Investment Case for Agricultural Lime in ETHIOPIA

August 2023

CIMMYT | CGIAR

BILL & MELINDA GATES foundation

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I. Executive Summary

Lime is the most viable solution to soil acidity, which causes yield reduction (more than 50%) in major cereal crops. More than 40%[1] of the country's cultivated land is currently affected by soil acidity with 28% (3.7 million hectares) identified as highly acidic (<5.5 pH). Acidic soils are particularly prominent in the SNNP (72%), Oromia (60%), and Amhara (35%) regions[2]. Soil acidity inhibits root growth and nutrient absorption, reducing yields of major crops such as cereals, including wheat, barley, and maize by more than 50%[3], which in turn affect food security and the livelihoods of farmers. Lime is a suitable and abundantly available solution to treating soil acidity in Ethiopia due to ample reserves, efficacy, local availability, and cost effectiveness (compared to other solutions).

However, making the case for the significant uptake of lime is complex – it is challenging to determine the actual benefits of lime in most contexts. Agronomy literature indicates that reaction time of lime can range anywhere from 6 months to over 3 years, depending on soil properties, level of acidity, and type of crop.[4] These interlinked dependencies create uncertainty amongst farmers leading to limited uptake of lime. Additionally, while the amount of fertilizer and other inputs farmers often use are measured in kilograms per ha, lime is typically measured in tons per hectare. This presents a particular logistical challenge, as it increases the cost of distribution, especially for the significant percentage of farmers who carry their inputs to their agricultural plots using traditional methods. Without targeted interventions, the gap between the total lime requirement of the country and the estimated annual lime demand (150,000 Mt)[5] will remain considerable over the years.

Given the complexity of the issue, it is critical to identify nodes of entry along the value chain that are likely to bring about economic benefits to suppliers and farmers. On the demand side, current level of awareness raising interventions have been limited to demonstration farms, where diffusion to other areas has largely been inadequate. Due to poor road networks and infrastructure, on the supply side, distribution costs accounts for 64% of the total end-user-cost of lime, making it considerably expensive for farmers to pay for last-mile delivery.[6] On the enabling environment side, there is a wide range of limitations around access to financing with inflexible loan repayment period and various fees incurred along the value chain for supply side actors, limiting efficiency gains, hence failing to reduce end-user cost. Considering these challenges, it is critical to demonstrate proof of concept to farmers and create sufficient evidence of demand that can attract participation and investment to improve supply and incentivize the need to address these inefficiencies.

Based on soil acidity levels, the SNNP and the Oromia regions have the highest potential for lime application, with an estimated economic surplus of 333,478.10 USD for SNNP and 11.13 million USD for Oromia. Specifically, the northwestern SNNP and the western Oromia regions have the highest potential economic surplus from the usage of lime on anchor crops: lentil, potato, sweet potato, bean, and ground nut in western Oromia, and potato, lentil, and sweet potato in northwestern SNNP. These rapidly scaling cereal crops take the lion's share of production in the SNNP region and are widely grown in the western Oromia region. The total

1 MoA, A Policy Document on Acidic Soil Management: Productivity and Economic Benefits of Using Agricultural Lime, 2020

2 Ministry of Agriculture and Natural Resources, Policy Brief: Unlocking the Potential for Transformational Agriculture Development of Acid Soils in Ethiopia, 2017

3 ATA, Strengthening Acid Soil Management System in Ethiopia, Sub-sector Diagnostic, Production, Distribution, Use and Application of Lime, 2015

4 MoA, A Policy Document on Acidic Soil Management: Productivity and Economic Benefits of Using Agricultural Lime, 2020; IFPRI, EIAR, Soil Acidity Problems in Ethiopia: Magnitude, Current Awareness and Practices, and Policy Actions, 2016; CIMMYT, Interview with Scott Wallace, 2021

5 ATA, Soil Health and Fertility Management Project: Lime Supply Chain Analysis, 2021

6 According to a 2018 assessment of a GIZ pilot project in these three regions, participating farmers have mentioned they are only willing to pay a price of 80 ETB per 100kgs, which does not include the cost of transportation to plots (last mile). This 80 ETB, according to the study, is a GIZ subsidized price and it is approximately only 40% of the full cost delivered price.

need/demand for these anchor crops - which covers the application period of lime from year 1 to year 3 - in both of these regions is 78,036.74 Mt. The potential economic surplus, because of this remediation using lime, is 93,468.93 USD in the northwestern SNNP region and 11.11 million USD in the western Oromia region.[7] This selection of crops is based on (i) currently available yield response data and (ii) are meant to show the economic surplus of lime application. With additional yield response data, it is possible to develop similar economic value for other nationally important crops, such as teff, sesame seed, and horticultural crops.

Capturing this opportunity in the western Oromia and northern SNNP regions requires targeted interventions on the demand, supply, and enabling sides. On the demand side, engaging in demand generating activities to disseminate proof of concept is essential to increasing uptake in both regions, with special attention to the SNNP region, where demonstration efforts have been relatively modest. At a district level, leveraging model farmers to showcase the benefits of lime can inspire farming communities to up-take liming. At a regional level, introducing subsidies that can lessen the financial burden of purchasing lime for the farmer can increase lime demand, at least in the short run. This is especially true for the SNNP region, which is located at great distance from supply areas and is mostly dependent on the supply from the Oromia region.[8] On the supply side, leveraging existing producers in the Oromia region – lime crushers and cement factories – that have already reached economies of scale in production and transportation – can significantly address any supply gaps in the SNNP region. There is also a need to de-risk investments for the private sector through removal/reduction of fees incurred along the value chain and ensuring ease of access to finance through loans at sub-market rates and providing business development services for small-scale lime crushing facilities in both regions. Investments to get to scale on the supply side, addressing these issues, could not only reduce costs in the selected regions, but also create economic surplus in other areas across the country where remediation through liming is needed.

Beyond lime, testing and comparing the effects of other potential interventions for management of soil acidity is essential to select the most appropriate course of action. Lower cost alternatives and solutions for acid soil management may emerge which can improve crop yield and farmer livelihoods more efficiently and cost effectively compared to lime. For example, consideration of upstream solutions to limit the spread of acidic soils. This entails the promotion of non-acidifying fertilizers such as Single Super Phosphate (SSP), Calcium Ammonium Nitrogen (CAN), and Nitrogen Phosphorous Potassium (NPK), and Mavuno (crop specific blended fertilizers).[9] This can be achieved by working with fertilizer manufacturers and agro dealers to promote the use of non-acidifying fertilizers and driving awareness among farmers on the effects of acidifying fertilizers on soils and crop yields. However, there are tradeoffs to using non-acidifying fertilizers such as higher transport and labor costs. Such fertilizers have a higher application rate as they require more quantities to provide the same amount of nitrogen as acidifying fertilizers such as Diammonium Phosphate (DAP) and urea which have higher nitrogen concentrations.

Strengthening the science base, specifically relating to yield response data for lime, and thorough analysis of alternative interventions is vital to making an investment case for the sector. The yield response data that is currently available is at an early stage and is being refined, making it difficult to draw causation inferences. Therefore, it is important for the data to improve before using it to make large investment cases for the sector. Once this is achieved, it is critical to compare lime to other potential interventions that can improve yields and farmer livelihoods so the farmer can make the best value-for-money farm investments.

7 Calculation assumes the cost of lime is $100 USD/Mt

8 ATA, Strengthening Acid Soil Management System in Ethiopia, Sub-sector Diagnostic, Production, Distribution, Use and Application of Lime, 2015

9 Mavuno planting fertilizer formulation: 10:26:10 + Calcium, Magnesium, Sulphur, Zinc, Copper, Manganese Boron, Molybdenum

II. Defining the Challenge

More than 40%[10] of the country's cultivated land is affected by soil acidity, with 28% (3.7million hectares) identified as highly acidic with pH less than 5.5 and is prominent in the SNNP (72%) Oromia (60%), and Amhara (35%) regions. Soil acidity inhibits root growth and nutrient absorption, reducing yields of major crops such as cereals, including wheat, barley, and maize by more than 50%.[11] An estimated 44% of fertilizers applied to acidic soils are lost due to reduced uptake efficiency in crops.[12] This has a considerable impact on the livelihoods of farmers as reduction in 1% of agricultural productivity is associated with poverty increase of 0.9%.[13] Therefore, without interventions, soil acidity threatens the livelihoods of farmers by reducing their agricultural yields and at a macro level, adversely impacting national food security.

Lime is the most suitable and available method to treat soil acidity. Lime is a viable solution compared to alternatives due to its impact on acidic soils over a relatively short period of time, in-country availability, and low cost (as a raw material). This is evidenced by Ministry of Mines and Petroleum estimates of the country having an abundant 900 million metric tons of limestone reserves[14], spread across various regions.

However, achieving significant uptake of lime is complex; it's challenging to determine the actual benefit of lime in most contexts, resulting in sub-par demand for lime. The agricultural lime literature indicates that the reaction time of lime can range from 6 months to over 3 years, depending on soil properties, level of acidity, and the type of crop the farmer is engaged in producing. This large web of dependencies, coupled with the distant locations of soil testing laboratories[15], creates complexities and cost uncertainties for farmers on the exact benefit of liming. Although there is increasing awareness of lime, most farmers lack knowledge on the potential returns of using lime – deeming it as a 'nice-to-have' rather than a necessity. On the other side, for farmers that do understand the benefits of lime as a result of the demonstrations that have been taking place in the past decade in certain areas, demand for lime remains limited to these demonstration areas and participating farmers.[16] This is evidenced by the sub-optimal demand observed in the country.[17]

[10] MoA, A Policy Document on Acidic Soil Management: Productivity and Economic Benefits of Using Agricultural Lime, 2020

[11] ATA, Strengthening Acid Soil Management System in Ethiopia, Sub-sector Diagnostic, Production, Distribution, Use and Application of Lime, 2015

[12] MoA, A Policy Document on Acidic Soil Management: Productivity and Economic Benefits of Using Agricultural Lime, 2020

[13] The Borgen Project, The World Bank Aids Smallholder Farmers in Ethiopia, 2021

[14] Ministry of Mines and Petroleum, Ethiopia Mining Cadastre eGov Portal, 2021

[15] Interview with Oromia Bureau of Agriculture, 2021; Note: Soil testing laboratories, for example in the Oromia region, are located as far as 250-300KMs away from demand areas.

[16] Interview with Dejen Lime Factory, July 2021

[17] ATA, Soil Health and Fertility Management Project: Lime Supply Chain Analysis, 2021

Category	Example binding constraints
Demand	• **Free handing of lime by Government and development partners has led to the increased use of lime** • However,**demand is limited to areas** with Government or development partners demonstration projects • As a result, **demand remains sub-optimal as compared to the depth of the issue**
Supply	• **Public-sector dominated investments have crowded out the private sector** investments • Consequently, **systemic (delays in public procurement) and infrastructural (predominantly human labor-driven) inefficiencies in the publictly owned lime processing** has resulted in diseconomies of scale • As a result, the **publicly owned lime crushers never realized their full production potential** • **Poor road infrastructure and remote location of tanners,**coupled with the large amount of agricultural lime needed (average22 tons/ha) to treat acidic soils, varying based on the extent of acidity, makes distribution and transportation expensive, accounting for ~64% of the cost of lime • **Absence of financial and non-financial incentives** have failed to make the sector attractive for private investment
Enabling environment	• **Absence of a national farm land management policy and regulatory framework** prevents the institutionalization and hence enforcement of good land management practices • **Convoluted processes-governing rural land administration as-well as quarry right-to-use (same as land tax), royalty, land compensation, and VAT fees** hinder private sector investment • The **lack of dedicated power-substations and the constant power disruptions,** increases the down time of lime crushing factories, lagging production • **Absence of concerted coordination** between farmers cooperatives and unions,Mfls, regional Bureau of Agriculture (BoAs) and Ministry of Agriculture, with regards of implementing the Lime Supply system impedes acidic soil rehabilitation efforts

Figure 1: Summary of binding constraints across the demand, supply, and enabling environment framework

Limited demand coupled with inefficient supply - underutilized production capacity and inefficient distribution - results in high prices for lime and makes the sector unattractive for private investment.

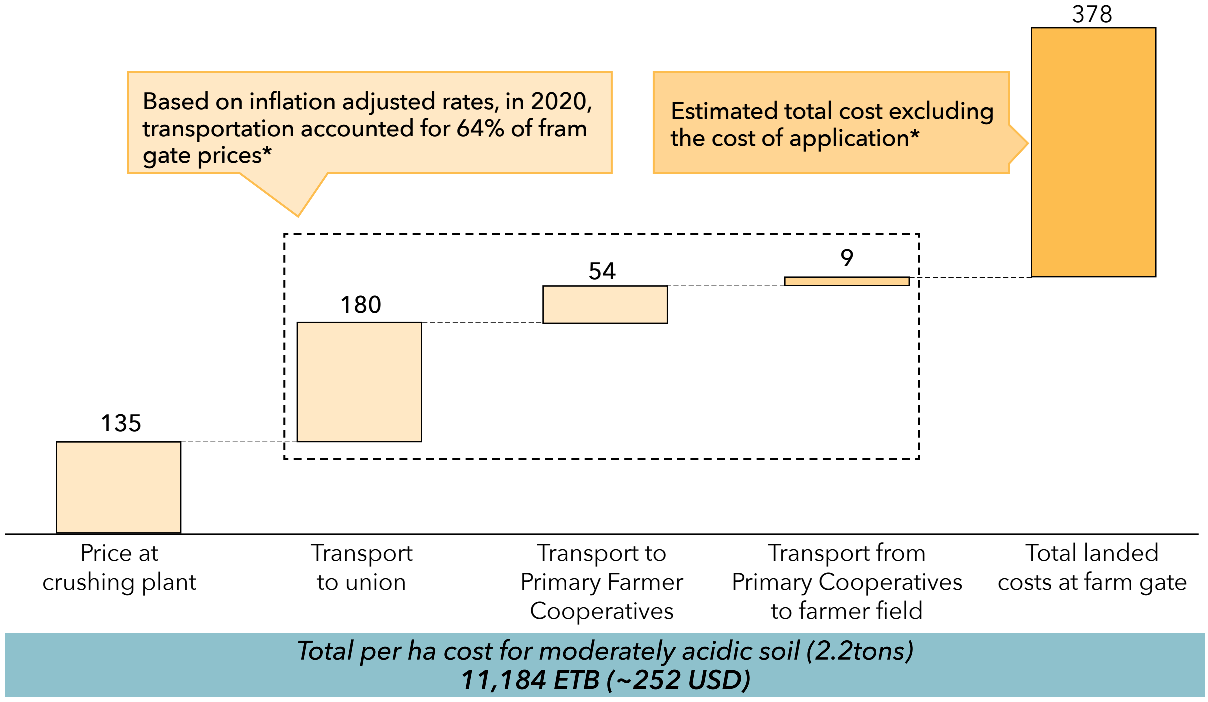
Until recently, the supply of agricultural lime in Ethiopia has predominantly been public-driven with lime processors whose production capacity has been heavily underutilized. The main three government-owned processing plants are – Kella at Butajira in the SNNP region, Guder in the Oromia region, and Dejen in the Amhara region, – with few private sector players, such as Dashen and Muger cement factories, recently joining the market. Despite these three government owned lime factories not being able to meet the total projected demand for lime, there have been limited efforts to involve the private sector in the lime supply chain. A recent ATA study[18] estimates that opening up the sector to private sector cement processors has the potential to fully meet the required amount of lime production for the next four to five years as private lime production capacity is estimated at 5.8 million tons per annum versus the 29,500 tons per annum capacity of government owned processing plants. Therefore, existing private sector actors - large scale cement manufacturing plants such as Muger cement, Derba cement, etc., - due to the economies of scale they have achieved in production, are likely well placed to improve production efficiency, decreasing the end-price of lime.

Long distances between lime deposits/ production and beneficiaries and poor road infrastructure have also constrained uptake, with transportation cost accounting for 64% of the total cost of lime. Lime reserves are primarily located in the eastern part of the country, while soil acidity issues are in the north-western and southern regions of the country. Farmers located in remote areas often use equines to transport lime and other inputs from the cooperatives/ Woredas to their farms. However, the quantity of lime required often makes it unviable to transport lime using equines. The limited demand and extensive distance to beneficiaries mean that the few vehicle owners located in remote Woredas do not view transporting small amounts of lime as a viable business opportunity. Similarly, farmer cooperatives have limited appetite to invest in providing resources for transportation.[19]

[18] ATA, Soil Health and Fertility Management Project: Lime Supply Chain Analysis, 2021

[19] FPRI, EIAR, CIMMYT, A Pilot Program to Rehabilitate and Enhance the Productivity of Acid Soils in Ethiopia, 2018

Estimated cost breakdown of agricultural lime along the value chain per quintals, (ETB) 2020



* Note: calculations are inflation adjusted using this formula: old price* (New 2020 CIP Index value: Open data for Africa Ethiopia data Portal, 2020; July 29, 2021,exchange rate = 44.38; cost of application for 2.2 tons of lime is assumed to be 2,877 aftwer inflation adjusting the REAP original assumption of 1,600, which factored in 16 labor days and a rental of cost a pair of oxn I Source REAP, Soil Acidity Problems in Ethiopia: Magnitude, Current Awarness and Practices, and Policy Actions, 2016; Dalberg Analysis of Interview insights, 2021, * Stakeholders stated the high fees of quarrying and royalty fees. However, the actual amount of fees remains unknown; Dalberg Analysis, 2020; Interview with Dejene Lime Factory, 2021

Figure 2: Inflation-adjusted cost-breakdown of agricultural lime along the value chain

Heavy taxation and fees for lime processors further hinders the development of the sector. There are multiple 'taxations' imposed along the value chain, including compensation fees (1.8 Mt/ha per year for 15 years), quarry right-to-use tax (same as land tax), royalty fees (4%)[20] and Value Added Taxes (VAT - 15%).[21] Large cement factories, who the government relies on for supplying agricultural lime, identify these fees as significant contributors to costs, which they ultimately pass down to farmers. According to these factories, in the event where demand increases five to ten-folds, there is a recognition that production costs would decrease to a certain level, however, the fixed heavy taxation and fees would still cut into their margins, making the sector as a whole unprofitable.[22]

Limited access to finance for both the demand and supply side actors stifles the sector's growth. On the demand side, the repayment horizon for lime received on credit is only one year, which is the same as fertilizers. This fails to account for (i) the bulky amount of lime needed to treat acidic soils as opposed to fertilizers (0.3Mt/ha) and (ii) the number of planting seasons it takes to see yield response. On the supply side, financing options tend to be tailored more to traditional fertilizers, which are inexpensive as compared to lime. This absence of tailored financing products that account for the bulky amount of lime needed to treat acidic soils, makes investment in lime unviable due to risk of low demand.

[20] Interview with Dashen Cement, 2022; Note: these figures are for the Amhara region and there might be variance in fees in other regions. *Other stakeholders have identified high land tax, which depends on the size of operation. However, actual amount remains unknown.

[21] Interview with MoA, 2021

[22] Stakeholder interviews, 2022

III. Nodes of entry

Our approach to building an investment case for lime is anchored on the need to identify nodes of entry that are likely to move the needle in terms of economic benefit of lime for suppliers and farmers. **Nodes of entry** are defined as areas with crops that are likely to generate the highest economic surplus with lime application and can serve as proof of concept for scaling lime uptake across the country in the longer term. **Economic surplus** was calculated using (the total hectares (ha) of the crop * yield improvement * farmgate price) – (total lime needed * price of lime).
This study primarily focuses on the economic surplus achieved within one growing season (to articulate the demonstration effect and simplify assumptions such as the time value of money for the poor). However, it is important to note that liming has multi-year benefits.

To identify the nodes of entry, we used a two-step process:

STEP 1: SELECTION OF RELEVANT CROPS

Relevant crops are prioritized based on yield response to lime and market price, in relation to the current price of lime. Relevant crops are defined as crops grown at scale, those aligned with government priorities, and cash crops with high potential for scale. To identify relevant crops, CIMMYT and Dalberg leveraged pixel level (approx. 1 km) data for each country which specifies a function for lime needed and potential yield benefits (on both aluminum toxicity and pH) for 26 crops. Regions and crops for liming were only considered where economic surplus was greater than zero. This allows for an investment case based on the potential for economic surplus.

STEP 2: BUILDING THE ECONOMIC CASE FOR LIME

The economic benefit of lime application on shortlisted crops is calculated and used to create heat maps to identify the highest potential economic value regions. As shown in Figure 1, the economic benefit of lime calculates the return on investment for a farmer (per Mt) due to the application of lime by considering yield increase and translating that to net monetary returns.

Note: Consequently, we calculated the benefit potentially accrued in future years by determining the residual benefit in future years – by using a discount rate of 50% in year 2 after lime application and 25% in year 3 after lime application. Moreover, crops were selected based on currently available yield response data and show the economic surplus of lime application in target regions. With additional yield response data, the analysis can be repeated to determine the economic value of using lime on other nationally important crops such as horticultural crops such as vegetables (green beans, snow peas, broccoli, asparagus, etc.), fruits (avocado, mango, papaya, banana, etc.) and flowers (roses and other flower crops such as gypsophilia, hypericum, etc.).

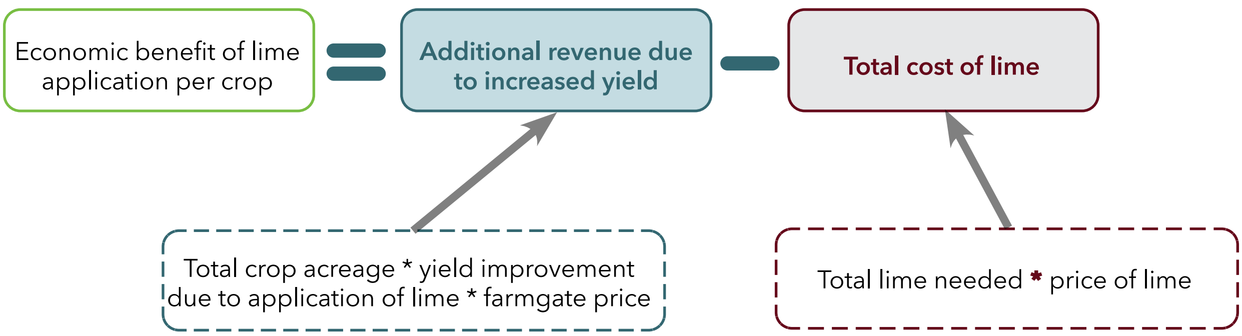
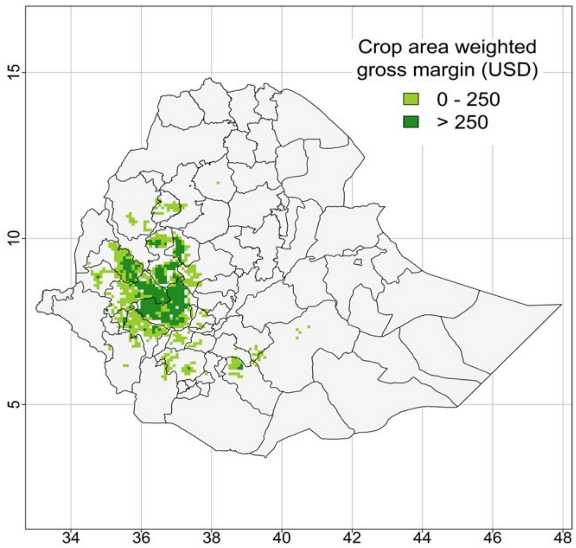


Figure 3: Economic benefit of lime application per crop calculation formula

The economic surplus maps are used to identify the highest economic value regions, which, combined with relevant crops, enable the identification of target markets for lime. In most regions, areas with moderate lime requirements have the greatest economic returns because soils need to get to a certain absolute threshold of pH and aluminum toxicity before effects of liming are observed. Hence, the highest economic value is in areas where this threshold can be achieved, with the lowest quantity of lime.

This approach enables us to size the overall economic benefit of lime, in relevant regions, for lime producers and farmers. The primary benefit for both lime producers and farmers is financial returns. Assuming the market reflects the potential demand, lime producers are incentivized to improve production capacity to reduce the cost of production. Assessment of current realities in the production and distribution of lime is required to pinpoint supply-side interventions needed to ensure adequate quality of lime, at an appropriate price to farmers, based on the expected economic surplus. On the demand side, farmers can generate additional income due to improved crop yield and reduced price of lime.



Zones of focus in the Oromia region
- Horro Guduru Wollega
- East Wollega
- West Wollega
- West Shewa
- Jimma
- Ilubabor
- Kellem Wollega

Zones of focus in the SNNP region
- Northeastern Dawro
- Keffa
- Sheka

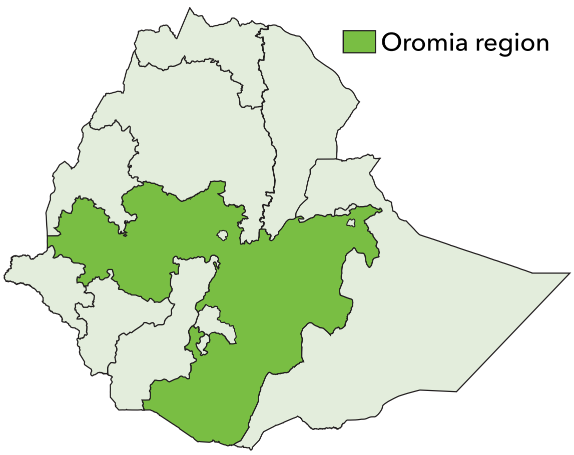
Figure 4: Highest economic value areas in Ethiopia

IV. Economic opportunities of lime

The western Oromia and the northern SNNP regions provide the greatest economic opportunity to increase farmer productivity through acidic soil remediation with potential economic surplus of 11.11 million USD and 93,468.93 USD, respectively.[24] The series of conditions that make these regions the most feasible areas for realizing opportunities from lime are detailed in the subsequent sub-sections.

Opportunities in the Oromia region

The Oromia region as a whole accounts for 50%[27] of all grain production in the country.



The region is the largest in the country in terms of both population (40 million, 36% of the total population of the country) and land area (286,612 km^2).[28] The average population density in the region is 75 persons per square-km.[29] The region's economy is primarily driven by agriculture, accounting for an average 49% of the region's GDP.[30] The major types of agricultural crops that grow in this region include cereals including maize, wheat, barley, teff, sorghum, soya beans, sunflower, sesame, linseed, and groundnuts.[31]

The region has an estimated cropland area of 6,218,000 ha with 60% (3,730,800 ha) heavily affected with acidity.[32] Oromia is formed of 21 zones and 336 Woredas[33] with large tracts of the cropland, an estimated 68%[34] of all farming Woredas, affected with soil acidity. Based on the 26 crops covered in the ex-ante analysis, the total demand - which covers the application period of lime from year 1 to year 3 - for lime in the Oromia region is 369,875 tones. While lime demand locations in the regions are located at an average 186km radius from the regional government-owned lime processing plant (Guder), it is estimated that there are over 8 large-scale cement factories that can serve as an alternative source of lime production, addressing supply gaps and cutting down distribution costs.[35]

Table 1: Summary of economic opportunities of lime in western Oromia and northwestern SNNP

	Western Oromia	Northwestern SNNP
Total market size for lime (Mt)	77,780.81	255.93
Total market size for lime producers (USD)[25]	7.78million	25,593
Total economic surplus (USD)[26]	11.11 million	93,468.93

[24] CIMMYT,2022; Note: calculations are based on the sum of the first three years of surplus.
[25] Calculation assumes cost of lime is $100 USD/Mt
[26] CIMMYT, 2022; Note: calculations are based on the sum of the first three years of surplus.
[27] CSA, Agricultural Sample Survey 2019/20
[28] PEFA, Oromia National Regional State: Performance Assessment Report, 2019
[29] Ibid
[30] Ibid
[31] ECCSA, Oromia Regional State Investment Short Profile, 2017; Hands-on Investment Guide: Oromia Regional State Ethiopia, 2015
[32] Ministry of Agriculture and Natural Resources, Policy Brief: Unlocking the Potential for Transformational Agriculture Development of Acid Soils in Ethiopia, 2017
[33] PEFA, Oromia National Regional State: Performance Assessment Report, 2019
[34] Ministry of Agriculture and Natural Resources, Policy Brief: Unlocking the Potential for Transformational Agriculture Development of Acid Soils in Ethiopia, 2017
[35] EIAR and HARC, Analysis of Agricultural Lime Value Chain in Ethiopia, 2022

In Oromia, we estimate that lime application on lentil, potato, sweet potato, bean, and ground nut plots can produce an economic surplus of 6.85 million USD within the first year and 11.13 million USD by the third year.[36] An analysis and evaluation of highly acidic areas within the region, crops with high yield response to lime (exchangeable acidity) and highest gross margins in the Oromia region highlights the highest economic opportunities for lime lie in the **western part of the region, specifically in Horro Guduru, East Wollega, West Wollega, West Shewa, Jimma, Ilubabor, Kellem Wollega zones**.

Specifically in the western Oromia region, lime applied to lentil plots can provide 4.12 million USD economic surplus within the first year and 6.69 million USD by the third year.[37] The total need/demand for lime (year 1 to year 3 application) in lentil production in the western Oromia region is 29,605.22Mt.

Potato provides 1.07 million USD economic surplus within the first year and 1.74 million USD by the third year from usage of lime.[38] During the same year/season potato was being cultivated on 6,925.79 hectarage of farmland, accounting for 50.56% of the regional hectarage used for potato cultivation. The total need/demand for lime (year 1 to year 3 application) in potato production in the western Oromia region is 3,131.85Mt.

Sweet potato provides 915,018.80USD economic surplus within the first year and 1.49 million USD by the third year from usage of lime.[39] During the same year/season sweet potato was being cultivated on 8,176.97hectarage of farmland. The total need/demand for lime (year 1 to year 3 application) in sweet potato production in the western Oromia region is 4,473.73Mt.

Bean provides 715,050.1 USD economic surplus within the first year and 1.16 million USD by the third year from usage if lime. Bean, in the 2019/2020 Meher season, was cultivated on 7,274.82 hectarage of farmland. The total demand for lime in bean production in the western Oromia region is 37,368.70 Mt.

Ground nut provides 20,882.44 USD economic surplus 33,909.29 USD by the third year from usage if lime. Ground nut was cultivated on 1,124.85 hectarage of farmland in the 2019/2020 Meher season. The total demand for lime, in the western Oromia region, for ground nut production is 3,201.31 Mt.

Table 2: Crops with highest gross margins in the Western Oromia region (in USD)

	Oromia region as a whole		Western Oromia		
	1st Year Surplus	2nd and 3rd year total surplus	% of total regional production	1st Year Surplus	2nd and 3rd year total surplus
Lentil	4,117,214	2,568,394	100%	4,117,214	2,568,394
Potato	1,085,700	677,279	98.94%	1,074,225	670,121
Sweet potato	915,018.8	570,805.2	100%	915,018.8	570,805.2
Bean	715,050.1	44,6061.9	100%	715,050.1	446,061.9
Ground nut	20,882.44	13,026.85	100%	20,882.44	13,026.85
Total	**6,853,865**	**4,275,567**		**6,842,390**	**4,268,409**

Note: Calculations for the Oromia region are based on data provided by CIMMYT, 2022. Western Oromia calculations, specifically percentage of total production in western Oromia relative to the whole of the Oromia region is calculated using zonal calculations for the selected zones (listed above) from the Central Statistics Agency (CSA's) Agricultural Sample Survey 2019/20. Therefore, the table indicates that western Oromia accounts for 100%, 98.94%, 100%, 100%, and 100%, of the total production of lentil, potato, sweet potato, bean, and ground nut, respectively, in the Oromia region. Subsequently, the 1st-3rd year surpluses for the western Oromia region are deduced based on these calculations. All calculations assume the cost of lime is $100 USD/Mt.

36 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year.

37 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year; calculations exclude the Kelem Wollega zone due to data gaps.

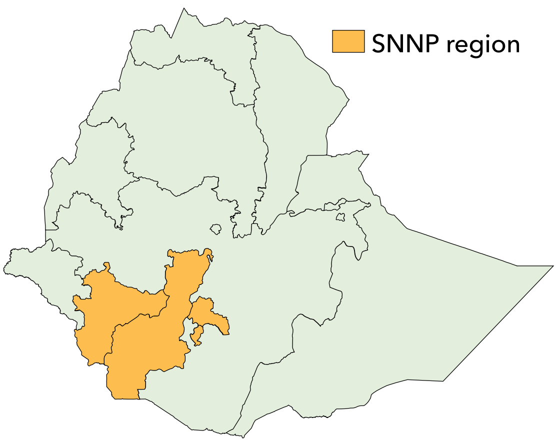
38 CIMMYT, 2022; Calculated using a 50% discount rate for the second year and a 25% discount rate for the third year; Kelem Wollega and Ilu Ababora zones are excluded from this calculation due to data gaps

39 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year ; calculations exclude the Kelem Wollega zone due to data gaps

The total 11.11 million USD economic surplus detailed above in the western Oromia region - as a result of usage of lime - has tangible impacts on the livelihoods of farmers in the region. Over 84% of the population in Oromia lives in rural areas with very limited off-farm job opportunities, especially for the youth.[40] The poverty headcount ratio in Oromia is 23.9%, just below the national average of 24%.[41] As of January 2020, the unemployment rate stood at 18.2% with women three times more likely to be unemployed than men.[42] While the direct impact of increased smallholder household income, as a result of this surplus, can be associated with increased expenditure on education and health outcomes, the indirect impacts are the long term multiplier effects these increased human development outcomes generate.

Opportunities in the SNNP region

The SNNP region as a whole accounts for 9%[43] of all grain production in the country. The total area of the region is estimated to be 109,015 km2 (10% of the country) with a population size of 20 million (18% of the total population of the country) .[44] The average population density in the region is 181 persons per km^2, making the region one of the most populous parts of the country.[45] The region's economy is primarily driven by agriculture, accounting for 43% of the region's GDP.[46] The major types of crops that grow in the region are root crops and cereal crops including maize, wheat, barley, teff, and pulses, oilseeds, vegetables, spices, coffee, and tea.[47]



The region has an estimated cropland area of 1,981,122 ha with 72% (1,426,408 million ha) heavily affected with acidity. The region is formed of 24 zones, subdivided into 136 woredas with large tracts of the cropland – an estimated 76%[48] of all farming Woredas – affected with soil acidity. Based on the 26 crops covered in the ex-ante, the total demand - which covers the application period of lime from year 1 to year 3 - for lime in the SNNP region is 71,665 tons. While lime demand locations in the regions are located at an average 218km radius from the regional government-owned lime processing plant (Kella at Butajira), the closest lime processors – cement industries – are located in the Oromia region, which can potentially increase the cost of distribution in the region as a whole, especially in the absence of economies of scale achieved in transportation.[49]

In the SNNP region, we estimate that lime application to potato, lentil and sweet potato plots can produce an economic value of 205,366.60 USD within the first year and 333,478.10USD by the third year from the usage of lime with anchor crops: potato, lentil and sweet potato.[50] An analysis and evaluation of highly acidic areas within the region, crops with high yield response to lime (exchangeable acidity) and highest gross margins in the SNNP region highlights the highest economic opportunities for lime lie in the **northwestern part of the region, specifically northeastern Dawro, Keffa, and Sheka zones**.

40 UNICEF, Situation Analysis of Children and Women: Oromia Region, 2020
41 Ibid
42 CSA, Key Findings on the 2020 Urban Employment Unemployment Survey, 2020
43 CSA, Agricultural Sample Survey 2019/20
44 PEFA, Southern Nations, Nationalities, and Peoples Region: Performance Assessment Report, 2020
45 Ibid
46 Ibid
47 Ibid
48 Ministry of Agriculture and Natural Resources, Policy Brief: Unlocking the Potential for Transformational Agriculture Development of Acid Soils in Ethiopia, 2017
49 ATA, Strengthening Acid Soil Management System in Ethiopia, Sub-sector Diagnostic, Production, Distribution, Use and Application of Lime, 2015
50 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year.

Table 3: Crops with highest gross margins in the northwestern SNNP region (in USD)

	SNNP region as a whole		Northwestern SNNP		
	1st Year Surplus	2nd and 3rd year total surplus	% of total regional production	1st Year Surplus	2nd and 3rd year total surplus
Potato	197,990.9	123,510.4	25.76%	50,992.99	31,810.38
Lentil	4,062.303	2,534.139	100%	4,062.303	2,534.139
Sweet potato	3,313.396	2,066.959	75.63%	2,505.896	1,563.225
Total	205,366.6	128,111.5		57,561.19	35,907.74

Note: Calculations for the SNNP region as a whole are based on data provided by CIMMYT, 2022. Northwestern SNNP calculations, specifically percentage of total production in the northwestern SNNP relative to the whole of the SNNP region is calculated using zonal calculations for the selected zones (listed above) from the Central Statistics Agency (CSA's) Agricultural Sample Survey 2019/20. Therefore, the table indicates that the selected northwestern SNNP zones account for 25.76%, 100%, and 75.63%, of the total production of potato, lentil, and sweet potato, respectively, in the SNNP region. Subsequently, the 1st-3rd year surpluses for the northwestern SNNP region are deduced based on these calculations. All calculations assume the cost of lime is $100 USD/Mt.

Specifically in the northwestern SNNP region, potato provides 50,992.99USD economic surplus within the first year and 82,803.37 USD by the third year from lime usage.[51] Potato is grown in the northeastern Dawro, Keffa, and Sheka zones of the region. During the same year/season potato was being cultivated on 573.46hectarage of farmland, accounting for 4.57% of the regional hectarage used for potato cultivation. The total demand for lime (year 1 to year 3 application) in potato production in the northwestern SNNP region is 132.18 Mt.

Lentil provides 4,062.30 USD economic surplus within the first year and 6,596.44 USD by the third year of lime usage.[52] Lentil occupied 46.3hectarage of land with an extra output/productivity of 12.79Mt during the same year/season. Based on this and the ex-ante analysis on lime need, the total need/demand for lime (year 1 to year 3 application) in lentil production in the northwestern SNNP region is 104.39Mt.

Sweet potato provides 2,505.90 USD economic surplus within the first year and 4,069.12 USD by the third year of lime usage.[53] Sweet potato occupied 11,596.13hectarage of land with an extra output/productivity of 30.28Mt during the same year/season, accounting for 75.63% of the regional production. Based on this and the ex-ante analysis on lime need, the total need/demand for lime (year 1 to year 3 application) in sweet potato production in the northwestern SNNP region is 54.89Mt.

The total 93,468.93 USD economic surplus detailed above in the northwestern SNNP region - because of usage of lime - has tangible impacts on the livelihoods of farmers in the region. Over 83% of the population in SNNP live in rural areas. Most people are farmers in the region, however, there are also agro-pastoralists and pastoralist communities in the south part of the region.[54] The poverty headcount ratio in SNNP is 21%, below the national average of 24%.[55] As of January 2020, the unemployment rate stood at 16.1% with women almost three times more likely to be unemployed than men.[56] Similar to the Oromia region, while the direct impact of increased smallholder household income can be associated with increased expenditure on education and health outcomes, the indirect impacts are the long term multiplier effects these increased human development outcomes generate.

51 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year.

52 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year; Sheka zone is excluded from this calculation due to production data gaps.

53 CIMMYT, 2022; calculated using a 50% discount rate for the second year and a 25% discount rate for the third year; Sheka zone is excluded from this calculation due to production data gaps.

54 UNICEF, Situation Analysis of Children and Women: Southern Nations, Nationalities, and People, 2020

55 Ibid

56 CSA, Key Findings on the 2020 Urban Employment Unemployment Survey, 2020

Key sensitivities

The overall economic surplus generated by lime application and its impact to farmers increase with a reduction in the price of lime. This impact will be different for different regions and crops.

Western Oromia region

On average, a 20% decrease in the price of lime leads to an approximately 22.74% increase in the total economic surplus generated from liming of lentil, potato, sweet potato, bean, and ground nut in the western Oromia region.

Northwestern SNNP region

On average, a 20% decrease in the price of lime leads to an approximately 8.89% increase in the total economic surplus generated from liming of potato, lentil, and sweet potato in the northwestern SNNP.

To increase economic surplus generated by farmers, interventions need to be aimed at reducing the farmgate price of lime, potentially through farmer subsidies (demand-side) and reducing production and distribution costs).

Table 1: Sensitivity analysis of the economic surplus due to liming western Oromia

	Value [lime price: 100USD/MT]	Value [lime price: 80 USD/MT]	% Increase
Total economic surplus by year 3[57]	11.11 million	13.64 million	22.74%

On a crop-by-crop basis, a decrease in cost of lime by 20% increases the economic surplus generated from liming of lentil, potato, sweet potato, bean, and ground nut by 14.38%, 5.83%, 9.78%, 104.52%, and 306.6%, respectively, in the western Oromia region.

Crop	Time of return	Value [lime price: 100 USD/Mt]	Value [lime price: 80 USD/Mt]	% Increase
Lentil	Economic surplus by year 3	6,685,608	7,647,078	14.38%
Potato	Economic surplus by year 3	1,744,346	1,846,057	5.83%
Sweet potato	Economic surplus by year 3	1,485,824	1,631,115	9.78%
Bean	Economic surplus by year 3	1,161,112	2,374,712	104.52%
Ground nut	Economic surplus by year 3	33909.29	137876.2	306.60%

Table 2: Sensitivity analysis of the economic surplus due to liming in the northwestern SNNP

	Value [lime price: 100USD/MT]	Value [lime price: 80 USD/MT]	% Increase
Total economic surplus by year 3[58]	93,468.93	101,780.6	8.89%

On a crop-by-crop basis, a decrease in cost of lime by 20% increases the economic surplus generated from liming of potato, lentil, and sweet potato by 5.18%, 51.39%, and 15.43%, respectively, in the selected northwestern SNNP zones.

Crop	Time of return	Value [lime price: 100 USD/Mt]	Value [lime price: 80 USD/Mt]	% Increase
Potato	Economic surplus by year 3	82,803.37	87,096.09	5.18%
Lentil	Economic surplus by year 3	6,596.44	9,986.65	51.39%
Sweet potato	Economic surplus by year 3	4,069.12	4,697.86	15.45%

[57] Considering the residual effect of lime application 50% of year 1-value in Year 2 and 25% of year 1-value in Year 3

[58] Ibid

V. What it will take to achieve the economic opportunity

Demand-side opportunities are focused predominantly on awareness raising activities, while supply-side interventions are anchored on solutions that make the sector commercially viable. Interventions that are related to awareness creation supersede those that have to do with making the sector more attractive with investors as without knowledge creation and dissemination, there would be no market to address.

Demand side opportunities

Limited demand is primarily driven by lack of proof of concept and insufficient supply, resulting in high end-user cost. The sustainability of demand is required to incentivize private sector investment in the supply chain. Therefore, it is pertinent to sequence and prioritize demand generating activities that can reduce the end-user cost of lime.

Interventions to boost demand include (i) focused demonstration campaigns, (ii) leveraging model farmers and agricultural extension workers, and (iii) mass soil testing campaigns.

- **Focused demonstration campaigns** in high acidity Woredas (75% in SNNP and 68% in Oromia) and on rapidly scaling crops (lentil, potato, sweet potato, bean and ground nut) in the selected regions can significantly increase access to the proof-of-concept that many farmers are yet to grasp when it comes to liming. This could be carried out by already experienced development partners – such as GIZ – who have been involved in the sector for almost a decade.

- **Leveraging model farmers and agricultural extension workers/development agents** as entry points to the community for the diffusion of lime knowledge to farmers can increase the pace of uptake in both regions.

- **Mass soil testing campaigns** could bring laboratories closer to demand sites and equip farmers with the necessary knowledge they need on the health status of their soil for both of these regions. This sets up the foundation needed to increasing knowledge on soil acidity and associated knowledge on liming.

Recommendations

Binding constraints	Challenges	Opportunities
Demand	• **Lack of demand** due to low awareness creation and lack of proof of concept	• **Mass demonstration campaigns** to raise awareness • **Leverage model farmers and extension workers** for diffusion of lime knowledge • **Mass soil testing campaigns** to increase farmers' soil health knowledge
Supply	• **High transportation costs** increase the total cost of lime for farmers and rendering it financially unviable for the commercial value chain • **Heavily under utilized publicly-owned lime processors** fail to meet increasing lime demand	• **Leverage existing producers** - small and large-scale - to address challenges in distribution to hard-to-reach communities and fill supply gaps,respectively • **Identify modalities of financial autonomy** for government owned processing plants

Figure 5: Summary of opportunities for the lime value chain

Supply side opportunities

The commercial viability of liming is hindered by various costs incurred at every segment of the supply chain, resulting in these costs getting passed down to the user (farmer). While the country has ample lime deposits available, making the solid business case for the availability of the raw material, fees incurred from the mining stage all the way to the processing and distribution stage, increases the end-user cost of lime, weakening the business case. Therefore, in the short run, strong government support is required to jumpstart private sector investment into the sector. This support will be required up until the sector matures and becomes profitable enough (with increased and sustainable demand) and creates a win-win situation for both suppliers and the consumers.

Interventions to increase commercial viability of liming include (i) leveraging existing producers, (ii) reducing/removing taxation/ fees incurred and, (iii) identifying modalities of financial autonomy for government-owned processing plants.

- **Leveraging existing producers** that already have the experience in the market and the know-how can address future supply gaps as a response to increased demand and also supply issues that are currently present in hard-to-reach farming communities.
    - **Small-scale lime crushers** are found all over the Oromia region. With increased capacity utilization, these crushers could be utilized to supply agricultural lime for their farming communities. In this case, increased capacity utilization translates to reduction in power interruptions that results in long downtime for machineries and introducing mechanization in the mining/crushing segment of the value chain that can increase efficiency, amongst other factors.
    - **Large-scale lime processing facilities** that are located across the Oromia region – having achieved economies of scale in production and transportation – can be leveraged to reduce the high end-user cost of lime for farmers especially located in the SNNP region due to lack of local and large-scale cement factories in the region.
- **Reducing/removing taxation/fees incurred** along the value chain can contribute to making the commercial case for suppliers to enter the market. In the Oromia and Amhara region, processors expressed high production costs incurred due to these levies that cut into their margins despite high demand scenarios, making the sector unprofitable. Therefore, reducing/ removing these levies – until the sector can become profitable on its own - can increase the commercial viability of the sector and also signal government commitment to the sector.
- **Identifying modalities of financial autonomy for government-owned processing plants** in the Oromia and the SNNP regions can address their current operational and capacity-related deficiencies.
    - For example, granting them financial autonomy in some parts of their operations, such as procurement up to a certain threshold, could streamline the purchase of machinery spare parts (that takes more than two months) and decrease machinery downtime[59]

[59] Stakeholder interviews, 2021

VI. Who is required to achieve the economic opportunity and how?

Realizing the economic opportunities of lime requires the collective efforts of various actors including the private sector, development actors and government. With each of their unique value addition and know-how, harnessing the opportunities of lime in the country requires the collaborative and coordinated efforts of these actors.

The private sector can support existing gaps in production/processing/distribution segments of the value chain through availing favorable financing tools that can address demand and supply side challenges. Building on the momentum of the government just recently opening up the sector for private sector participation, the interventions detailed below are within the reach of the private sector.

Financing interventions for demand-side challenges include (i) capacity building of MFIs/ banks and other financial institutions to develop expertise in agriculture finance and create appropriate loans for farmers[60]

- **Capacity building of financial institutions to develop expertise in agricultural finance** that will enable them to create financial mechanisms to de-risk agriculture from their loan portfolios would ease financial burdens for farmers. This will empower MFIs with the know-hows of creating:
    - o **Flexible payment options** for farmers that will allow them to make repayments on their loans according to their harvest cycle and cashflows.
    - o **Time appropriate inputs/loans** that would enable farmers to increase yields and returns.
- **Attention should be given to traditionally marginalized groups in agriculture, such as women and the youth,** in the capacity building of financial institutions to understand the unique challenges these segments have in accessing agricultural finance.

[60] MasterCard Foundation, Smallholder Farmer Report Ethiopia, 2019

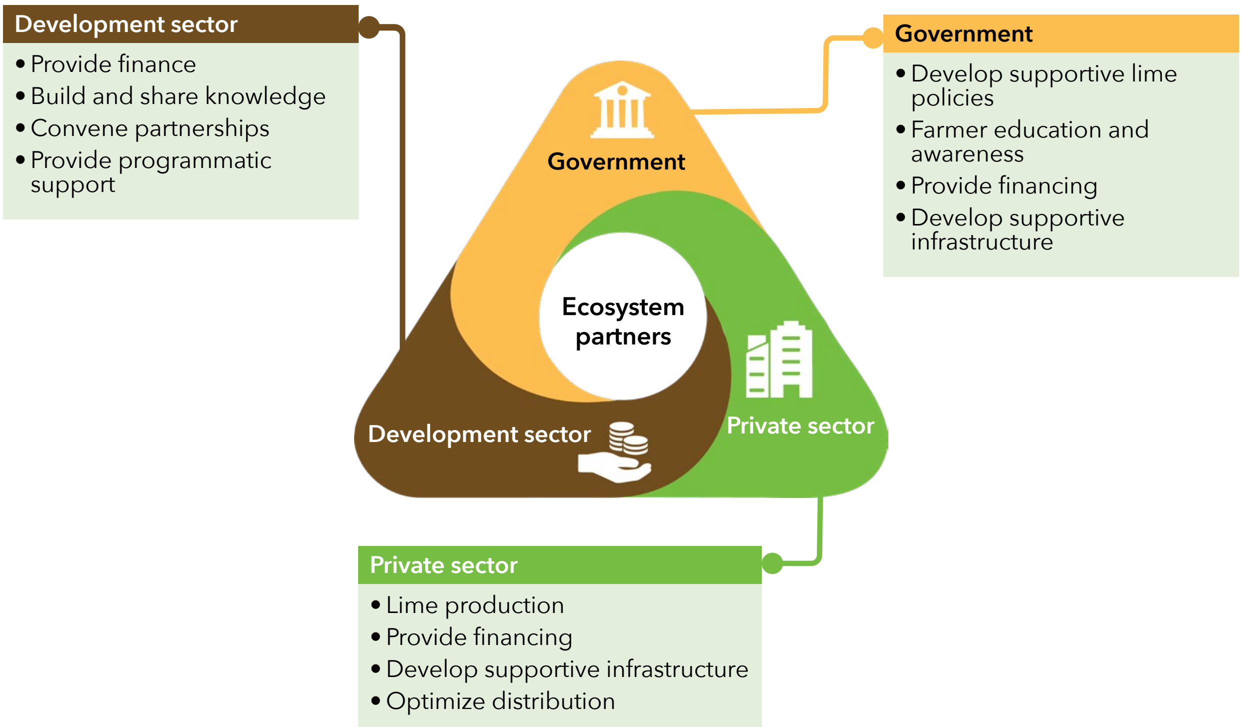


Figure 6: Role of ecosystem partners for successful implementation

Financing interventions for supply-side challenges include (i) availing sub-market/ guaranteed capital for investors, and (ii) business support services.

- **Availing sub-market capital** to supply side actors – especially those already involved in cement production and have the know-how and capabilities – can incentivize large investment into the sector. This is mostly applicable in the Oromia region, since there are very limited large scale cement manufacturers in the SNNP region. However, having achieved economies of scale in production and transportation in the Oromia region, these cement companies can further fill supply gaps in the SNNP region. Providing loans at below market interest rate – specifically for lime producers - can further signal government and private sector commitment to the lime sector, effectively lessening the perceived/actual risk of entering the market.
- **Business support services** are especially needed for small-scale lime crushers that are found in both regions to increase their organizational, management, and communication capabilities enough to make them investment ready. As demand increases overtime, these small-scale lime crushers would be instrumental in supplying lime to their hard-to reach remote surroundings, which is especially important for the SNNP region.

The development sector is vital to creating support for the initial proof-of-concept the sector needs in order to prove long-term viability. For over a decade, various development actors have been supporting awareness creation efforts on the demand side and most recently providing required infrastructure for government-owned lime crushing facilities. Keeping this momentum, the development sector can continue (i) raising lime awareness and increase efforts around (ii) strengthening the evidence base for lime, and (iii) providing programmatic support as needed.

- **Raising lime awareness** and increasing the overtime demand for lime is an intervention that supersedes all other efforts as without lime awareness/low demand, it is impossible to make a case for lime and develop a market for the sector. Therefore, the development sector can continue its demonstration efforts in coordination with the LSS mechanism to reduce the risk of undermining commercialization efforts in demonstration areas/surroundings. This is especially important for the SNNP region as most demonstration efforts are limited to the Oromia and Amhara regions[61]
- **Strengthening the evidence-base for lime** is important to increase the scientific case and increase buy-in from all levels of policy makers (federal and regional). The data gaps in lime literature including yield response to lime of various crops and variation in lime needed per ha based on soil conditions, crop types, and other factors need to be thoroughly studied to aid evidence-based policy advice.
- **Exploring alternatives to limi**ng/identifying other solutions to acidic soil management will be worthwhile to limit the spread of acidity. This includes the promotion of non-acidifying fertilizers such as Single Super Phosphate (SSP), Calcium Ammonium Nitrogen (CAN), and Nitrogen Phosphorous Potassium (NPK). This can be achieved by working with fertilizer manufacturers in the country and agro dealers to promote the use of non-acidifying fertilizers and drive awareness among farmers on the effects on acidifying fertilizers on their soils and crop yields. In addition, wood ash and biochar can be extensively explored as solutions for managing soil acidity. This requires monitoring and evaluation efforts as well as piloting to accurately assess and document the impact of soil acidity management solutions before replicating these solutions to other acidic parts of the country. (refer to annex table 2 for further analysis of solutions for managing soil acidity)
- **Providing programmatic support as needed** can fulfil the gaps that exist in physical infrastructure (machinery, soil testing kits, etc.,) and human resources (training – capacity building) in federal/regional agriculture bureaus as well as lime crushing facilities in both regions[62]

61 EIAR and HARC, Analysis of Agricultural Lime Value Chain in Ethiopia, 2022
62 Ibid

The government can create an enabling/favorable environment aimed at the development of the sector through supportive regulatory frameworks. Lessening the risk of engaging in a nascent market that has loosely defined value chains requires significant government backing and support. These include (i) the introduction of a national farmland management policy, (ii) supply-side incentives and, (iii) strengthening the current lime supply chain system.

- **Introduction of a farmland management policy** is a preventative measure the government can implement to slow down soil acidification. Ensuring soil health, at a macro level, is a good agricultural practice that prevents soil degradation, as a whole, going beyond the issue of acidification
- **Supply-side incentives** in the production, processing, and/or distribution nodes of the value chain can de-risk private investment and make the sector more attractive for supply-side actors. Signaling strong commitment from the government by introducing supply-side incentives can address investor's uncertainties that are primarily associated with the sectors' poorly defined supply chains and commercial viability as a result of lack of demand.
  - o **Reducing/removing taxation/fees** incurred at various parts of the value chain -specifically for processors involved in the production of agricultural lime - is a win-win solution that can significantly decrease the production cost of lime for suppliers and lower-end user cost for farmers.
- **Strengthening the current lime supply chain system** is a low-hanging fruit 'quick-win' solution that can effectively and efficiently align suppliers in the private sector, regional agricultural bureau, and farmers to create a well-defined/mature supply chain. Increasing the capacity of the lime supply change system and its ability to bringing stakeholders together in a coordinated manner can significantly decrease the free-handing of lime in Woredas where commercialization efforts are already underway and increase the diffusion of lime knowledge and know-how.

VII. Conclusion and next steps

The insights provided in this report are still preliminary as the data used are preliminary as GAIA continues to refine these data. Therefore, more data refinement is needed before we can recommend large investments by the government and private sector actors. However, given a high level of confidence in the economic benefit in the identified markets, efforts on the supply and demand-side should begin to be implemented to build momentum and to validate success before the development of national investments in 18-24 months.

As a next step, we recommend the following:

- **Continued research and refinement of yield response data.** The yield response data used in this report is preliminary and GAIA is continuing to refine these data, which is particularly important to building the science/evidence base to inform large investment cases for the sector. However, we have a level of confidence that we will see economic benefit in areas articulated in this investment case. Therefore, it makes economic sense to begin piloting of supply and demand side interventions of high value areas as outlined in this report, which will serve to build momentum as a use-case that can be scaled-up and diffused to other parts of the country.
- **Development of national investment plans.** Based on these learnings, in 18-24 months, undertaking a detailed market sizing analysis, assessment of supply and demand subsidies, and the sequencing of these activities is needed to create an informed national investment plan. This analysis would also include a comparison of whether investment in lime a smart value-for-money decision for farmers is as opposed to various ways their money could be spent to increasing crop production and farmer livelihoods. Upon completion, the national investment plan would be presented to and reviewed by key national stakeholders (public sector, private sector, development partners).

VIII. Annex

Annex table 1: List of stakeholders consulted and CIMMYT work packages reviewed

List of country stakeholders interviewed	
Ministry Of Agriculture	Director of Soil Fertility Directorate
Dashen Cement	Marketing Lead for Dashen Cement
CIMMYT work packages reviewed during Phase II	
Ex-ante analysis: Characterization of Acid Soils in Ethiopia; Analysis of on-Farm Trials from One Acre Fund	Characterizes the acidic soils in the focus countries
Value Chain Analysis	Studies the national policy environment related to agricultural lime in Ethiopia
Agricultural Lime Policy Review in East Africa	Studies the agricultural lime value chain in Ethiopia

Annex table 2: Analysis of solutions for managing soil acidity

Factor	Fertilizing residual materials (FRMs)	Vermicompost	Acid tolerant seeds	Lime	Wood ash
Soil impact	Neutralizes soil acidity over time	Neutralizes soil acidity faster than conventional compost and chemical fertilizers	No neutralizing impact as soil continues to acidify without treatment	Neutralizes soil acidity over time	Neutralizes soil acidity quicker than lime
Availability	Not produced locally or regionally therefore limited access in country	Could be produced at large scale locally - Guder Lime Factor in the Oromia region already has a vermicompost production center	While some are readily available, such as, potato and wild oats, the type of triticale prevalent is an imported hybrid cross between wheat and oats	There are sufficient lime deposits in the country, however, lime is not sold by agro-dealers and easily accessible by farmers, particularly SHFs	Any burnt wood can be used as wood ash, but due to the large amounts needed and detrimental climate risks associated, it may not be readily available
Cost	High cost due to need for imports	Increased cost due to the need to mix with fertilizer	Relatively inexpensive if produced in-country	Lime is relatively inexpensive (cost of distribution results in high end user prices)	Wood ash is relatively inexpensive
Ability/Ease of use	Easier to use as it is in granulated form	Easy to use as it only requires following the furrow plowed with a line of application	Easy to use compared to soil acidity management methods	Lime in its powder form is difficult to apply to farms as it is easily blown away by wind and requires safety precautions	Wood ash is in powder form, making it difficult to apply to farms as it is easily blown away by wind and requires safety precautions
Climate impact	Relatively ecologically sustainable	Ecologically sustainable	May contribute to increasing acidity of the soil	Releases carbon dioxide in processing and also in its reactions with the soil once applied on the farm	Releases carbon dioxide in processing and also in its reactions with the soil once applied on the farm

From the farmer's perspective, indicates high difficulty/barriers, indicates medium, and little or not difficulty/barriers to implementation

Annex table 4: Summary of some variables related to economic opportunities for lime in Western Oromia and Northwestern SNNP for key crops.

	Western Oromia	Northwestern SNNP
Average yield response to exchangeable acidity from liming (MT/ha)	0.71	0.19
Lime application per ha	2.66	0.27
Additional revenue within one year (USD) per ha	500.06	87.10
Additional revenue by the third year (USD) per ha	812.25	141.43
Economic surplus within one year (USD) per ha	234.03	60.29
Economic surplus by the third year (USD) per ha	380.02	97.90