farmer.

75% to 80%
the continent's cultivated area is degraded

12.5%
loss upto harvest in Sub Saharan Africa

Coffee, cocoa, tea, cashew and sisal
crop yields are lower than global average in East Africa

~$ 34 bn+
Missed revenue

~$ 552
Potential increase in smallholder farmers' revenue

3 mn+
smallholder farmers growing these 5 crops would be impacted

Note: Amaly has selected 5 sample crops for the purpose of this analysis as these are some of the major exported items from East Africa and are vulnerable to post-harvest losses and waste.

Sources: Amaly Legacy analysis, FAO[1], AGNES Africa[53] and Wageningen University and Research[9]

Paths to Unlock Value

Research and Controlled Trials — 1

Research and controlled trials are critical in unlocking data, insights and value, especially in terms of proving the efficacy of value-creation levers and selecting farming practices to derisk investments. This entails a comprehensive evaluation of different agricultural approaches in regions, environments and terrains that offer high financial and economic opportunities, focusing on levers that maximise output while minimising environmental impact.

Waste Reduction and Conversion of Waste to Value — 2

Effective operations to reduce waste supported by multi-stakeholder partnerships to convert waste to value are critical paths in unlocking value. This requires a combination of **i) a** granular understanding of crop value chains and processes, procedures and policies that could be applied at each stage of the value chain to reduce waste, **ii)** the economic value of waste byproducts, and **iii)** partnership avenues to convert the waste to valuable byproducts at scale.

Proactive Asset Management — 3

Proactive asset management and operating partners are crucial to unlocking value in degraded farmland by optimising performance and reducing costs. This includes a series of value-creation initiatives that enhance crop quality and yield, while reducing costs, including water and nutrient conservation, coupled with robust risk mitigation mechanisms.

Amaly is well positioned to co-invest resources in degraded farmland opportunities with significant social and environmental impact potential and act in the capacity of an asset manager for large institutional investors, leveraging its multidisciplinary team on-ground, government relationships, knowledge of regulatory landscape and policy considerations, network of local partners and scientific team to execute large scale mandates in East Africa.

NOTES

Chapter 1

A. **Carbon Sequestration**

No Tillage

- Historical losses due to simulated Intensive tilling practices ranged from 5%–13% of the 133 Gt C of global cumulative SOC losses attributable to agriculture. Ref: Modest capacity of no-till farming to offset emissions over 21st century
- Non-tillage system has 10–15 % more carbon stocks than soil under conventional tillage. Ref: Changes in soil organic carbon fractions and residence time five years after implementing conventional and conservation tillage practices

Cover Cropping

- Cover cropping increases soil organic carbon SOC in near-surface soils by an average of 15.5%. Ref: A meta-analysis of global cropland soil carbon changes due to cover cropping

Intercropping

- Intercropping of grain legumes and cereals increased soil organic carbon sequestration by 15% compared to monoculture in Africa. Ref: Ecosystem service provision of grain legume and cereal intercropping in Africa
- The crop sequestered-C relative increase for intercrops to sole crops values have seasonally varied between 42.06 and 77.75%. Ref: Carbon Sequestration as a Function of Intercropping Management Practice and Different Nitrogenous Fertiliser Types

Crop Rotation

- Crop rotation implementation increased soil sequestration by 18.01% in semi-arid regions. Ref: Carbon sequestration potential of sustainable agricultural practices to mitigate climate change in Indian agriculture: A meta-analysis
- Substantial increase from 0.5%–2.5% soil carbon comes with a maximum increased yield of 2.5 tonnes for both wheat. Ref: Soil carbon ensures arable crop production against increasing adverse weather due to climate change

Composting

- The consecutive use of mature garden/food organics compost for 12 years in a study has shown carbon retention rates of 45% to 50%, while the use of pasteurised garden organics compost indicated about 30% carbon retention. Ref: The benefits of using compost for mitigating climate change

Agroforestry

- The transition from agriculture to agroforestry significantly increased SOC stock by 26%, 40%, and 34% at 0–15, 0–30, and 0–100 cm respectively.
- Switching from uncultivated/other land uses to agroforestry increased SOC by 25% at 0–30 cm. Ref: Soil carbon sequestration in agroforestry systems: a meta-analysis

Reduced Synthetic Fertiliser

- An additional 43–58% increase in C sequestration. Ref: Manure and Mineral Fertiliser Effects on Crop Yield and Soil Carbon Sequestration: A Meta-Analysis and Modelling Across China

Water Conservation

- The results indicated that the average annual increase rate of SOC was 5.43%. Ref: The effect of soil and water conservation measures on soil organic carbon in a typical small watershed in the Mollisol region of Northeast China

B. **Increase in Yield**

No Tillage

- No-till farmers obtained maize yields that were 16% higher than farmers who abandoned no-till and 45% higher than farmers who never used this technology. Ref: Impact of No-Till Technologies in Ghana
- With reduced tillage, the crops in the treatments with organic fertilisers yielded 2–13% more grains. Ref: Effect of organic fertilisers and reduced-tillage on soil properties, crop nitrogen response and crop yield: Results of a 12-year experiment in Changins, Switzerland

Cover Cropping

- Cover crops on average increased yields by 12%. Ref: Cover crops as a tool to reduce reliance on intensive tillage and nitrogen fertilization in conventional arable cropping systems
- 3.1% and 4.3% increase in yield post-cover crop for corn & soybean respectively. Ref: Cover Crops Provide Multiple Benefits, Higher Yields. US Department of Agriculture

Intercropping

- Intercropping appears to give a 16-29% larger yield per unit area than monocultures. Ref: Intercropping Increases Yields While Reducing the Use of Fertilisers. Wageningen University & Research
- Intercropping averagely increases crop yields by 23% on African soil. Ref: A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects

Crop Rotation

- The yield of maize improved by up to 11 % due to crop rotation. Ref: Crop rotation in the summer rainfall area of South Africa.
- A diversified crop rotation improved spring wheat yield by up to 30% in no-tillage and by 13% under ploughing compared with monoculture. Ref: Effects of Crop Rotation on Spring Wheat Yield and Pest Occurrence in Different Tillage Systems: A Multi-Year Experiment in Finnish Growing Conditions

Composting

- In 2018, 2019 and 2020 samplings, the 10% compost soils improved crop yield by 115%, 30% and 61% respectively. Ref: Utilization of Compost as a Soil Amendment to Increase Soil Health and to Improve Crop Yields
- Sorghum yield tripled on the 10 Mg ha-1 compost plots and increased by 45% on the 5 Mg ha-1 compost plots, compared to no-compost plots. Ref: Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa

NOTES

Agroforestry
- Agroforestry cropping systems increased the yield of the major staple crop, maize by nearly 100% under smallholder conditions. Ref: Scaling up Agroforestry to Achieve Food Security and Environmental Protection among Smallholder Farmers in Malawi
- Incorporating agroforestry into climate-smart agriculture interventions, increased maize yields on average, by 20% for participation, and 2% for the intensity of fertiliser trees. Ref: Agroforestry as a pathway to agricultural yield impacts in climate-smart agriculture investments: Evidence from southern Malawi

Integrated Pest Management
- The mean yield increase in yield across crops by 40.9% and Increase in rice yield by 12%.. Ref: Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa
- IPM practices increased yields by 20%, on average. Ref: A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects

Reduced Synthetic Fertiliser
- Synthetic nitrogen fertiliser substitution practices involving chicken manure, pig manure, and crop straw increased crop yields by 4.79, 7.68, and 3.28%, respectively. Ref: Replacing Synthetic Nitrogen Fertiliser with Different Types of Organic Materials Improves Grain Yield in China: A Meta-Analysis
- Comprehensive economic cost-benefit evaluation showed that partial organic substitution increased economic benefit per unit area by 37–46%. Ref: How does partial substitution of chemical fertiliser with organic forms increase sustainability of agricultural production?

Water Conservation
- Drip irrigation significantly increases crop yields by 28.92%, 14.55%, 8.03%, 2.32%, and 5.17% relative to flooding irrigation, border irrigation, furrow irrigation, sprinkler irrigation, and micro-sprinkler irrigation, respectively. Ref: Review on Drip Irrigation: Impact on Crop Yield, Quality, and Water Productivity in China
- During drought conditions, sorghum grain yield and revenue with stone lines and grass bands were over 50% greater than that of the control, by an average of 450 kg ha-1. Ref: Water Conservation Methods and Cropping Systems for Increased Productivity and Economic Resilience in Burkina Faso

C. **Reduction in Fertiliser Requirement**

No Tillage
- No tillage, improved the total Nitrogen accumulation by 11.5% and enhanced N translocation quantity, rate, and contribution by a range of 6.2–23.3%. Ref: No-till and nitrogen fertiliser reduction improve nitrogen translocation and productivity of spring wheat via promotion of plant transpiration

Cover cropping
- Crops grown in fields after legumes can take up at least 30 to 60% of the N that the legume produced. Ref: Sustainable Agriculture Research and Education
- Mean drainage reduction of 27 mm compared to bare soil. Ref: The role of cover crops in improving soil fertility and plant nutritional status in temperate climates. A review

Intercropping
- The increased N use efficiency in intercropping can reduce the requirements for fossil-based fertiliser N by about 26% on a global scale. Ref: Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertiliser N: A global-scale analysis
- Intercropping requires 120 kg-N ha–1, i.e. 33% less fertiliser to produce this conventional yield. Ref: Co-benefits of intercropping as a sustainable farming method for safeguarding both food security and air quality

Crop Rotation
- Using legumes in rotations or intercrops can restore soil nutrients, improve soil carbon and reduce reliance on fertiliser use by 50%. Ref: Can agroforestry option values improve the functioning of drivers of agricultural intensification in Africa?
- In a corn-soybean rotation, total N and dissolved Phosphorous losses in subsurface drainage discharge were reduced by an average of 7% and 14%, respectively. Ref: Effectiveness of Conservation Crop Rotation for Water Pollutant Reduction from Agricultural Areas

Composting
- Biochar plus compost (T6) reduced NH_3 loss via volatilization by 36-37% while compost alone (T5) reduced NH_3 loss by 23%. Ref: Co-application of biochar and compost with decreased N fertiliser reduced annual ammonia emissions in wetland rice

Agroforestry
- Potato poplar and maize poplar system. Ref: Pesticide and Fertiliser Pollution Reduction in Two-Alley Cropping Agroforestry Cultivating Systems
- Agroforestry systems reduced nutrient losses by 50%. Ref: Reductions in water, soil and nutrient losses and pesticide pollution in agroforestry practices: a review of evidence and processes

Integrated Pest Management
- Insecticide use can be dramatically reduced (by 95%). Ref: IPM reduces insecticide applications by 95% while maintaining or enhancing crop yields through wild pollinator conservation
- Most farmers in the IPM treatment groups reported a decrease in chemical use from 29% to 35%. Ref: Impact of integrated pest management in rice and maize in the Greater Mekong Subregion

Reduced Synthetic Fertiliser
- The use of nitrogen fertiliser may be reduced by 3 to 32%, via increased manure recycling from 30% in 2015 to 34 to 70% in 2050, depending on fertilisation measures and cropping systems. Ref: Replacing synthetic fertiliser with manure requires adjusted technology and incentives: A farm survey across China

NOTES

- N leaching was reduced by 44.6% and soil organic carbon (SOC) concentration increased by 12.5% compared to synthetic N fertiliser alone. Ref: Combined applications of organic and synthetic nitrogen fertilisers for improving crop yield and reducing reactive nitrogen losses from China's vegetable systems: A meta-analysis

Water Conservation

- Fertigation can save about 20–40% of fertiliser. Ref: EFFICIENT USE OF WATER AND FERTILISERS IN IRRIGATED AGRICULTURE: DRIP IRRIGATION AND FERTIGATION
- Nitrogen applied through the nutrient solution was 75% lower in subirrigation phosphorus, potassium, calcium and magnesium applied were 66%, 59%, 70% and 74% lower, respectively. Ref: Water and Fertiliser Use Efficiency in Subirrigated Containerised Tomato

D. **Reduction in Water Requirement**

No Tillage

- Enhanced 16-25% efficiency of this practice in soil water storage with zero tillage. Ref: Conservation tillage and water availability for wheat in the dryland of central Chile
- No tillage reduced runoff by 21.9% and 27.2% compared to reduced tillage and conventional moldboard plough respectively. Ref: No-tillage controls on runoff: A meta-analysis

Cover Cropping

- Retain soil water by 1-4% and increase in water use efficiency by 10%. Ref: Cover cropping impacts on soil water and carbon in dryland cropping system
- Rye cover crop reduced drainage by 12%. Rye cover crop effects on maize: A system-level analysis

Intercropping

- Increased crop water productivity by 45–67%. Ref: Intercropping Optimizes Soil Temperature and Increases Crop Water Productivity and Radiation Use Efficiency of Rainfed Potato
- Enhanced water use efficiency by 24%. Ref: Enhancing the system's productivity and water use efficiency through coordinated soil water sharing and compensation in strip-intercropping

Crop Rotation

- Mitigates groundwater decline by 19% or more. Ref: Diversified crop rotations enhance groundwater and economic sustainability of food production
- Reducing cropping density (harvests per year) from 2 to 1.5 decreased the average annual water requirement and irrigation demand by 14 % and 33 %, respectively. Ref: Diversified crop rotations reduce groundwater use and enhance system resilience

Composting

- Mulching can reduce the irrigation requirements of plants by up to 70%. Ref: Conserving water using compost
- Composted cattle manure applied to the soils showed a positive effect, improving infiltration and decreasing runoff volumes by up to 20%. Ref: A review of the impact of compost on soil properties, water use and crop productivity

Agroforestry

- Crop water consumption be reduced by 15% to 30% lower inside tree windbreaks compared to open field conditions. Ref: Water productivity of tree windbreak agroforestry systems in irrigated agriculture – An example from Ferghana Valley, Kyrgyzstan
- Agroforestry systems reduced surface runoff, soil, organic carbon, and related nutrient losses by 58%. Ref: Reductions in water, soil and nutrient losses and pesticide pollution in agroforestry practices: a review of evidence and processes

Reduced Synthetic Fertiliser

- Reduced synthetic fertiliser treatment had 37.89% and 52.49% lower soil water storage deficit degree. Ref: Effects of partial organic fertiliser replacement combined with rainwater collection system on soil water, nitrate-nitrogen and apple yield of rainfed apple orchard in the Loess Plateau of China: A 3-year field experiment

Water Conservation

- 32% groundwater savings through water productivity improvements and another study showed that water productivity can reduce total water consumption by 53%. Ref: Reducing water scarcity by improving water productivity in the United States

Chapter 3

A. **Drip Irrigation**

- Drip-irrigation study sees 37% reduction in water use and five percent increase in yield
- New design cuts costs, and energy needs for drip irrigation, bringing the systems within reach for more farmers.
- Review on Drip Irrigation: Impact on Crop Yield, Quality, and Water Productivity in China
- Fertigation to recover nitrate-polluted aquifer and improve a long-time eutrophicated lake, Spain

B. **Microsprinklers**

- The water-saving potential of using micro-sprinkling irrigation for winter wheat production on the North China Plain
- Performance of Groundnut (Arachis hypogaea L) Under Drip and Micro Sprinkler Fertigation System
- Solar-Dripper.com DRIP IRRIGATION EFFICIENCY AND WATER SAVING
- Measurements of evaporation during sprinkler irrigation

C. **Smart Irrigation Sensors**

- European Commission. Smart irrigation reduces water wastage
- Evaluating the Use of Intelligent Irrigation Systems Based on the IoT in Grain Corn Irrigation
- More Crop Per Drop: Saving the World through Smart Irrigation

NOTES

D. **Cover crop and Mulching**
- US Department of Agriculture. Cover Crops Reduce Crop Loss During Drought
- Cover crops can increase soil moisture by as much as 10%
- Impact of cover crop on corn-soybean productivity and soil water dynamics under different seasonal rainfall patterns
- Cover cropping reduces the negative effect of salinity on soil microbiomes

E. **Half-Moon / Semi-circular Bunds**
- Soil and water conservation management on hill slopes in Southwest Ethiopia. I. Effects of soil bunds on surface runoff, erosion and loss of nutrients
- Nutrient management and water use efficiency for sustainable production of rain-fed crops in the World's dry areas

Chapter 4

A. **Land Policy**
- Tanzania Investment Center
- USAID: Land Tenure Profile of Burundi
- Federal Democratic Republic of Ethiopia Rural Land Administration and Land Use Proclamation
- APPROACHES TO RURAL LAND DISPUTE RESOLUTION MECHANISMS IN THE ETHIOPIAN RURAL LAND LEGISLATIONS: REGIONAL STATES BASED ANALYSIS
- Malawi Land Act (Amendment Act 2022)
- Malawi National Land Policy 2002
- Malawi Investment and Export Promotion Act, 2012
- Mozambique Ministry of Land and Environment
- Government Portal of Mozambique
- Organic Law determining the use and management of land in Rwanda
- Rwanda National Land Policy 2019
- Rwanda Ministry of Environment
- FAO, Uganda Registration of Titles Act
- Uganda Investment Code Act, 2019
- Zambia Lands Act
- Zambia Land and Deeds Registry Act
- Zambia Town and Country Planning Act
- Primary interviews conducted with government representatives and other relevant stakeholders

B. **Investment and Trading Policy**
- Kenya Crops Act, 2013
- Kenya Agriculture and Food Authority Act, 2013
- Kenya Pest Control Products Act
- Tanzania Plant Protection Regulations, 1998
- Tanzania Seeds Act, 2003
- World Bank Group. Creating Markets in Burundi
- Eduardo C. M., Nienke M. B, and Léonidas N. AGRICULTURAL SCIENCE AND TECHNOLOGY INDICATORS Burundi
- Ethiopian Investment Commission
- FAO. Ethiopian Seed Law Proclamation
- Malawi National Agricultural Investment Plan
- Malawi National Export Strategy II
- Mozambique Ministry of Agriculture and Rural Development
- MOZAMBIQUE NATIONAL AGRICULTURAL INVESTMENT PLAN
- Rwanda Ministry of Agriculture and Animal Resources
- Rwanda Development Board
- Uganda Ministry of Agriculture, Animal Industry and Fisheries
- Uganda Government Citizen Interaction Centre. UIA’s Incentives for Domestic and Foreign Investors
- Uganda Investment Center
- Primary interviews conducted with government representatives and other relevant stakeholders

C. **Water and Energy Policy**
- Burundi Water Code
- FAOLEX Database
- Ethiopia Ministry of Water and Energy
- Malawi Draft Environmental and Social Management Framework
- Pranab B, Brendan C. Mozambique Off-grid solar power in Mozambique: opportunities for universal energy access and barriers to private sector participation
- Rwanda Water Resources Board
- Tanzania Water Resources Management Act, 2009
- Uganda Ministry of Water and Environment
- Uganda Electricity Regulatory Authority
- Zambia Water Act
- Zambia Water Resources Management Act, 2011
- Zambia Energy Regulation Board
- SmartSolar Zambia
- Primary interviews conducted with government representatives and other relevant stakeholders

REFERENCES

1. FAO, Hand-in-Hand Geospatial platform. 2024, FAO.
2. Polaris Market Research (2022). Regenerative Agriculture Market Share, Size, Trends, Industry Analysis Report, By Practice (Holistic Planned Grazing, Agroforestry, Pasture Cropping, Agroecology, Aquaculture, Silvopasture, Others); By Application; By Region; Segment Forecast, 2022 - 2030. New York Ciry, NY, USA, Polaris Market Research: 119.
3. Karas, S. (2013). "Could Regenerative Agriculture Increase the Nutritional Quality of Our Food?" Center for Regenerative Agriculture and Resilient Systems, California State University. Could Regenerative Agriculture Increase the Nutritional Quality of Our Food? Accessed 01/24/2024.
4. Regenerative Farmers of America (2011). "Can Regenerative Agriculture Improve the Nutritional Content of Food."Regenerative Farmers of America. Can Regenerative Agriculture Improve the Nutritional Content of Food? Accessed 01/24/2023.
5. THE IMPACT OF IRRIGATED AGRICULTURE ON A STABLE FOOD SUPPLY. M.F. Dowgert, Netafim
6. University College London (2021). "Intensive agriculture could drive loss of bees and other tropical pollinators." University College London. Intensive agriculture could drive loss of bees and other tropical pollinators Accessed 01/24/2024.
7. The Conscious Challenge (2019). "Agriculture & Soil Degradation." The conscious challenge. Agriculture and Soil degradation (2019) Accessed 01/24/2024.
8. Petry, D., S. Avanzini, A. Vidal, F. Bellino, J. Bugas, H. Conant, S. Hoo, S. Unnikrishnan and M. Westerlund (2023). Cultivating farmer prosperity: Investing in Regenerative Agriculture. Boston, MA, Boston Consulting Group.
9. Snel, H., Y. Saavedra and I. Koomen (2018). Hotspot Analysis on Food Loss and Waste in African Agriculture. Wageningen University, Wageningen Centre for Development Innovation.
10. Goodwin, L. (2023). "The Global Benefits of Reducing Food Loss and Waste, and How to Do It." World Resource institute (2023). The Global Benefits of Reducing Food Loss and Waste, and How to Do It Accessed 01/20/2024.
11. Driven To Waste: The Global Impact of Food Loss and Waste on Farms, 2021 World Wildlife Fund
12. Christopher, J. (2022). Tanzania on right track in tackling post-harvest losses. The Citizen, Centre for Coordination of Agricultural Research and Development for Southern Africa .
13. Musyoka, C. (2020). Improve post-harvest practices for food security, Mount Kenya University.
14. Debebe, S. (2022). "Post-harvest losses of crops and its determinants in Ethiopia: tobit model analysis." Agriculture & food security 11(1): 1-8.
15. Ariong, R. M., D. M. Okello, M. H. Otim and P. Paparu (2023). "The cost of inadequate postharvest management of pulse grain: Farmer losses due to handling and storage practices in Uganda." Agriculture & Food Security 12(1): 20.
16. World Bank (2020). Rwanda: Food Smart Country Diagnostic. Washington, DC., World Bank.
17. Helvetas Mozambique (2018). Helvetas and WFP promote “Zero Post-Harvest Loss”, Helvetas Mozambique.
18. United Nations House (2022). "From Food Loss To Food Gain." United Nations Zambia (2022). From Food Loss To Food Gain Accessed 01/24/2024.
19. Kate Ambler, Alan de Brauw, Susan Godlonton (2017). “Measuring postharvest losses at the farm level in Malawi”.
20. Krishna, V. V. and M. Mkondiwa (2023). "Economics of crop residue management." Annual Review of Resource Economics 15: 19-39.
21. Rotta, N. M., S. Curry, J. Han, R. Reconco, E. Spang, W. Ristenpart and I. R. Donis-González (2021). "A comprehensive analysis of operations and mass flows in postharvest processing of washed coffee." Resources, Conservation and Recycling 170: 105554.
22. Schuit, P. and S. Macatonia (2023). "Why Regenerative Agriculture is Necessary for the Future of Coffee Production." Union Roasted (2023). Why Regenerative Agriculture is Necessary for the Future of Coffee Production Accessed 01/24/2024.
23. Coffee Farmers. Fairtrade Foundation
24. TechnoServe. Cashew Shells: from Waste to Energy & Profit -TechnoServe (2022). "Turning Waste into Profit." https://www.technoserve.org/blog/turning-waste-products-into-profit/ Accessed 01/24/2024.
25. Souza, K. O., A. G. Silveira, M. M. Lopes, C. F. Moura, E. O. Silva, J. F. Ayala-Zavala, L. S. Soares and M. R. A. Miranda (2019). "AVG and GA3 prevent preharvest fruit drop and enhance postharvest quality of'BRS 189'cashew." Scientia Horticulturae 257: 108771.
26. Nguyen, T. (2023). "Coffee farmers embrace regenerative agri-practices for better incomes: Nestle." The Investor Vafle Magazine (2023). Coffee farmers embrace regenerative agri-practices for better incomes: Nestle Accessed 01/24/2024.
27. M. Adzanyo, J. Fitzpatrick, S.P. Rowel, K. Weyori. 2019. Guidebook on the Cashew Processing Process.
28. Otieno, H. M., B. A. Alwenge and O. O. Okumu (2019). "Coffee production challenges and opportunities in Tanzania: the case study of coffee farmers in Iwindi, Msia and Lwati Villages in Mbeya Region." Asian Journal of Agricultural and Horticultural Research 3(2): 1-14.
29. Igbinadolor, R., L. Yahaya, C. Jayeola and S. Adeleke (2017). "Addressing the post-harvest wastages and under-utilization of cashew apple in Nigeria: A review." The International Journal of Science & Technoledge5(7): 1-4.
30. Lucia, A. and G. Garry (2017). "The cashew value chain in Mozambique: analysis of performance and suggestions for improvement." International Journal on Food System Dynamics 8(3): 208-221.
31. Brito de Figueirêdo, M.C., et al., Environmental assessment of tropical perennial crops: the case of the Brazilian cashew. Journal of Cleaner Production, 2016. 112: p. 131-140.
32. Murphy, M. and T. Dowding, The coffee bean: A value chain and sustainability initiatives analysis. University of Connecticut, Stamford CT USA, 2017.
33. (2021). International Scientific Conference "Biologization of the Intensification Processes in Horticulture and Viticulture" BIOLOGIZATION 2021, Krasnodar, Russia, EDP Sciences.
34. C. Kourmentza a, Ch.N. Economou b, P. Tsafrakidou b, M. Kornaros b. (2018). Spent coffee grounds make much more than waste: Exploring recent advances and future exploitation strategies for the valorization of an emerging food waste stream.
35. Joint FAO/IAEA Program, Agricultural water management, I.A.E. Agency, Editor. 2023.

REFERENCE

36.Water Scarcity. World Wildlife Fund
37.Brouwer, C., A. Goffeau, and M. Heibloem, Rainfall and Evapotranspiration, in Irrigation Water Management: Training Manual No. 1 - Introduction to Irrigation. 1985, FAO.
38.Wikifarmer. Maize Water Requirements and Irrigation Systems
39.Tiwari, K. N. and N. S. Raghuwanshi (2023). Border Irrigation System. Irrigation Engineering.
40.Kuchta, D. M. (2022). "Furrow Irrigation: How It Works and 4 Ways to Improve This Technique." Treehugger.com. Furrow Irrigation: How It Works and 4 Ways to Improve This Technique Accessed 01/24/2024.
41.Samiha, O., E. Kasem, A. E.-H. Zouhry and S. Abdel-Wahab (2020). "Sustainable intensive cropping to reduce irrigation-induced erosion: Changing cropping sequence under sprinkler irrigation practice." Moroccan Journal of Agricultural Sciences 1(1).
42.Olagunju, K. O., K. A. Olagunju, A. I. Ogunniyi, A. O. Omotayo and Z. Oyetunde-Usman (2023). "To own or not to own? Land tenure security and production risk in small-scale farming." Land Use Policy 127: 106584.
43. Omusula, C. and P. Wanjama, Kenya's Digitization of Land Records Enhances its Capacity to Monitor and Report Progress on National, Regional and Global Development Commitments. 2022.
44. NIRAS, Land registration: the foundation of sustainable development in Ethiopia. 2023, NIRAS.
45. Evidence on Demand, Climate and Environment Infrastructure. Rwanda Land Tenure Regularisation Case Study
46. African Development Bank Group, Technologies for African Agricultural Transformation (TAAT). 2024, African Development Bank Group.
47.Ministry of Agriculture, L., Fisheries and Cooperatives,, Food: Our Health, Wealth and Security, L. Ministry of Agriculture, Fisheries and Cooperatives, Editor. 2021, Republic of Kenya.
48.FAO and FAOLEX, Zambia National Agricultural Policy 2012-2030, M.o.A.a.C.-O. Zambia, Editor. 2011: UNEP-LEAP.
49.G. Gabiri, K. C. Luswata, E. Sebuliba, J. Nampijja. Accelerating Impacts of CGIAR Climate Research for Africa, 2022. Climate-Smart Agriculture in Uganda.
50.Power for all, Powering Agriculture With Renewable Energy: A Just Transition for Food Systems, P.f. All, Editor. 2023.
51.KOSAP, Component 3: Stand-Alone Systems and Solar Water Pumps for Community Facilities, in KOSAP Project Components. KOSKenya Off-Grid Solar Access Project.
52.GEAPP, DREAM Initiative Builds First Solar Mini-grid Powered Large Scale Irrigation System to Power Agriculture in Africa. 2022, Global Energy Alliance for People and Planet.
53.Land Degradation and Climate Change in Africa. Africa Group of Negotiators Expert Support (2020).

LEGAL DISCLAIMER

The information provided in this document is for general informational purposes only. All information in the document is provided in good faith, however, Amaly makes no representation or warranty of any kind, express or implied, regarding the accuracy, adequacy, validity, reliability, availability, or completeness of any information in this document.

By reading this document, you agree that the use of any information from this document is at your own risk. You further agree that Amaly, including its subsidiaries, affiliates, partners, directors, employees, or agents, shall not be liable for any direct, indirect, incidental, consequential, or punitive damages or any loss of profits or revenues, whether incurred directly or indirectly, or any loss of data, use, goodwill, or other intangible losses, resulting from (1) your access to or use of or inability to access or use the information in this document; (2) any conduct or content of any third party on this document; (3) any information obtained from this document; and (4) unauthorised access, use, or alteration of your transmissions or content, whether based on warranty, contract, tort (including negligence), or any other legal theory, whether or not we have been informed of the possibility of such damage.

You are advised to consult with an appropriate professional before making any decisions based on the information provided in this document. Nothing contained in this document shall be construed as providing consultation or advice.

The information in this document is provided "as is," with no guarantee of completeness, accuracy, timeliness, or of the results obtained from the use of this information, and without warranty of any kind, express or implied, including, but not limited to warranties of performance, merchantability, and fitness for a particular purpose.

In no event will Amaly, its related partnerships or corporations, or the partners, agents, or employees thereof be liable to you or anyone else for any decision made or action taken in reliance on the information in this document or for any consequential, special, or similar damages, even if advised of the possibility of such damages.

This document does not constitute investment advice, financial advice, trading advice, or any other sort of advice and you should not treat any of the document's content as such. Amaly does not recommend that any securities, assets, or tokens be bought, sold, or held by you. Do conduct own due diligence and consult expert financial advisor before making any investment decisions.

bridge between funders hopes and an impactful legacy

Amaly Legacy Research Fellows

We are grateful for the valuable contribution of Amaly legacy fellows who devoted their valuable time to support our research efforts. Our fellows come from diverse professions and walks of life which enriched our perspectives on the topics discussed in this report

ALYA HEGAZY
Fellow | Regen Ag
Amaly Legacy

ASMA ALABED
Fellow | Regen Ag
Amaly Legacy

DOREEN OMITTO
Fellow | Regen Ag
Amaly Legacy

MARTHA JEPKIRUI
Fellow | Regen Ag
Amaly Legacy

MAURICE NJOROGE
Fellow | Regen Ag
Amaly Legacy

MOHAMMAD NAFIL
Fellow | Regen Ag
Amaly Legacy

ELIZABETH OBODE
Fellow | Regen Ag
Amaly Legacy

PAMELA TANNOUSS
Fellow| Regen Ag
Amaly Legacy

WAHU GATHU
Fellow| Regen Ag
Amaly Legacy

Authors of the Report

DR. CHARLES MORTON
Partner | Regen Ag
Amaly Regen Ag Studio

DR. HECTOR HERNANDEZ
Partner | Regen Ag
Amaly Regen Ag Studio

HEMANGI SARMA
Strategy Lead | Regen Ag
Amaly Asset Management

WAHID A KAMALIAN
Partner | Regen Ag
Amaly Asset Management

2024

With valuable contributions from

info@amalylegacy.com
podcast.amalylegacy.com
linkedin.com/company/amalylegacy
instagram.com/amaly.legacy