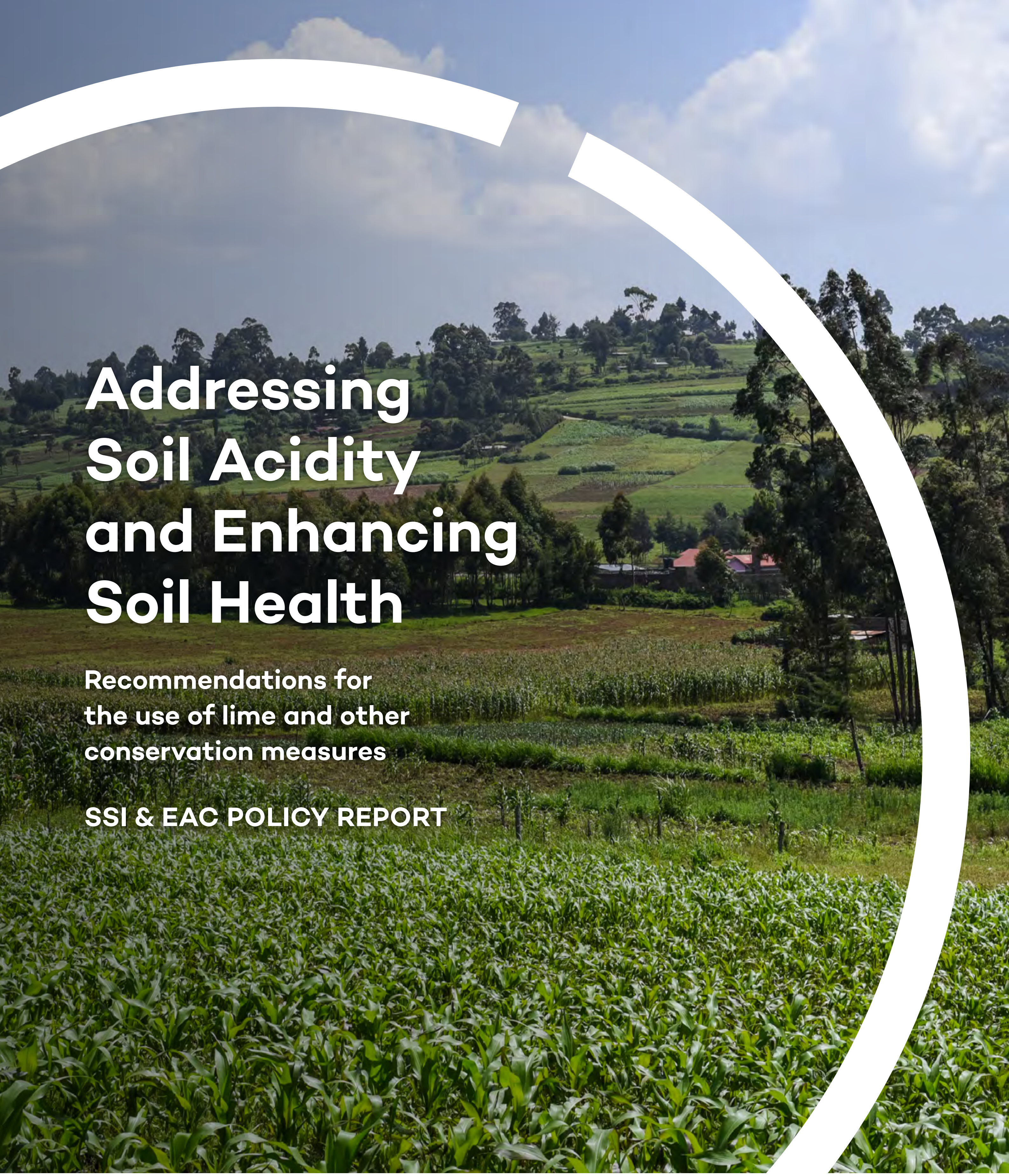

Addressing Soil Acidity and Enhancing Soil Health

Recommendations for the use of lime and other conservation measures

SSI & EAC POLICY REPORT

IISD International Institute for Sustainable Development

SSI State of Sustainability Initiatives

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The work of the EAC is guided by the Treaty, which established the Community. The Treaty was signed on 30 November 1999 and entered into force on 7 July 2000.

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As one of the fastest growing regional economic blocs in the world, the vision of EAC is to be a prosperous, competitive, secure, stable and politically united East Africa, and the mission of the Community is to widen and deepen economic, political, social and cultural integration in order to improve the quality of life of the people of East Africa through increased competitiveness, value added production, trade and investments.

Addressing Soil Acidity and Enhancing Soil Health: Recommendations for the use of lime and other conservation measures

October 2024

Written by Erika Luna and Cristina Larrea

Photo: iStock

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Executive Summary

This policy report addresses the critical issue of soil acidity in the East African Community (EAC). It provides actionable recommendations for EAC partner states, the EAC Secretariat, and other relevant stakeholders.

Key findings highlight that the application of agricultural lime, when paired with broader soil conservation measures, such as those embedded into integrated soil fertility management, has the potential to tackle soil acidity and increase soil health. To effectively reach farmers in high-priority areas, a holistic and short-term approach is proposed in this document, laying the groundwork for future scaling of interventions.

Coordination among stakeholders is crucial, especially those involved in the lime value chain. Collaborative efforts between various actors will enhance resource utilization and support the widespread adoption of sustainable soil management practices. Furthermore, the private sector plays a vital role in establishing robust lime value chains.

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1.0 The Issue: Soil acidity

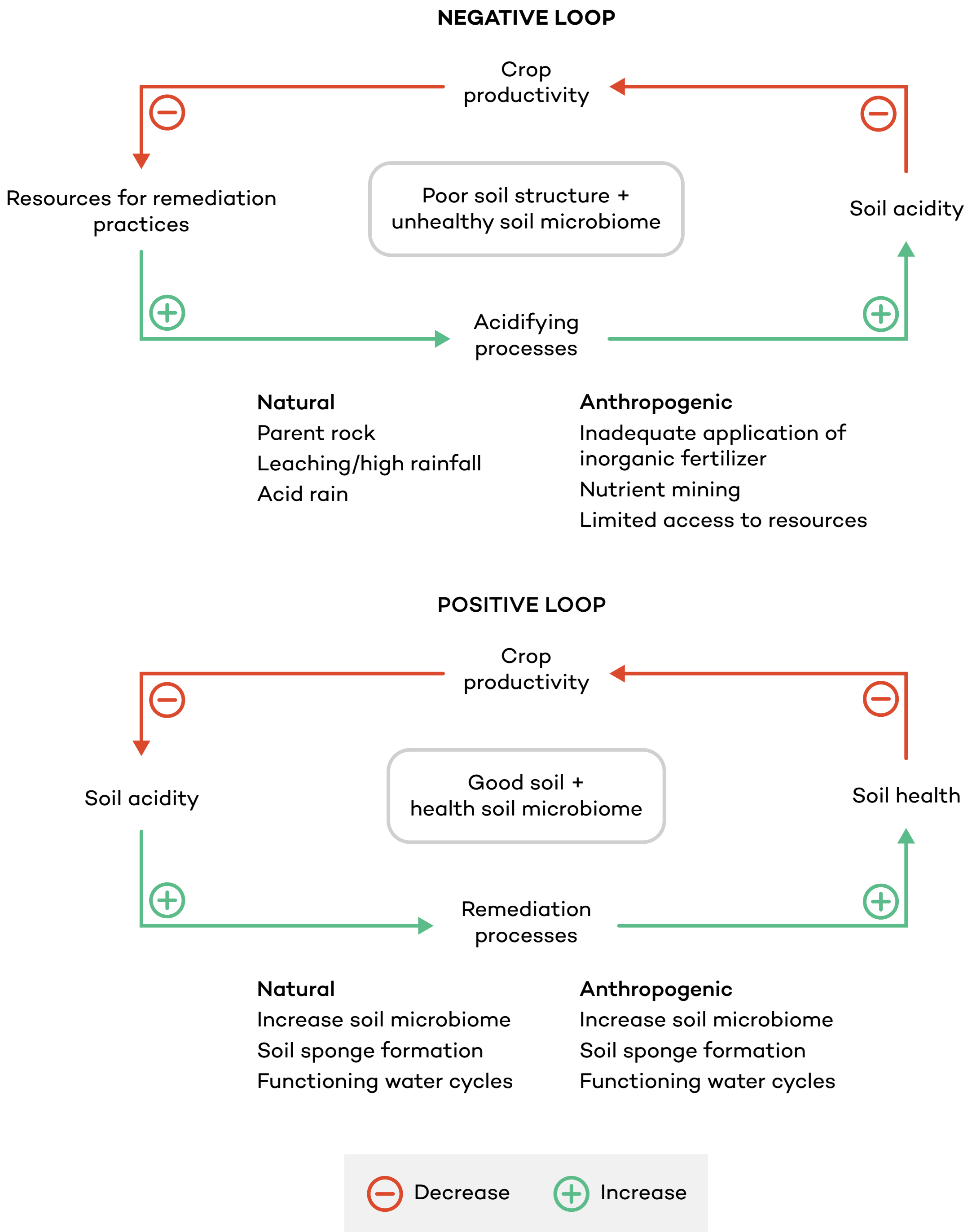
1.1 Soils in East Africa Are Acidic by Nature

The soils found in East Africa have an inherently acidic nature, a characteristic that has significant implications for agricultural practices in the region (Agegnehu et al., 2021). Moreover, recent trends indicate a troubling decline in overall soil health across the area. It is concerning to note that more than 60% (2.3 billion ha) of the arable land in East Africa is now estimated to be degraded (Bationo & Fening, 2018; Zingore & Njoroge, 2022), pointing toward a widespread and alarming deterioration in the quality and productivity of soils. This degradation seriously threatens agricultural sustainability, food security, and producers' livelihoods in the region, underscoring the urgent need for targeted interventions and sustainable land management practices to reverse this trend and restore soil health.

Soil acidity (when pH levels are below 6.5) is both a symptom and a cause of an unhealthy soil system. Acidic soils in East Africa are caused by a variety of interconnected factors, each contributing to the overall decline in soil pH levels and fertility. Figure 1 illustrates the negative and positive feedback loops in which soil acidity is embedded. As seen on the left side of the diagram, acidifying processes (both natural and anthropogenic) can lead to reduced crop productivity, which in turn makes resources (such as financial) less available to farmers to tackle the acidification. On the other hand, a positive feedback loop is one where remediation practices (natural and anthropogenic) result in less acidity, improved productivity, and better overall soil health.

Representatives of EAC partners states and IISD experts after completing signature of workshop report.

Figure 1. Feedback loops of soil acidity



Source: Authors' elaboration.

1.2 Causes of Soil Acidity in East Africa

Several factors cause soil acidity in East Africa. They include the following:

- **increase in intensive crop production systems**. The heightened demand for food in both local and international markets due to increased population, among other aspects, often leads farmers to intensify agricultural practices that can degrade soil quality over time (Agegnehu et al., 2021; Giller et al., 2021). One of those practices is the insufficient replenishment of organic and inorganic nutrients. As farmers step up their agricultural practices to boost yields, there is often a lack of adequate replenishment of essential nutrients to the soil. This imbalance leads to nutrient depletion and can contribute to soil acidification (Esilaba et al., 2023). Furthermore, continuous cultivation of the same crops (monocropping) without proper crop rotation or fallow periods can deplete soil nutrients and organic matter, leading to soil acidification (Aleminew & Alemayehu, 2020). In addition, without adequate rest periods or soil management practices that can replenish nutrients and organic matter, continuous cultivation can lead to soil exhaustion and acidification.
- **inadequate and high fertilizer use**. For healthy soil, it is imperative to maintain a positive nutrient balance by replacing nutrients that are lost during cropping seasons. This can be achieved by applying chemical fertilizers. However, overapplying fertilizers, especially those high in nitrogen, can increase acidification.
- **low application of organic matter**. Organic matter plays a crucial role in maintaining soil pH balance and fertility (Zingore & Njoroge, 2022). Sub-Saharan Africa is characterized by extremely low levels of organic matter, which is not only related to the low application of organic matter by farmers but also by the predominance of coarse-textured soils (Zdruli & Zucca 2023). Continuous cultivation exacerbates this condition
- **complete removal of crop residues**. Removing crop residues deprives the soil of essential organic matter and nutrients. Crop residues and manure are essential, especially in smallholder farming systems that rely on organic residues to maintain soil fertility. In East Africa, the removal and burning of crop residues have resulted in soil deterioration, reducing productivity as well (Baudron et al., 2014). Leaving crop residues on the soil can contribute to productivity by boosting other fertilizers' efficiency (Bationo & Fening, 2018).
- **limited access to soil amendments**. Many farmers in East Africa may have limited access (due to lack of availability and/or high costs) to soil amendments such as lime or other materials that can help to neutralize soil acidity and improve soil health.
- **lack of information and enabling policy**. Limited data, information, and awareness on soil acidity's extent, severity, and impacts, and lack of an enabling policy environment and instruments to address it.

1.3 Consequences of Soil Acidity

Some of the symptoms and consequences of soil acidity observed in East Africa are outlined below.

- **soil toxicity**. In highly acidic soils, certain elements, such as aluminum and manganese, become more soluble and can reach toxic levels for plants. These toxic concentrations adversely affect root growth, nutrient uptake, and overall plant health.
- **low microbial activity**. Acidic soils create unfavourable conditions for beneficial soil microorganisms, such as bacteria, fungi, and earthworms. These microorganisms play critical roles in nutrient cycling, organic matter decomposition, and soil structure improvement. Reduced microbial activity in acidic soils diminishes their capacity to perform these vital functions.
- **low soil buffering capacity**. Soil buffering capacity refers to soil's ability to resist changes in pH when acidic or alkaline substances are added. Acidic soils typically have a low buffering capacity, meaning they are more susceptible to pH fluctuations. This makes it challenging to maintain optimal soil pH levels for plant growth.
- **reduced nutrient use efficiency**. Soil acidity affects the mobilization and bioavailability of nutrients such as nitrogen (N), phosphorus (P), and sulfur (S), and basic cations, which has both environmental and economic implications, not only at farm level but national scales.
- **limited plant growth and crop yield**. The combined effects of nutrient deficiencies, soil toxicity, reduced microbial activity, and low buffering capacity hinder plant growth and development, ultimately limiting crop yields. Plants struggle to establish healthy root systems and efficiently absorb water and nutrients from the soil, resulting in stunted growth, poor crop quality, and decreased yields.
- **economic implications for farmers**. Soil acidity directly impacts farmers' livelihoods. Lower yields translate to reduced profits and economic losses for farmers, especially in regions where agriculture serves as the primary source of income. Additionally, addressing soil acidity through soil amendments and corrective measures entails additional costs for farmers, further affecting their economic viability.

The factors contributing to the gradual acidification of soils in East Africa and their consequences pose major challenges to agricultural sustainability, food security, producers' livelihoods, and the region's economy. Addressing these issues requires holistic approaches that focus on sustainable soil management practices, including the use of lime as a key entry point.

2.0 Methodology

We have used a qualitative research methodology to develop the priorities and recommendations presented in this policy report. First, we conducted an extensive review of existing and recent literature (>2018) related to how soil acidity has been addressed in East Africa and adjacent regions. This literature review encompassed peer-reviewed academic articles, reports, policy documents, and other relevant sources to gather comprehensive background information. Countries included in this literature review are Kenya, Rwanda, Ethiopia, Tanzania, Nigeria, and Cameroon.

Second, we conducted interviews with key stakeholders, including development partners, to gather firsthand information and insights related to the evolution of the use of lime and other soil conservation measures in the region. Conversations were held from November 2023 to January 2024 with partner organizations that have extensive experience with in-country work addressing this issue.

- Fahari Marwa, Head of Agriculture and Food Security Department at the East African Community (EAC)
- João Vasco Silva, Agronomy-at-Scale Data Scientist, Sustainable Agrifood Systems, Guiding Acid Soil Management Investments in Africa (GAIA) Project at the International Maize and Wheat Improvement Center (CIMMYT)
- Steffen Schulz, Project Manager, Integrated Soil Fertility Management Project at Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Asseta Diallo, Senior Program Officer, Soil Fertility and Fertilizer Systems at the Alliance for a Green Revolution in Africa (AGRA)
- James Ellison, Agricultural Innovations Lead at One Acre Fund

After collecting the data from the literature review and interviews, we analyzed the information to develop six strategic priorities and supporting actions with practical short-term and long-term components to address soil acidity in the EAC. The proposed approach was shared again for feedback from some of the stakeholders mentioned above—specifically, Fahari Marwa and Steffen Schulz, for which we are very thankful.

Finally, the draft of this document was shared with policy officials from EAC partner states at a workshop held in collaboration with the EAC Secretariat in Nairobi from May 21 to 22, 2024. The objective of the workshop was to discuss the strategies presented in this document to address soil acidity in the region and others that partner states have implemented. The workshop also aimed to discuss and define next steps for policy-makers in developing an approach to tackle soil acidity at national and regional levels. The input from delegates was later integrated into this final document.

3.0 Addressing Soil Acidity From a Holistic Soil Health Perspective

As explained in the introductory section of this policy report, soil acidity is a multilayered issue that does not have a one-size-fits-all solution. Tackling soil acidity requires a holistic set of solutions that are tailored to local social and environmental contexts. Moreover, soil acidity is, in the end, a symptom of an unhealthy soil system, and therefore, the solutions should not be narrowly focused on acidity but be geared toward improving soil health.

Healthy soil is the foundation of sustainable agriculture (International Crops Research Institute for the Semi-Arid Tropics, 2024). Healthy soils support crop productivity, preserve water quality, safeguard human and environmental health, and mitigate climate change.

This holistic soil health perspective has also been increasingly incorporated into international, regional, and national initiatives that call for the sustainability of African food systems. At the recent Africa Fertilizer & Soil Health Summit celebrated in Nairobi on May 2024, the Heads of State and Government of the African Union committed to "reverse land degradation and restore soil health on at least 30% of degraded soil by 2034" (African Union, 2024). Some of the actions to achieve this 10-year goal include the following: repurposing subsidy programs to encourage smallholder farmers to invest in soil health; promoting conservation and management of natural resources for increasing climate change resilience; strengthening research and extension systems; and promoting organic agriculture (African Union, 2024).

At the national level, the EAC partner states are continuously working toward creating a conducive policy environment to promote soil health. For instance, the Ministry of Agriculture and Livestock Development in Kenya launched in 2023 the Agricultural Soil Management Policy; its core objective is to tackle declining soil fertility from a comprehensive approach to soil health and sustainable agricultural practices (Business News Zambia Newspaper, 2024). Similarly, in Rwanda, the government launched the National Agricultural Policy in 2018, which promotes sustainable agricultural practices like agroforestry and supports the increasing use of organic fertilizer as part of integrated soil fertility management (ISFM) practices in conjunction with a gradual phase-out of fertilizer supply that contributes to soil acidification.

The formulation of supporting policies like the ones mentioned above and political will are crucial to creating an enabling environment for the six strategic priorities discussed below. All strategic priorities, although explained separately, are highly interconnected. We acknowledge that some countries in the region have already advanced in implementing some of them, but these strategic priorities can be a baseline toward a more healthy and sustainable production system.

In the following section, we elaborate on the six strategic priorities that we identified to be crucial in addressing soil acidity as part of a holistic approach to recovering and maintain soil health.

4.0 Strategic Priorities to Address Soil Acidity in the EAC: A focus on high-priority areas

Based on the information collected and analyzed by IISD, we present to the EAC six strategic priorities and one supporting action that can help address soil acidity in the short term. It also considers long-term actions that can contribute to overall regional needs in terms of boosting agricultural productivity and climate resilience. The six strategic priorities are as follows:

- define high-priority areas (HPAs)
- scale up soil testing services
- demonstrate lime application and ISFM
- increase the awareness of farmers and other actors
- develop the lime value chain
- supporting actions

The objective of these initial and short-term strategies is to target HPAs. We consider that prioritizing areas based on a few characteristics (explained below) can catalyze the demand and supply of lime in conjunction with the adoption of soil conservation practices.

In HPAs, farmers will have access to knowledge, capacity building, and agricultural inputs that tackle soil acidification. This initial approach will also help develop the value chain of lime and other agricultural inputs. In consequence, agro-dealers and lime crushers also need to play an active role in effectively distributing the agricultural inputs that can amend soil acidity. The purpose of developing these positive offer–demand cycles in HPAs is that they will eventually reduce the costs of using lime, especially in transportation. In other words, inputs like lime will be far more available and affordable. These positive offer–demand cycles can help boost the role of private sectors in investing in the lime value chain.

The second reason to address soil acidity in HPAs is to enhance stakeholder coordination to ensure the positive cycle develops. Stakeholders—from farmers and current extension agents to government officials, lime value chain actors, and development partners—can all connect and collaborate in HPAs. With enhanced coordination that guarantees a continuous supply and demand of lime, each HPA could reach and benefit a tangible number of farmers within the radius.

After this initial set of strategies has been implemented in the HPAs, the approach can be scaled up to reach regions that were not initially categorized as HPAs.

Figure 2. Proposed key strategies to address soil acidity in the EAC: A focus on HPAs[1]

Source: Authors' elaboration.

4.1 Define HPAs

What?

The first and most important step is to define HPAs, where treating soil acidity is an urgent matter. But soil acidity is not the only factor to consider in identifying these areas. HPAs are defined by the intersection of different factors, including

- **soil characteristics**: Data on current soil characteristics can help define the degree of soil acidity. While pH is an important indicator, to fully assess the acidity level of the soil, we should also consider collecting data on aluminum toxicity and exchangeable acidity. HPAs will, therefore, be those regions where $pH < 6.5$.
- **crop productivity and type of crop**: Although a region might be facing high levels of soil acidity, the definition of the HPA should consider the current productivity of their crops to assess the degree to which acidity impacts yields. It should also consider the crops that respond positively to lime based on existing data.
- **input availability and distribution capacity**: To address soil acidity as soon as possible and at a low cost, HPAs should ideally have systems in place to provide access to lime and other agricultural inputs, such as organic and inorganic fertilizers. For instance, such systems may include transportation infrastructure and an adequate network of agro-dealers to deliver inputs to farmers.
- **extension service systems in place**: The definition of HPAs should also consider the availability of agricultural extension services that could showcase how to implement soil conservation practices and the use of lime to address soil acidity. Depending on each country's availability of extension services, these could be leveraged or expanded to accommodate additional interventions related to soil acidity management. In doing so, governments can collaborate and seek the support of organizations already working on the ground, such as civil society organizations or community workers in charge of current extension services.

[1] Supporting actions include data collection and monitoring and evaluation.

These HPAs can offer infrastructure, networks, and institutional support that can expedite the implementation of interventions with farmers to address soil acidity to maximize their impact.

How?

Policy-makers can leverage different resources and avenues to define HPAs. Some of these include the following:

- **gathering data for decision making, including through focus group discussions**: Identifying HPAs requires collecting data on the factors mentioned above, or leveraging existing data (legacy data). For instance, detailed soil acidity maps[2] are available and can be very useful for spotting HPAs; data on crop productivity can help identify those crops that are relevant to target; data on current distribution points of agricultural inputs and transportation networks (i.e., agro-dealers, terms of road conditions) can help to map input availability and distribution capacity. In addition, focus group discussions with local stakeholders should also be considered. To holistically assess the needs of a determined area, it is critical to hear and consider the voices of farmers, community leaders, and other agricultural experts in the area. This participatory approach ensures that the mapping of HPAs is informed by local knowledge, enhancing the relevance and effectiveness of interventions.
- **overlapping maps of HPAs with lime-crushing sites**: HPAs could also be identified through geospatial analysis of acidic soil areas and the location of lime-crushing sites and/or cement factories. Where results of this spatial analysis show that there is a lack of lime producers or cement factories near acid areas, a transportation route could be mapped to increase efficiency and assess the capacity to transport large quantities of lime.

Who?

The government can partner with research institutions, academia, development organizations, private sector stakeholders (e.g., lime crushers), and farmers to collect the necessary information and define the HPAs. For instance, the privately owned lime crushers and cement factories could provide the government with the geographic location of their production centres, as well as their current access to road infrastructure that could reach farmers. Lime producers and cement factories can also provide data to the government for estimating the volumes of lime they produce and their demand. Governments can incentivize lime crushers and cement factories to share these data by presenting the business model and benefits of covering an increasing demand from farmers at certain locations. The government can

[2] Examples of soil databases:
Food and Agriculture Organization of the United Nations, *Global Soil Information System*: https://data.apps.fao.org/glosis/?share=f-6756da2a-5c1d-4ac9-9b94-297d1f105e83&lang=en
International Soil Reference and Information Centre, *World Soil Information*: https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/b3df7f8d-aa90-4206-a11c-5d95b4dd2327
iSDA Africa, *Field Level Soil Map for Africa*: https://www.isda-africa.com/isdasoil/#intro
Africa Geoportal: https://www.africageoportal.com/pages/Data%20Library

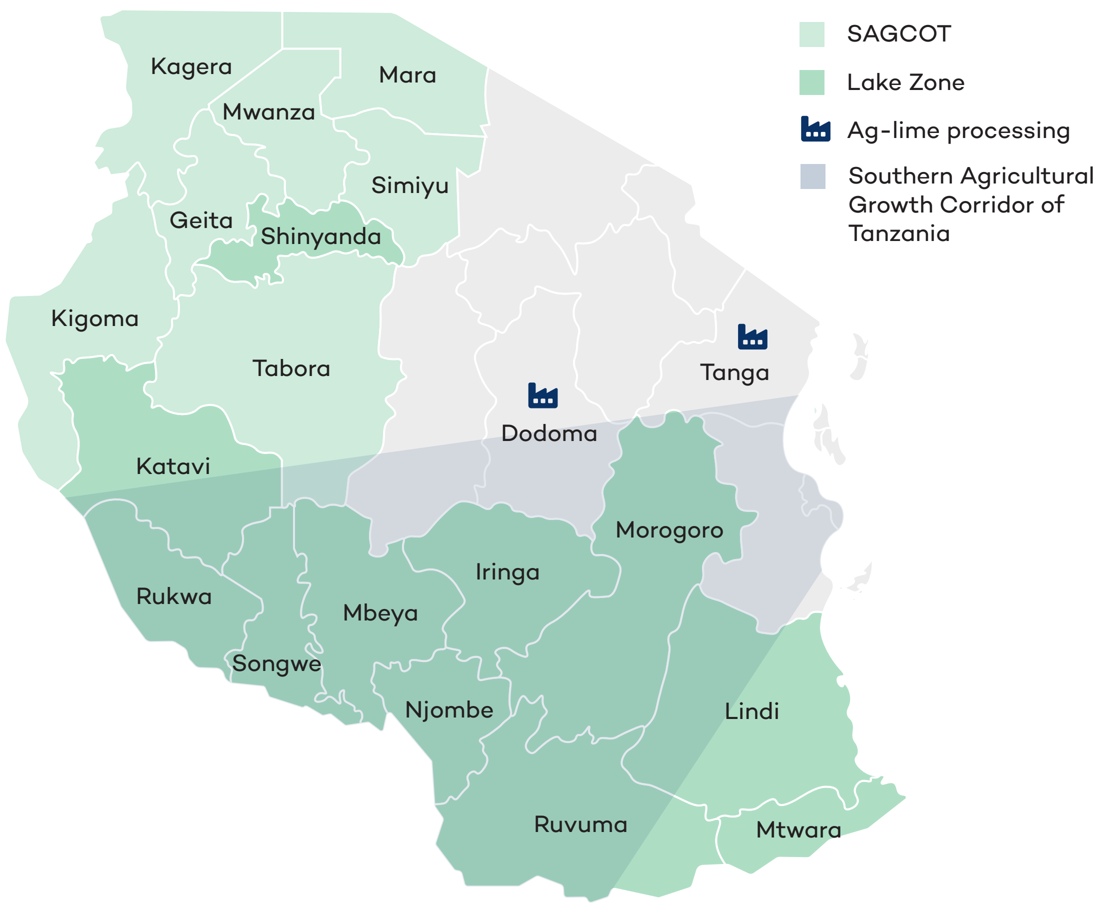
also prioritize the development and/ or improvement of transportation roads to support the distribution of lime in HPAs.

Examples

There are a few examples of initiatives that have identified HPAs by gathering data or overlapping soil acidity maps with lime-crushing sites. For instance:

The Consultative Group for International Agricultural Research (CGIAR), through CIMMYT, has collected data to identify HPAs as part of the GAIA project. In a collection of case studies for each East African country, CIMMYT presents spatial data of agricultural lime processors' locations in relation to areas with the greatest potential to increase farmer productivity through acidic soil remediation (Figure 3). Data about the yield response to lime and market price are also integrated into the analysis. Altogether, these data ("nodes of entry") inform and support a business case for lime (CIMMYT, 2023).

Figure 3. An example of spatial data overlaps from CIMMYT's 2023 study



Note: The figure shows the Southern Agricultural Growth Corridor of Tanzania and its proximity to lime processors in Tanzania

Source: International Maize and Wheat Improvement Center, 2023.

Regarding farmers' participation in informing HPAs, researchers from the University of KwaZulu-Natal investigated soil acidity causes and indicators through farmers' knowledge and perspectives in Ethiopia. This participatory rural appraisal could help better design an appropriate intervention tailored to the local context (Abate et al., 2017).

4.2 Scale Up Soil Testing Services

What?

The provision of soil testing services would ideally involve establishing the necessary testing facilities. However, laboratories can represent a big investment and can be hard for farmers to access. Therefore, a short-term and cost-effective solution would be to provide farmers in HPAs with rapid soil testing kits to assess pH levels and nutrient content.

By providing rapid testing kits, combined with capacity-building initiatives on how to use the kits, agricultural stakeholders can empower farmers to make informed decisions about soil management practices (including the quantity and type of lime to use), enhance soil health, and improve agricultural productivity.

This strategic priority heavily relies on the whole life cycle of data, from collection to analysis, interpretation, and sharing. Therefore, in addition to providing testing kits, it is crucial to invest in defining measures and approaches to harmonize data collection, analysis, and interpretation of the results and train the correspondent teams. The government can also develop a centralized information system on soils to gather existing and new data.

How?

The following strategies should be applied to provide comprehensive soil testing services.

- **distribute rapid soil testing kits and explain how to use them to farmers**: Dispense rapid soil testing kits to farmers for on-farm testing. Farmers are trained on how to use these kits effectively to assess soil acidity levels and nutrient status in their fields.
- **provide soil acidity testing services to farmers**: Offer training programs for existing extension agents (such as community workers and village-based advisors) on soil acidity testing techniques, support the organization of outreach events to raise awareness among farmers about the importance of soil testing, and provide subsidized or free testing services to farming communities. In addition, farmers could be incentivized to collect their soil data by making it a requirement to access subsidized agricultural inputs like lime (Workshop participants, personal communications, May 22, 2024).
- **develop guidelines for harmonization of data collection, analysis, and interpretation of soil acidity**: Standardized methods to collect and analyze information can guarantee that farmers in one region are characterizing their soil and following the same decision-making process to address acidity as farmers in a different region. Extension agents can receive training based on these guidelines and enhance multi-scale coordination efforts.

- **create (or leverage existent) national or regional soil information systems**: Utilize and merge existing data (legacy data) from previous data collection efforts from government and secondary sources (i.e., CIMMYT, AGRA) and collaborate with data providers to establish a process to integrate or update soil information continuously. These information systems can also help monitor the soil's characteristics before and after applying lime and ISFM.
- **digitalization**: Invest in digitalization of data collection of soil acidity. For instance, establish a digital registration system for farmers that allows communication with the government and other relevant stakeholders.

Who?

In an initial phase, it would be ideal for governments to find funding mechanisms to subsidize the cost of rapid soil testing kits (see discussion of the Global Green Growth Institute below) and partner with existing extension services working at the grassroots level to expand the reach of soil testing services. As for training, the government can partner with non-governmental actors who can support the capacity-building efforts with existing or new extension agents.

While extension agents could be trained by organizations providing capacity building on sustainable agricultural practices (e.g., One Acre Fund in Rwanda), on harmonized methods to collect, analyze, and interpret the results from soil testing kits, with investment from public and private sources, the government can collaborate with research institutions to create or update a national soil information system with up-to-date soil data (i.e., acidity, nutrients, exchangeable acidity).

Examples

Scaling soil testing services can be challenging; however, there are a few examples in the region showcasing how partnerships between stakeholders could improve farmers' access to knowledge and capacity to conduct soil testing.

Regarding improving capacity for data collection, a collaboration in Kenya between the Kenya Agricultural and Livestock Research Organization, the Ministry of Agriculture, Gatsby Africa, the International Fertilizer Development Center, the African Plant Nutrition Institute, Pwani University, Maseno University, and Rongo University resulted in the development of a comprehensive handbook for practitioners who work with farmers (Esilaba et al., 2023). The handbook provides practical guidance on soil acidity management, including information on soil testing, lime application, and soil amendment strategies. In addition, it helps explain the reasons for soil testing by walking readers through the methods and steps to conduct soil sampling and analysis. Practitioners have found the handbook to be a valuable resource for farmers and extension agents in Kenya.

Regarding data analysis, in a report published by Kenya Markets Trust, in collaboration with Gatsby Africa, researchers elaborate on the importance of soil testing to guide the right types and quantities of fertilizers, lime, and seeds. However, they acknowledge the current lack of soil testing services due to the high costs, suggesting partnering with research organizations like the Kenya Plant Health Inspectorate Service and Kenya Agricultural &

Livestock Research Organization to facilitate access and distribution among farmers. These organizations provide soil testing services ranging between KES 1,000 to KES 2,000 (USD 8 to USD 16) (Kenya Markets Trust, 2020).

Regarding data sharing, the GAIA project by CIMMYT, supported by the Bill & Melinda Gates Foundation, has made an acid soils dashboard available that provides state-of-the-art data and open access information on acid soil management for major crops in sub-Saharan Africa at a high spatial resolution (CIMMYT, n.d.). Specifically, there is concrete information on soil properties (pH in water, exchangeable acidity, cation exchange capacity), lime requirements, yield loss and profitability information for cereals, legumes, roots and tubers, and other non-food crops.

Tanzania Soil Information Service contains databases of near-real-time, statistically representative field, laboratory, remote sensing, and GIS collections for evaluating the country's soil fertility. Moreover, the Government of Rwanda, partnered with the Centre for Agriculture and Bioscience International (CABI) to develop the Rwanda Soil Information Services to provide a centralized resource to better understand the state of soils (CABI, n.d.).

4.3 Demonstrate Lime Application and ISFM

What?

Lime application should be demonstrated in HPAs as a short-term strategy to address soil acidity. By following recommended dosage rates, considering the frequency of application, using standardized methods for lime determination, and drawing from examples of best practices, agricultural stakeholders can demonstrate lime application to farmers as one component of sustainable soil management practices. However, lime is not a one-size-fits-all solution, and it is, therefore, important to know other viable alternatives or complementary components.

Representatives of EAC partners states working at the workshop held in May 2024

To maximize its effectiveness in restoring soil health, lime should be combined with ISFM practices. ISFM practices are essential for sustainable agricultural development and to tackle soil acidity: they improve soil structure, enhance nutrient availability, and promote overall soil health (Amede et al., 2019). Some ISFM practices include minimizing the use of machinery and reducing tillage, using crop residues as soil cover, implementing intercropping, crop rotation, and diversification, applying organic matter and biochar, and integrating forages. When combined with lime application, ISFM practices complement the effects of lime in addressing soil acidity and improving soil fertility. This integrated approach enhances soil fertility, improves crop productivity, and contributes to the resilience and sustainability of agricultural systems.

One additional consideration when demonstrating the application of lime and ISFM practices is to target specific crops. Most research regarding the effectiveness of lime in increasing yields has mostly focused on staple crops. Therefore, there is not enough proof to state that lime is always the best amendment to address soil acidity for all crops and scenarios. This crop-specific approach ensures that interventions are tailored to the specific needs of different crops and regions.

How?

Training sessions for farmers or the establishment of demonstration plots can help to illustrate lime application and ISFM practices. We provide the following guidelines and considerations that should be integrated into the demonstration of lime application and ISFM practices.

For lime application:

- **apply a recommended dose**: The recommended lime application rate varies depending on the severity of soil acidity and other factors. Typically, a dosage of 2 to 5 tonnes per hectare is recommended, with a specific recommendation of 2.2 tonnes per hectare for moderately acidic soils (CIMMYT, 2023). This dosage is determined based on soil test results and the targeted pH level for optimal crop growth (CIMMYT, 2023).
- **frequency**: Lime application is not a one-time fix and needs to be repeated periodically to maintain optimal soil pH levels. The frequency of lime application depends on various factors, including soil type, cropping system, rainfall patterns, and the rate of soil acidification. In general, lime is applied every 2 to 4 years, but the frequency may vary depending on the specific context and ongoing monitoring of soil pH levels (CIMMYT, 2023). In between applications of lime, farmers should adopt soil conservation measures throughout the year to enhance soil health and maximize the lime's effectiveness. These can include soil and water conservation measures, such as the use of cover crops, mulching, residue management, and water-spreading weirs, as well as ISFM, mixed cropping, agroforestry systems, and organic farming (Cartsburg et al., 2024).
- **standardized methods to determine lime amount and quality**: Standardized methods must be applied to determine the appropriate amount and quality of lime to be used in each case. Soil testing is crucial to assess current pH levels, determine lime requirements, and select the most suitable type of lime (e.g., agricultural lime or dolomitic lime). Additionally, factors such as lime particle size, purity, and reactivity

are considered when determining the quality of lime to ensure effective soil amendment (Agegnehu et al., 2021).

For ISFM practices, the following measures are recommended:

- **set up demonstration plots for selected crops to apply ISFM and other soil conservation measures**: These demonstration plots serve as practical examples for farmers to observe and learn about the integrated approach to soil fertility management. Selected crops are grown using ISFM techniques, such as applying organic and inorganic fertilizers, using cover crops, and incorporating crop residues into the soil.
- **promote the use of sustainable agricultural practices in the demonstration plots**: Use crop residues as soil cover to protect against erosion, improve soil moisture retention, and enhance soil organic matter content. Rotate and diversify crops to enhance soil fertility and break pest and disease cycles. Use organic matter through composting or green manure to improve soil health and fertility. Minimize the use of machinery and excessive tillage to preserve soil structure and reduce soil erosion. These are all examples of practices that can be used as preventive measures and solutions to soil acidification.
- **train extension services, community workers, or village-based advisors**: Train existing or new extension services leveraging the demonstration plots. These extension agents can, in turn, organize trainings for farmers at the demonstration plots or at their farms or communities. They can also help link farmers with other agricultural stakeholders (agro-dealers, cement factories, government agents). They will then disseminate knowledge to farmers living within the HPA, conduct trainings, visit farmers in their communities, and facilitate lime application with the adoption of ISFM practices and other soil conservation techniques.

Who?

Demonstrate Lime Application and ISFM

Good coordination among agricultural stakeholders is essential to help farmers mainstream the use of lime with ISFM and other soil conservation measures. Government agencies, in partnership with international development agencies, can encourage and support technical assistance providers or non-governmental organizations to train extension agents and establish robust monitoring and evaluation systems of farmers' use of lime and soil conservation practices.

Although farmers may know or will know about soil acidity and how to treat it, a significant barrier is the monetary resources needed to purchase inputs such as lime. Government agencies can collaborate with financial institutions, microfinance organizations, and development agencies to ensure farmers can access financial resources for agricultural inputs, including lime and soil conservation materials. By facilitating access to credit, grant programs, or subsidy schemes, partnerships between governments and other actors can help farmers overcome financial barriers and enable them to invest in sustainable soil management practices.

Examples

Demonstrate Lime Application and ISFM

The Soil Fertility Improvement Directorate of the Ministry of Agriculture and Natural Resources in Ethiopia produced a policy brief in collaboration with CIMMYT, the International Food Policy Research Institute, the Participatory Ecological Land Use Management, and GIZ. The brief outlines strategies for addressing soil acidity in Ethiopia, including recommendations for lime application. It highlights the importance of soil testing and the use of appropriate lime dosages to improve soil conditions and enhance agricultural productivity (Ministry of Agriculture and Natural Resources [Ethiopia], 2017).

In Rwanda, the One Acre Fund offers training focused on farmers' behavioural changes needed to improve soil health over time by providing holistic approaches, which include climate-smart techniques in land management, the production and application of compost, use of agricultural lime, and intercropping (One Acre Fund, personal communication, January 8, 2024).

In academia, researchers led by Mateete Bekunda from the International Institute of Tropical Agriculture released a study that discusses the integration of multiple technologies, including ISFM practices, for sustainable agricultural intensification in East and Southern Africa. It highlights the importance of combining soil fertility management strategies with soil conservation practices to improve agricultural productivity and mitigate soil acidity. Through case studies and examples, the publication demonstrates the effectiveness of integrated approaches to address soil fertility challenges and promote sustainable agricultural development (Bekunda et al., 2022).

4.4 Increase Awareness of Farmers and Other Actors

What?

Increasing awareness of soil acidity and potential solutions is critical to addressing the issue in the short and long terms in HPAs. This implies raising awareness of private sector (e.g., farmers, lime crushers, cement factories, agro-dealers, etc.) and public sector actors (e.g., policy officials beyond ministries of agriculture, such as trade and environment).

Increasing awareness at the farm level requires government agencies to engage with existing or new extension agents in HPAs, such as community workers or village-based advisors, as they are a vital component of community-driven agricultural extension programs promoting sustainable soil management practices, and they also serve as links between farmers and governments.

These extension agents' roles involve several responsibilities and activities, including implementing awareness campaigns that are crucial for disseminating information and promoting the adoption of sustainable agricultural practices, from lime application to ISFM and other organic-oriented practices (e.g., agroecology). By implementing awareness campaigns through participatory approaches—using different communication channels such as radio, flyers, farmer field days, farmer exchange visits, and conducting continuous trainings—extension services can effectively disseminate information, build farmer capacity, and promote the adoption of lime and ISFM, ultimately improving soil health and agricultural productivity.

An additional consideration is that (in parallel to showcasing producers how to use lime and ISFM) these practices should integrate local Indigenous knowledge that promotes sustainable agricultural practices.

Increasing awareness at other levels of the value chain, from lime producers to government officials, could be done by establishing a national platform, steering committee, or task force that involves multiple stakeholders.

How?

Government agencies can help increase farmer awareness on the use of lime and ISFM by supporting different activities. These include

- **onboarding existing extension agents or recruiting new farmers to become extension agents in the communities of each HPA**: Existing extension agents, such as community workers or village-based advisors, can be appointed to support increasing farmer awareness. They can also be selected from among experienced and respected farmers in the communities of the HPAs (International Institute of Rural Reconstruction, 2021) based on their knowledge of local agricultural practices, leadership qualities, and the trust they command among fellow farmers. The appointment or recruitment process ensures that extension agents are well-regarded and influential figures in their communities, enabling effective knowledge dissemination and adoption of recommended practices.
- **training extension agents**: Extension agents take part in comprehensive training programs to equip them with the necessary knowledge and skills to address soil acidity and promote ISFM and sustainable soil management practices. Training topics include understanding the problem of soil acidity, conducting soil tests, interpreting soil test results, and implementing lime application, ISFM and other soil conservation practices. Through hands-on training sessions and capacity-building workshops, extension agents gain the expertise needed to effectively support, raise awareness among, and train farmers in their communities.
- **extension agents raise awareness and train farmers in HPAs**: Once trained, extension agents serve as local experts in charge of raising awareness and delivering training sessions and workshops to farmers in HPAs. They share their knowledge and practical experience on soil acidity management, soil testing, lime application, and other relevant topics. They use locally adapted training materials and demonstration plots to facilitate learning and encourage the adoption of recommended practices among fellow farmers.
- **participatory activities**: Extension agents can organize on-farm demonstrations to showcase sustainable soil management practices in action, including lime application, ISFM techniques, and other soil conservation measures. Farmer field days and exchange

visits provide opportunities for farmers to learn from each other's experiences, ask questions, and gain hands-on experience with new practices. Activities at demonstration plots, such as field walks and training sessions, demonstrate the effectiveness of interventions and encourage farmer engagement and participation.

- **use of various communication channels**: Awareness campaigns use a variety of communication channels to reach a diverse audience. These channels may include radio broadcasts, distribution of flyers and informational materials, and organizing field days and workshops. Extension agents play a crucial role in disseminating information and facilitating communication between extension services and farmers in their communities.
- **trainings throughout the year**: Continuous training sessions are conducted throughout the year to educate farmers on soil conservation practices, including the benefits of lime application, ISFM, and other soil management techniques. These trainings cover a range of topics, including soil health, nutrient management, crop rotation, and erosion control. Specific emphasis is placed on lime promotion at least 2 weeks before sowing starts to ensure timely implementation and maximize the benefits of lime application for upcoming planting seasons.

Government agencies can also help increase awareness of soil acidity and on the use of lime and ISFM among value chain actors, policy-makers, and civil society organizations.

- **task force or a committee**: This would be a specialized unit made of representatives of interested parties, including farmers, policy-makers, lime crushers, cement factories, and extension services that meet and collaborate to increase awareness about soil acidity and to jointly develop action plans/ solution (i.e., policies, programs, and strategies).

Who?

Partnerships between agricultural extension services, farmer organizations, and non-governmental organizations are essential to increasing farmers' awareness of soil acidity, lime application, ISFM, and other soil conservation practices. The government can motivate, encourage, or support organizations such as One Acre Fund, which have extensive experience in delivering awareness campaigns, training programs, and information dissemination activities.

Extension agents can also play a crucial role in bridging the gap between farmers and various stakeholders, including input suppliers, lime crushers, financial institutions, and government agencies. They can facilitate communication, collaboration, and commercial relations between farmers and these external actors, ensuring access to agricultural inputs, services, and support mechanisms. They can also advocate for the interests of farmers and serve as a conduit for information exchange and feedback between the community and external stakeholders.

Finally, government's commitment and leadership are essential for creating a dedicated taskforce or committee that can ensure not only increasing awareness across sectors but also coordinated efforts, effective policy coherence and implementation, and sustained support for soil health initiatives. For instance, all policies, national plans or strategies concerning agriculture, and soil management, would need to incorporate measures to address soil acidity and recover soil health.

Examples

Multiple organizations, at public and civil society levels, already have strong systems in place to disseminate information to farmers. For instance, AGRA uses a "going-beyond-demos" approach that focuses on engaging farmers through participatory on-farm demonstrations, farmer field days, and exchange visits. This approach emphasizes farmer participation and ownership of interventions, leading to increased adoption and sustainability of practices (AGRA, 2016).

In Rwanda, the One Acre Fund conducts trainings throughout the year to educate smallholder farmers on sustainable agricultural practices, including soil conservation and fertility management. These trainings cover a range of topics relevant to farmers' needs and priorities, with a focus on promoting the adoption of lime application and other soil management practices (Rwanda Agriculture and Animal Resources Development Board, 2023).

On the academic side, the International Institute of Rural Reconstruction's publication *Regenerating Our Soils* highlights successful case studies and success stories from the Regenerative Agriculture Project in Kenya. It features examples of extension agents who have been instrumental in promoting soil regeneration and sustainable agriculture practices in their communities. These extension agents have played a pivotal role in training fellow farmers, disseminating knowledge, and fostering collaboration between farmers and various stakeholders, contributing to the revitalization of soils and the improvement of agricultural livelihoods (International Institute of Rural Reconstruction, 2021).

4.5 Develop the Lime Value Chain

What?

Ensuring Supply

Ideally, there should be a lime producer and distributor in each HPA. However, the reality is that lime extraction sites are usually far from those areas that need it the most. Furthermore, while farmers can be aware of the problem of soil acidity and the solution (applying lime and ISFM practices), current lime production is not enough to cover farmers' needs. In the regions where it is available, lime can be expensive due to the low supply that current factories are producing. Drawing from the Ethiopian experience, public ag-lime factories require support to increase capacity to produce, store, and distribute lime, particularly with effective planning and distribution processes (Oumer et al., 2023). An option to support the production of public factories is to complement supply with private factories.

In addition, to guarantee supply, we should also engage actors with greater capacity that can complement the supply from current lime crushers, such as cement factories. Cement factories produce lime for manufacturing cement. The advantage of cement factories is that they already have either their own fleets of trucks or well-established contracts (and bargaining power) with transport companies that have the capacity to transport large quantities of lime. An additional lime source could come from small-scale lime extraction that is closer to smallholder farmers. Several countries of the EAC already produce small-scale lime (Mshiu et al., 2012).

Address Transportation Issues

Transportation (last-mile distribution[3]) has been found to be the weakest stage of the lime value chain, representing 50% of the total cost (Ministry of Agriculture and Natural Resources [Ethiopia], 2017).

Addressing transportation issues, particularly in the last-mile distribution of lime, is crucial to ensuring timely access to agricultural inputs and reducing production costs. By adopting strategies such as optimizing distribution centres, aggregating demand through cooperatives, engaging youth in last-mile delivery, and exploring cross-border transportation opportunities, agricultural stakeholders can overcome transportation challenges in the lime value chain, ensuring it is not only available but also accessible to farmers when they need it (every 2 to 4 years, depending on the soil).

Overcoming Lack of Storage Infrastructure

As previously mentioned, current producers and distributors face storage limitations. However, while it would be ideal to have warehouses that store bagged granulated lime close to farmers, this can increase unnecessary costs. Lime producers could consider transporting the input to farmers in bulk. Moreover, since lime is an inert material,[4] it can be directly dumped on the fields months before farmers need to apply it. In cases where storage infrastructure exists, this can help ensure the availability of lime, especially in areas where agricultural inputs are not readily accessible.

How?

Below, we elaborate on the strategies and considerations that are integral to the development of the lime value chain.

- **ensuring supply**: Diversifying the production of lime through public and private lime-producing companies (including small-scale lime crushers), as well as cement factories. Lime crushers, private and public, would need resources (machinery and distribution planning) to reach their full production capacity.
- **mapping lime production sites**: Create maps of current lime crushers and cement factories and assess their spatial distribution in relation to farmers' locations. In addition, maps should incorporate data on current lime production capacities and distribution networks (roads, rails, etc.).

[3] Last-mile distribution refers to the very last step of the supply chain distribution process, when products or goods (lime in this case) move from storage hubs to their final destination (One Acre Fund, 2021).

[4] Inert materials are those solids that are neither chemically nor biologically reactive, are denser than water, and will not decompose.

- **optimizing distribution centres or actors near farmers**: Distribution centres should be strategically located at or close to farming communities to minimize transportation distances and costs. By positioning distribution centres near farmers, transportation logistics are streamlined, and the last-mile delivery of lime becomes more efficient and cost-effective. An alternative to a physical distribution centre would be assigning the role of last-mile distributor to an organization with the capacity to take orders from farmers and distribute directly to them.
- **aggregating demand for lime distribution through cooperatives**: Cooperatives or other organizations can play a key role in aggregating demand for agricultural inputs, including lime, from smallholder farmers in a specific geographic area within the HPAs. Allocating distribution activities to cooperatives reduces transportation costs per unit of lime (Amede et al., 2019). These aggregators also facilitate collective bargaining and negotiation with lime suppliers, such as cement factories, further optimizing distribution channels. In these cases, lime is transported from the crusher site to the cooperative.
- **creating jobs through youth engagement in last-mile sales, delivery, and application**: Engage youth in last-mile sales and delivery from the aggregator point to the farm. They can also help to apply lime. This approach not only addresses unemployment issues but also helps to improve the efficiency of transportation and distribution networks. Youth can also be trained and employed as sales agents or delivery personnel, using bicycles, wheelbarrows, or other means of transportation to reach remote farming communities (Amede et al., 2019).
- **exploring cross-border transportation opportunities**: There is potential to explore cross-border transportation options for lime, particularly in regions where borders are close to lime production areas. Cross-border transportation may offer cost-effective solutions by leveraging existing trade networks and infrastructure (CIMMYT, personal communication, November 22, 2023).
- **packaging of lime**: There is an advantage to using high-grade lime since it requires a lower application dose to achieve desired soil pH levels (Amede et al., 2019). Additionally, granulated lime is preferred over powdered lime as it is less bulky and easier to handle during storage and transportation (Amede et al., 2019).
- **improving storage conditions**: Agricultural lime can be either dumped on the field to use later or stored in a dry, non-refrigerated warehouse to prevent moisture absorption and preserve its efficacy. The warehouse should be equipped with adequate ventilation to maintain optimal storage conditions. Lime bags can be stacked on wooden pallets to facilitate airflow and prevent direct contact with the ground, reducing the risk of contamination and spoilage (One Acre Fund, personal communication, January 8, 2024).
- **estimating demand**: To avoid surplus and ensure efficient inventory management, governments can ensure estimates of the current lime demand from farmers in the HPAs. These estimates are based on factors such as crop area, expected lime application rates, and historical demand patterns. By accurately estimating demand, storage infrastructure can be optimized to accommodate the required quantity of lime without excess inventory buildup (One Acre Fund, personal communication, January 8, 2024).

Who?

Government agencies have a crucial role in addressing the issues presented above by promoting an enabling environment that can boost the lime value chain. For instance, governments should secure transportation infrastructure so lime and other agricultural inputs can reach remote communities. This also includes support with planning more efficient transportation routes in HPAs. In addition, the government can contribute to increasing lime production and distribution capacity of public and private lime crushers and cement factories. The support could be in the form of machinery to crush lime or in the form of supporting affordable finance.

Through a collaborative platform, transportation stakeholders (public and private) can leverage resources and coordinate efforts for wider access to lime and agricultural inputs. In practical terms, this means transporting lime from the lime crusher/cement factory to the farm. Collaborating with a development partner to map routes with GPS data could help reach farmers living in remote areas. Furthermore, the role of cooperatives could be twofold: first, by collecting crushed lime and distributing it to members and second, by aggregating demand for lime at the farmer level, which in turn boosts their bargaining power to negotiate better prices and improves last-mile access and lowers distribution costs.

Examples

Multiple case studies exist relating to the challenges associated with developing a sustainable lime value chain. However, there are only a couple that have documented actions addressing these challenges. The lack of success stories speaks to the importance of working collaboratively to catalyze the lime supply chain at local, national, and regional levels.

An example of this comes from private sector collaboration in Kenya, where industry actors secured two investment projects to support the local production of lime. The investments are backed up by a feasibility study that demonstrated that if local production is leveraged, it could reduce production costs by 23%, create jobs, and save foreign exchange.

As for embarking private sector companies, in Mali, the first large-scale lime mining producer (Carriere et Chaux du Mali SA) has received funding from the International Finance Corporation of the World Bank. The investment will provide an alternative to lime products imported mainly from Europe for mining and agricultural markets.

Regarding diversifying the production of lime and the role of small-scale production, in Tanzania, a research project found the potential for diversifying the existing hydrolime production to generate lime products for local use, and particularly for sale to local smallholders cultivating coffee. These efforts, however, should include an environmental, social, and impact assessment to ensure the mining activities don't negatively impact communities (Mshiu et al., 2012).

Representatives from GIZ's project developers in Ethiopia emphasized that one of the main challenges in the lime value chains is transport. Through different outputs (policy briefs and infographics), GIZ, in collaboration with the Ministry of Agriculture in Ethiopia, has provided different recommendations to address distribution issues related to lime. By optimizing distribution centres, aggregating demand through cooperatives, and engaging youth in last-mile delivery, transportation issues in the lime value chain can be effectively addressed, ultimately benefiting smallholder farmers and promoting agricultural transformation (MOA - Ethiopia, 2017).

Another example comes from the One Acre Fund and its work to provide last-mile delivery for farmers across sub-Saharan Africa. As of 2021, the organization, through delivery experts, has distributed "more than 90,000 tons of farm inputs within walking distance of farmer's homes every year across six countries in [sub-Saharan Africa]" (One Acre Fund, 2021). This system, designed for distributing inputs such as seeds and fertilizer, has also been expanded to include lime. James Ellison, Agricultural Innovations Lead at One Acre Fund, explained that the organization works in tracing routes (with GPS) and invests in trucks to move the product from distribution centres to the farmers, and it stores products in its own warehouses.

4.6 Supporting Actions

What?

While the strategies mentioned above are considered a priority, these should not overlook the need to include supporting actions to eventually scale up this short-term approach focused on HPAs and contribute to developing a long-term strategy to address and prevent soil acidity. These supporting actions include

- **collecting more data on soil acidity and yield response to lime and alternative interventions in target crops**: Despite existing evidence, there is a recognized need for additional data on soil acidity levels and yield responses to lime application and alternative interventions in certain locations and for selected crops (CIMMYT, 2023). Comprehensive soil testing and monitoring programs are essential to gather data on soil pH levels, nutrient content, and crop yields in various agroecological zones. These data help inform decision-making processes and enable targeted interventions tailored to specific soil and crop requirements.
- **monitoring and evaluation**: Data could be collected every season at the farms in the HPA to generate evidence on the effectiveness of this combined approach (lime + ISFM + soil conservation practices). Monitoring various parameters—including soil pH levels, nutrient content, crop yields, and farmer adoption rates of sustainable practices—could provide evidence to measure the impact of interventions, identify areas for improvement, and inform decision-making processes.

How?

Possible supporting actions could include the following:

- **investing in soil lab facilities**: While rapid soil testing kits are an excellent approach to collecting initial data on soil pH and nutrients, the need for more comprehensive data on soil characteristics, such as aluminum toxicity and exchangeable acidity, could only be determined at soil labs. Therefore, it would be necessary to eventually invest in soil testing laboratories in a medium- and long-term approach. These labs are equipped with the necessary equipment and trained personnel to conduct a range of soil analyses.

- **developing impact/cost analyses for the use of lime in other crops that are important for the region with additional yield response data.** With additional yield response data, it becomes possible to develop impact and cost analyses for other regionally important crops. This involves assessing the economic feasibility and potential benefits of lime application, ISFM practices, and soil conservation measures for a broader range of crops. By conducting thorough cost-benefit analyses, policy-makers and stakeholders can prioritize interventions and allocate resources effectively.
- **access to finance**: Financial access aims to reduce associated costs of lime distribution as demand for lime increases. Therefore, we expect that the buoyant demand-supply cycle can make inputs like lime more affordable for farmers and would only require some up-front investments in the first stages by the government with development agencies

The government could also collaborate with the transportation sector to cover part of the distribution cost as part of their corporate social responsibility schemes, which can lower the farmer's share of the costs. In addition, the government could provide subsidies in an initial phase to farmers for the purchase of lime. In Rwanda, for instance, the government introduced a subsidy to cover the cost of 20,500 tonnes with the potential to amend 8,200 ha of land (Rwanda Agriculture and Animal Resources Development Board, 2023).

Furthermore, government agencies could also seek financial support to implement projects that promote the use of lime and ISFM by articulating the effects of soil health in terms of climate mitigation and resilience. Partnerships with environmental agencies, climate change organizations, and conservation groups can also support the integration of lime application and the adoption of soil conservation practices into climate mitigation strategies. For instance, institutions such as CGIAR, CIMMYT, and CABI have funded projects for supporting farmers adopting climate mitigation practices, including some related to the use of lime and soil conservation (Coles, 2023). Initiatives that align the use of lime with soil management techniques and climate-smart agriculture practices can contribute to sustainable land management, carbon sequestration, and building resilience in agricultural systems (UN Food and Agriculture Organization, 2017).

Who?

It is important to strengthen the scientific base of yield response data for lime at the farms in the HPA. Research centres such as CIMMYT could take a leading role here. CIMMYT has already been involved in documenting soil acidification in the region and has undertaken the enormous task of generating a large data set that can inform stakeholders in different jurisdictions about top-priority crops. Collaborations with research institutions, universities, and agricultural research organizations are crucial to strengthen the scientific base of yield response data for lime application. These collaborations—in the form of research projects, field trials, and data collection efforts—can generate evidence-based insights into the agronomic effectiveness of lime and its impact on crop yields, soil health, and agricultural productivity, which is useful for farmers and governments.

Examples

As part of the continuous knowledge generation on soils and their response to lime or alternative fertilizers and soil conservation measures, institutions like CGIAR have taken the lead in the East African region. For instance, they partnered with the Rwanda Agriculture and Animal Resources Development Board to launch the Rwanda Soil Information System project, which aims to develop recommendations around the use of fertilizer and lime based on soil characteristics. The goal is also to develop a National Soil Information Service that can serve as a monitoring tool of soil properties across the country (Samuel, 2022).

The previously mentioned GAIA project by CIMMYT has also emphasized the importance of data collection for crop-specific approaches. In a series of case studies for Ethiopia, Kenya, Rwanda, and Tanzania, CIMMYT researchers explore an investment case for agricultural lime in each country, highlighting the importance of data collection and analysis of soil acidity remediation at the crop level in order to improve agricultural productivity (CIMMYT, 2022). The investment case demonstrates the potential benefits of lime application for specific crops and provides recommendations for targeted interventions based on crop-specific requirements and local conditions.

In regard to financial mechanisms, In Ethiopia, the Global Green Growth Institute has designed an innovative financial mechanism through which the Development Bank of Ethiopia established a lime investment fund and endowed it with a loan. The fund invests in lime production/purchase, transport, and application on the field. As farmers adopt the use of lime with ISFM and other soil conservation measures, they can experience increases in agriculture productivity and incomes after 1–2 years. At that time, farmers start paying a service fee to the investment fund for the lime application service they received, which helps pay the cost of producing, transporting, and applying lime. Then, the investment fund recovers its investment and can repay the loan to the Development Bank of Ethiopia (Global Green Growth Institute, 2024).

An example of a healthy looking soil in Kenya.

5.0 Conclusions

The proposed six strategies have been identified as priorities that focus on the combined adoption of agricultural lime, ISFM, and sustainable soil conservation measures to address and prevent soil acidity. To make these measures attainable, the strategies concentrate on actions in HPAs. At each HPA, government agencies and other agricultural stakeholders have a role to play and can collaborate to facilitate the development of the lime value chain and the appropriate use by farmers.

Furthermore, by leveraging existing extension services, farmers can gain knowledge, tools, and resources needed to address soil acidity and enhance agricultural productivity. By integrating multiple strategies, this approach aims to create sustainable and resilient agricultural systems that address soil acidity and cover broader regional priorities such as agricultural productivity, climate change resilience, and, ultimately, food security.

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Appendix A. Roadmap Checklist

In order for countries to start taking the strategic priorities into actions, we have developed a checklist that can be integrated into an action plan. Each item should be allocated to a particular actor (depending on the country), and the roadmap should elaborate on how each action will be implemented (in terms of financing and technical resources).

Strategic priority 1: Define HPAs

- collect data on soil characteristics
- collect data about crop productivity and crop type
- complement data with information from focus group discussions
- assess the availability of agricultural inputs and distribution capacity
- assess current extension services system
- overlap maps of HPAs with location of lime-crushing sites

Strategic priority 2: Scale soil testing services

- provide rapid soil testing kits to farmers
- provide capacity building and soil acidity testing services to farmers
- develop guidelines for harmonization of data collection, analysis, and interpretation of soil acidity test results
- create (or leverage existing) national or regional soil information systems
- digitalize data collection methods with farmers

Strategic priority 3: Demonstrate lime application and ISFM

- establish standardized methods for extension agents to recommend the use of lime and/or ISFM, and the necessary doses, lime quality, and frequency rates
- set up demonstration plots for selected crops to apply lime + ISFM, or only lime, or only ISFM
- promote the use of Indigenous knowledge and sustainable agricultural practices in the demonstration plots
- train extension services, community workers, and/or village-based advisors

Strategic priority 4: Increasing awareness of farmers and other actors

- onboard existing extension agents or recruit new farmers to become extension agents in the community of each HPA
- develop capacity building and training for extension agents
- develop capacity building for extension agents to farmers
- create participatory activities (e.g., farmer field days).
- use various communication channels

- deliver trainings throughout the year
- establish a task force or a committee

Strategic priority 5: Develop the lime value chain

- ensure supply by diversifying the production of lime
- map lime production sites and distribution networks
- ensure supply of other agricultural inputs, such as organic fertilizers
- define and optimize distribution centres or actors near farmers
- aggregate demand for lime and distribution through cooperatives
- engage youth in last-mile sales, delivery, and application
- explore and facilitate cross-border transportation opportunities
- optimize the packaging of lime
- address storage conditions
- collect data to estimate the supply and demand of lime

Supporting activities

- invest in soil lab facilities
- collect more data on soil acidity and yield response to lime and alternative interventions in target crops
- develop impact cost analyses for the use of lime in other crops that are important for the region with additional yield response data
- collect data for monitoring and evaluation purposes

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