Dalberg

East Africa Lime Sector Analysis: Tanzania

August 2021

EXECUTIVE SUMMARY

Soil acidity has critical adverse impacts that threaten Tanzania's food security, agribusiness potential, and industrialization agenda. Soil acidity reduces major crop yield. For instance, maize faces a 40% loss in production on acidic soil. Reduction in crop output yield also affects agribusinesses and agro-industries as they receive less agricultural inputs for processing; thus, their viability decreases. Soil acidity also reduces the effectiveness of fertilizers. This is significant as Tanzania has increased its fertilizer use from 8.6kg/ha in 2011 to 15.9kg/ha in 2018;[1] however, soil acidity reduces the effectiveness of fertilizer uptake by up to 70% on acidic soil, equating to a loss of about USD 30 million annually from lost nutrient efficiency.[2] This particularly impacts smallholder farmers' (SHFs) productivity and income, as well as their economies-as money spent on fertilizer yields little result. Consequently, crop output yield reduction and lost nutrient efficiency due to soil acidity reduces agricultural economic gains. The economic impact of yield impediment on major crop outputs due to soil acidity is estimated to be more than USD 470 million per year. If optimal crop production was ensured, excess supply could be exported, resulting in additional economic gain.

Currently, 14.3 % of Tanzania's 32.7 million hectares of cropland is acidic, and solutions to treat soil acidity remain out of reach for most farmers. While several solutions to addressing soil acidity exist globally, including Fertilizing Residual Materials (FRMs), oyster shells, acid-tolerant seeds and crop rotation, and wood ashes, differing availability and effectiveness of these solutions in the local context, as well as cost factors, limit farmer uptake.

With sufficient lime reserves in Tanzania, lime presents a viable solution to address acid soils. Conversations with two lime manufacturers with lime mining rights indicated sufficient high-quality lime reserves in Tanzania. One manufacturer possessed 126 hectares for limestone mining (eight million tons of limestone) and another 80.94 hectares of limestone (assumed to be ~five million tons[3]), which can be mined for the next 100 years.* Beyond these two lime deposits, there are numerous others located in different areas of Tanzania, although the quality of lime at these deposits remains unverified.

However, the lack of demand is a key binding constraint to the effective supply of lime. Despite smallholder farmers contributing the majority (75%) of Tanzania's agricultural production, current demand for lime is restricted to large commercial farmers and a few local government authorities, supported by civil society for demonstration plot use. Due to a combination of both limited awareness of soil acidity issues and smallholder farmer cash flow challenges, demand for lime among smallholder farmers remains severely low, despite its critical need. Demand challenges are exacerbated by the lack of policies that protect smallholders' investments on the land they farm, as most of them are tenants rather than owners of farming land. Consequently, the need to

[1] The Global Economy, Tanzania: Fertilizer Use, 2021
[2] AFAP (African Fertilizer and Agribusiness Partnership), Lime scoping study – Tanzania, 2018
[3] Based on ~8m tons divided by 126 hectares equates to ~63500 tons per hector. Assuming similar dimension of depth of reserves and that lime deposits in Tanzania are evenly spread

* Note: There are differences in how limestone deposits are evaluated in Tanzania, with some analyses including the amount of lime deposits in tons, while other analyses record the thickness of lime or the geographic coverage (acreage) of lime. For further details, please see Information on Lime Deposits and Quality in Tanzania

address soil acidity to achieve improved agricultural productivity remains largely unheeded by smallholder farmers.

Beyond demand side challenges, on the supply side, there are several key challenges across the value chain and in the enabling environment, affecting the quality and availability of lime. Two substantial supply side costs are high distribution costs which significantly increase the end cost of lime and storage limitations which constrain last-mile access and off-season production. In the enabling environment, limited initiatives to increase farmer awareness and high fees and taxes impact suppliers, hence limiting investment or new suppliers from entering the market. Without addressing demand and the gaps in the enabling ecosystem, there is likely to be limited appetite to strengthen the supply chain. Policy gaps such as the lack of national awareness and high fees and taxes in the supply chain's mining, processing, and distribution nodes further limits demand and supply. Achieving sustainability and attracting investment to scale the lime sector requires specific interventions to address the demand and supply side challenges, along with supportive policies and incentives.

ACRONYMS

Ag-lime	Agricultural Lime
DAP	Di-Ammonium Phosphate
FRMs	Fertilizing Residual Materials
GAP	Good Agricultural Practices
MoA	Ministry of Agriculture
NGOs	Non-Governmental Organizations
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SHFs	Smallholder Farmers
TanSIS	Tanzania's Soil Information System
TARI	Tanzania Agricultural Research Institute
TZS	Tanzanian Shilling
USD	US Dollar

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I. INTRODUCTION

In Tanzania, 14.3% of cropland is acidic, and with farmers increasing fertilizer use, particularly di-ammonium phosphate (DAP) and urea, this percentage is likely to increase. Despite only covering 14.3% of cropland (4.7 million hectares (ha)), acidic soils are widespread in Tanzania and likely to increase. This is because crop growing practices and DAP fertilizer, commonly and increasingly used, contribute to soil acidity.[4] Out of these 4.7 million ha, soil acidity is a binding constraint to crop growth on 2.5 million ha of cropland due to the severely high acidity levels (pH < 5.5).[5] High soil acidity is concentrated in the Northern highlands, parts of the Lake Zone, and the Central and Southern highlands, which are also food basket regions; these regions have the highest annual maize and staple crop production. Therefore, Tanzania's current and future food security is threatened by the concentration of acidic soil in food-producing regions.

Among solutions for managing soil acidity, lime is the most effective and accessible approach to achieving efficient agricultural output. Solutions to address soil acidity include

- **Fertilizing Residual Materials (FRMs)** which combine fertilizing and liming components; however, they remain scarce in developing countries due to the lime processing requirements for effective blending.[6]
- **Oyster shells** are composed of calcium carbonate, and when crushed and composted, can reduce soil acidity. However, similar to FRMs, oyster shells are scarce in African countries - Senegal is the only African country that currently produces oysters commercially; hence, supply is likely to be insufficient to fulfill Tanzania's and the regions liming needs.[7]
- **Acid-tolerant seeds and crop rotation** involves planting relatively acid-tolerant crops such as potato (or using genetically modified acid-tolerant seeds), followed by more acid-tolerant and lower yield crops such as wild oats or triticale and eucalyptus. While this approach provides a temporary solution to growing crops on acidic soil, it does not address the root cause of diminishing yields due to soil acidity.
- **Wood ashes** are relatively easy to obtain in Tanzania. While wood ash is more soluble and reactive (it changes the soil pH more quickly) than ground limestone, the quantity of wood ash required is two to four times the quantity of limestone needed.
- **Limestone** requires large volumes but is relatively easy to obtain. Given the abundance of limestone deposits in-country, lime presents the most viable solution for acidic soil management in Tanzania.

Table 1 below draws a comparison between different soil acidity management approaches.

[4] AFAP (African Fertilizer and Agribusiness Partnership), Lime scoping study – Tanzania, 2018
[5] AFAP (African Fertilizer and Agribusiness Partnership), Lime scoping study – Tanzania, 2018
[6] Nutriliming agents | FRM and alternatives to agricultural lime (agro-100.ca)
[7] The Guardian, "Oyster shells will give your soil a balanced boost", 2021

Table 1: Analysis of solutions for managing soil acidity

Factor	Fertilizing residual materials (FRMs)	Oyster shells	Acid tolerant seeds	Lime	Wood ash
Soil impact	Neutralizes soil acidity over time	Neutralizes soil acidity over time	No impact on soil acidity	Neutralizes soil acidity over time	Neutralizes soil acidity quicker than lime
Availability	Not produced locally or regionally, therefore, limited access in-country, and imports are expensive	Scarce in African countries - Senegal is the only African country that currently produces oysters commercially. Hence, there is a high likelihood of insufficient supply	Tanzania produces and imports some acid-tolerant seeds	There are sufficient lime deposits in the country; however, lime is not sold by agro-dealers and is easily accessible by farmers, particularly SHFs	Any burnt wood can be used as wood ash, but due to the large amounts needed, it may not be readily available
Cost	High cost due to need for imports	High cost due to 1. Global supply 2. Need for imports	Relatively inexpensive if produced in-country, high cost if imported	Lime is relatively inexpensive (cost of distribution results in high end-user prices)	Wood ash is relatively inexpensive unless it is commercially sold
Ability/Ease of use	Easier to use as it is in granulated form	Relatively easy to use compared to alternatives; can be harvested any time of the year	Easy to use compared to soil acidity management methods	Lime in powder form is difficult to apply to farms and handle; requires safety precautions	Wood ash is in powder form and is difficult to apply to farms and handle, requires safety precautions
Climate impact	Relatively ecologically sustainable	Can be sustainably farmed. Oysters purify the water and act as carbon capturers, sequestering nitrogen and carbon dioxide	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

Indicates high difficulty/barriers, indicates medium, and indicates little or no difficulty/barriers to implementation

*Note: Levels of difficulty in implementing are from the farmer perspective except for climate impact, which is evaluated from a national standpoint

While agricultural liming is a critical component of improving yields and food security, it is important to place liming solutions within broader efforts to develop the sector. Soil acidity is only one of several dynamics influencing agricultural productivity in Tanzania. As such, addressing soil acidity is not the cure-all to addressing agriculture productivity issues. There are challenges across the agriculture value chain: minimal mechanization, limited uptake of improved seeds and fertilizers, poor post-harvest handling mechanisms, and a need for improved market linkages, particularly export markets. Thus, focusing on expanding lime adoption should complement rather than substitute other parallel efforts and investments to boost agriculture productivity.

The GAIA Project is seeking to enhance its contribution towards healthier soils and land management towards smallholder enterprises development by developing a thorough understanding of the lime sector across all stakeholders while considering the interlinked demand, supply, and enabling environment systems. By tackling soil acidity, which greatly affects agricultural productivity, The GAIA Project aims to design and develop a national investment plan for the lime sector in Tanzania, thereby playing a critical contributing role in enhancing food security agricultural economic gains in the country.

This study set out to identify the key challenges on the supply side and identify opportunities to address the challenges. The approach to evaluating the supply side considered

challenges in the value chain and challenges in the enabling ecosystem, including policy and access to finance. This study aimed to answer the following questions:

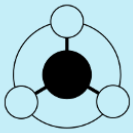
- What are the key binding constraints to the effective supply of lime?
- What are the needs and ambitions of supply chain actors?
- What can be done to improve the supply of lime in Tanzania?
- What are the opportunities and challenges in the lime value chain in Tanzania?

For this study, we implemented a mixed-methods approach with three key steps. We reviewed relevant research documents, including policy documents, industry reports, past research covering agricultural lime regulations, acidic soil management, sectoral diagnostics, and market potential analyses. In addition, we conducted stakeholder discussions to expand our qualitative analysis and insights. Our conversations focused on understanding the constraints and opportunities for ag-lime in Tanzania by speaking with 11 stakeholders spanning government, private sector, NGOs and donors, sector experts, and researcher organizations (see full list of stakeholders consulted in the annex).

The purpose of this document is to provide the context of the lime sector in Tanzania, highlight the challenges in the industry with a particular focus on the supply side, and outline opportunities for unlocking the binding constraints and remaining barriers to growth.

II. Defining and understanding the challenges in the lime supply chain

Figure 1: Overview of challenges in the lime sector

Category	Binding constraints
Demand 	• **Limited awareness of the importance of soil health and little knowledge of soil acidity management** have contributed to low demand for lime • **Cost factors also influence demand for lime particularly for smallholder farmers.** Existing demand is largely driven by commercial farmers • **The high cost of lime to the end consumer is largely driven by the cost of distribution;** distribution accounts for more than 40% of the final price of lime
Supply 	• **Limited warehousing facilities** affect lime processors' ability to produce lime in a timely manner and ensure high utilization • **Distribution is a binding constraint in the supply chain**, driven by limited demand, diseconomies of scale, and informality • **Few agro-dealers stock lime**, and those who do are less rurally located. Generally, agro-dealers face a lack of adequate storage facilities for lime
Enabling environment 	• While the Government of Tanzania has made **strides towards increasing soil testing by supplying mobile soil testing kits, the kits are barely used**, and most smallholder farmers (SHFs) do not test their soil before using inputs such as lime • **Lime is currently taxed as a mineral** rather than an agricultural input in Tanzania, accumulating several royalties and fees • While there has been considerable government effort towards encouraging fertilizer use across the country, there has been **limited encouragement of lime use, arising from limited understanding of soil health and productivity challenges posed by soil acidity**

The demand side

Limited demand is a binding constraint to the increased supply of ag lime in Tanzania

Limited awareness of the importance of soil health and inadequate knowledge of soil acidity management across different stakeholder categories in Tanzania has resulted in minimal demand for lime. Tanzania's soil health analysis and mapping approach has been largely decentralized and conducted by large commercial farmers, a few agricultural input suppliers, and a few regional government players supported by civil society. Consequently, information on soil acidity and the importance of lime remains siloed to very few stakeholders, with limited national reach.

From a nationwide perspective, most national soil acidity maps are based on legacy data, with a few site-specific updates provided (such as soil testing in the Southern Agricultural Growth Corridor regions – SAGCOT). Tanzania's Soil Information System (TanSIS) was launched relatively recently in 2015. Prior to this, country-wide soil property maps with full coverage dated back to the 1990s. There is, therefore, limited understanding of soil needs and acidity at a national level. One constraint to extensive soil testing and soil health analysis is that it is prohibitively expensive. SoilDoc, a common portable soil testing kit, retails at USD 4,000, which is an exorbitant price for

farmers, even for members of cooperatives.[8] In addition, soil testing kits require the repurchase of reagents, posing a significant impediment since reagents are often not available in the market, need to be imported, and are often not readily or promptly procured. Reagent depletion depends on the number of samples taken with a soil testing kit; for instance, reagents for a kit covering 1-2 villages can last about three months.[9] While the Ministry of Agriculture has procured and continues to purchase mobile soil testing kits to generate understanding of Tanzania's soil health, these portable soil testing kits are expensive, last only a few years, and there are often challenges with agricultural extension officers' ability to interpret their results for farmers accurately.[10] As a result, most soil testing kits are not used, further exacerbating the lack of awareness. However, with government and development partner investment in purchasing portable soil testing kits and capacity building for extension officers, soil testing through portable kits such as SoilDoc may provide farmers with a practical and affordable soil testing method. Soil tests can cost TZS 7,000/= per test ($3), not including the labor cost of a professional to conduct the testing.[11] If an extension officer can conduct ten tests in one day, a conservative figure, the total cost for a farmer could be just under 10,000 TZS ($4.30).[12]

From the farmers' perspective, Good Agricultural Practices (GAP) training provided by the government are not harmonized and have little emphasis on soil testing and using lime to manage soil acidity. While there is national emphasis on the use of fertilizer, very few regions emphasize soil testing and managing soil acidity by using lime[13]. In addition, there are some disparities in GAP training offered by region, sometimes due to a lack of civil society and private sector coordination and support. This is evidenced by preliminary training and demonstrations of lime use in a few regions such as Njombe and Iringa. Smallholder farmers particularly rely on information and the availability of agricultural extension officers from the public sector when encountering productivity issues. However, at times, agricultural extension officers are not available when needed and, when they are, do not have the awareness and knowledge of soil testing and liming to pass on to the farmer. Consequently, most farmers have limited awareness and little incentive to understand details of their soil's health and have limited knowledge of the benefits of liming.

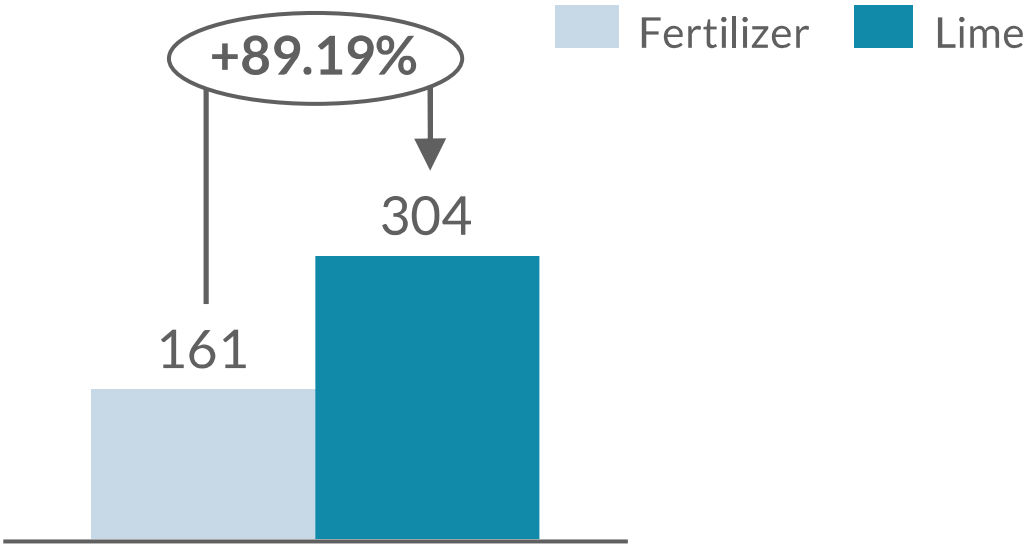
Furthermore, efforts from development partners and the private sector to increase lime awareness, demand, and uptake have had limited wide-scale impact. They are often restricted in scale, and most farmers do not adequately understand or trust private sector messaging. While a few development partners, in collaboration with the private sector, have offered training and targeted communication to encourage soil testing and lime use, farmers are more likely to believe and trusted messaging from the government. Hence, development partner and private sector initiatives for increasing the awareness of lime have been limited for two reasons; first, because farmers have low trust in private sector messaging, and second because development partner efforts have been independent and limited in geographic scale focusing on specific regions and councils. Without a nationwide effort from the government to develop a thorough understanding

[8] USAID Feed the Future, Evaluation of Portable Soil Test Kits Promoted for Use by Smallholder Farmers to Make Site-Specific Fertilization Decisions, 2017
[9] Dalberg, stakeholder interviews, 2021
[10] Daily News, Govt to procure mobile soil testing kits for all councils, 2021;
[11] USAID Feed the Future, Increasing Maize Yields with Soil Testing and Subsidies in Tanzania, 2020
[12] USAID Feed the Future, Increasing Maize Yields with Soil Testing and Subsidies in Tanzania, 2020
[13] Stakeholder interviews

of soil acidity and its solutions, it is difficult to accurately position lime as a solution for soil acidity management and encourage farmer uptake of lime.

Besides awareness, the end cost of lime further restricts demand, particularly for smallholder farmers. The large quantities of lime required for acidic soil present a high-cost barrier to smallholder farmers. Lime presents a significant cost for smallholder farmers- on average, 2.5 metric tons per hectare of lime are needed for acidic soil, costing USD 103 – 112 /metric tons. Meanwhile, smallholder farmers' annual income ranges from USD 516- 1032; thus, per hectare, the costs of lime amount to about 27-50% of smallholder farmers' annual income. In addition, as shown in **Error! Reference source not found.**, lime is ~90% more expensive than fertilizer. The familiarity of fertilizer use and the lack of awareness of the benefits of lime mean that smallholder farmers often forgo lime in favor of fertilizer, improved seeds, other inputs, and labor.

Figure 2: Costs of lime vs. fertilizer per hectare in USD[*14]*



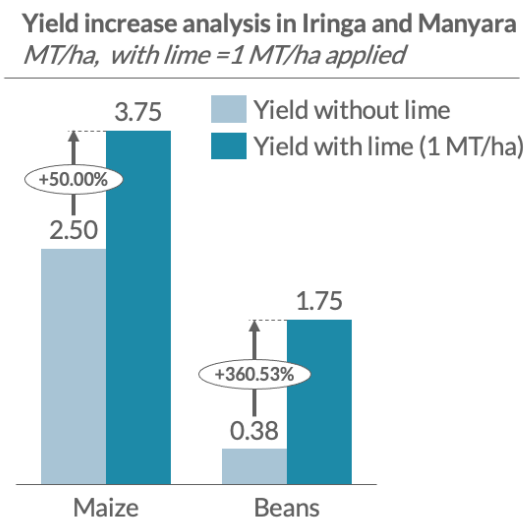
In addition, the yield improvements resulting from lime, and comparable profit increases are likely to be insufficient to justify the current cost of lime, especially for maize, a commonly farmed smallholder staple. Lime application trials for maize, beans, and barley resulted in yield improvements of 50%, 360%, and 220%, leading to comparable profit increases for farmers of USD 84.30, USD 589.70, and USD 2,268.60 respectively. Nevertheless, for maize, this is not enough to cover the costs of lime needed.

Figure 3: Yield improvements with lime[15]

[*] Please note that this makes a comparison of the annual investment in fertilizer (often recurring), while lime needs a 3-4 year investment to neutralize acidic soil and then is likely no longer needed

[14] AFAP, Lime Scoping Study – Tanzania, 2018

[15] AFAP, Lime Scoping Study – Tanzania, 2018



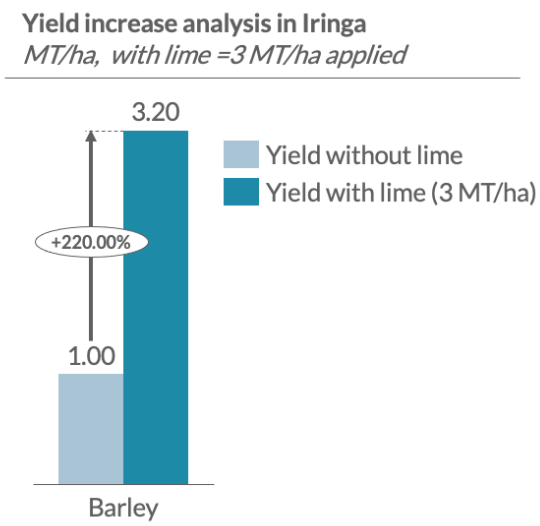


*Table 2: Yield improvement and revenue analysis** [16,17,18,19]

Price of lime (USD/ha) *assuming 2.5 MT/ha	Yield increase	Maize yield (MT/ha)	Maize revenue (USD) (USD 150/MT)	Beans yield (MT/ha)	Beans revenue (USD) (USD 819.40/MT)
	0%	2.5	375	0.38	311.27
	25%	3.13	468.75	0.48	389.22
312.5	50%	3.75	562.50	0.57	467.06
	75%	4.38	656.25	0.67	544.90
	100%	5.00	750.00	0.76	622.74

*Note: These revenues do not account for costs incurred by the farmer for inputs (seed costs can range from USD 50 to 100/ha, fertilizer costs from USD 161/ha) and labor. As a result, we estimate that using lime results in a loss for farmers producing maize and beans unless there are yield increases of more than 50% and 75% respectively.

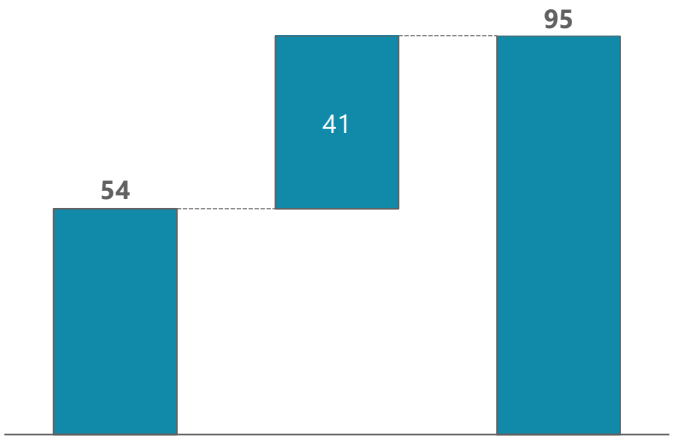
For maize and beans, yield increases from 0-50% are unlikely to be sufficient to cover the costs of lime and other essential inputs needed. Therefore, amplifying farmer demand and willingness and ability to pay for ag lime, needs significant yield improvements. Yield improvements can be facilitated though soil testing which informs agricultural practices and input

[16] Bank of Tanzania, Annual Report 2019-2020, 2020
[17] Netherlands Enterprise Agency, Seed Potatoes Tanzania, n.d,
[18] Dalberg Stakeholder interviews (price of maize), 2021
[19] AFAP, Lime Scoping Study – Tanzania, 2018

purchase, correct lime application practices, and improved quality of lime. Another demand enabler would be ensuring low ag lime prices (which can be achieved through reducing costs in the value chain or offering a subsidy). To optimize the ag lime value chain, demand and supply side efforts are needed, i.e., increasing awareness and improving lime application practices on the demand side, and improving quality and reducing costs on the supply side.

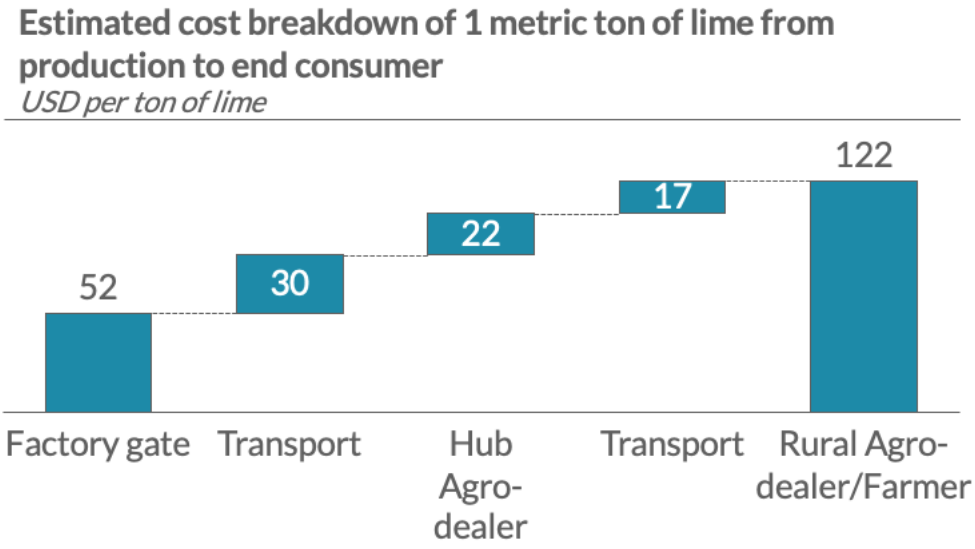
The high-end cost of lime is primarily driven by distribution costs, which, as shown in **Error! Reference source not found.**, account for more than 40% of the final price of lime. On average, each metric ton of lime costs USD 43 to transport. In Tanzania, distribution is often informal. As a result, while final transport costs may roughly depend on the distance, prices vary depending on the season. For example, the cost of transportation during the rainy season is higher than during the dry season due to the difficulty in navigating and transporting bulk products on dilapidated rural roads. Smallholder farmers mainly purchase their inputs, including lime, from agro-dealers, their closest purchase point. However, they can seldom afford lime unless they are part of subsidized programs or credit purchase schemes from Farmer Based organizations like One Acre Fund. Despite the burden of costs falling heavily on farmers, transportation costs also squeeze lime suppliers' margins as they attempt to keep the final price down to encourage demand. As a result, manufacturers and distributors have little incentive to supply areas where demand is low (for instance, where only a few farmers need lime and have low acreage) unless farmers are willing to take on the full burden of transportation costs and are likely to be repeat customers. Ultimately, farmers bear the cost burden of lime since there is limited competition among suppliers to keep costs and hence, prices low.

Figure 4: Estimated cost breakdown of 1MT of lime from production to end consumer, USD/MT



Price range	USD 40 – 60	USD 41 - 60	USD 95– 125
Main sales	Large-scale commercial farmers	Large and medium- scale farmers	Small holder farmers

*Figure 5: Cost breakdown among lime supply actors**



*Net profit for Agro-dealer is USD 8.70 per MT after handling and marketing costs

Another cost-associated constraint is the long-term investment required for lime and inadequate land rent policies that further disincentivize farmers' investment in lime. Lime takes about two to four years to change soil pH. Only then do farmers realize improved crop yields and a return on their investment. In addition, smallholder farmers have limited incentive to purchase lime in large volumes for effective soil treatment through broadcasting application (spreading lime across the entire farm as compared to spot-treatment of lime – which is using lime at the crop site). Expected yield increases utilizing banding applications and spot treatment are less than broadcasting, approximately 15 - 20% above untreated soils in year one.[20] This is because most smallholder farmers rent the land they farm on and may not have the assurance that they can continue to lease the land to reap the full benefits of the long-term investment in lime. Given their lower incomes, without rapid evidence of success. SHFs are reluctant to invest in using lime.

Moreover, as shown in Table 2, current lime practices do not adhere to best practices and recommendations for using lime, resulting in sub-optimal outcomes that further dampen demand for lime. For example, most smallholders apply lime during the planting season (rainy season) instead of two months before the rains for maximum effectiveness. The timing of farmer lime application (during the rainy season) also leads to distribution challenges and inconveniences suppliers. In addition, farmers often use a spot treatment of lime instead of across the entire field, which results in lower lime effectiveness and lengthier and more variable outcomes. As a result, current demand for lime is limited to commercial farmers and some local governments, supported by civil society for demonstration plot use.

[20] AFAP (African Fertilizer and Agribusiness Partnership), Lime scoping study – Tanzania, 2018

Table 3: Current vs. best practices in ag lime application

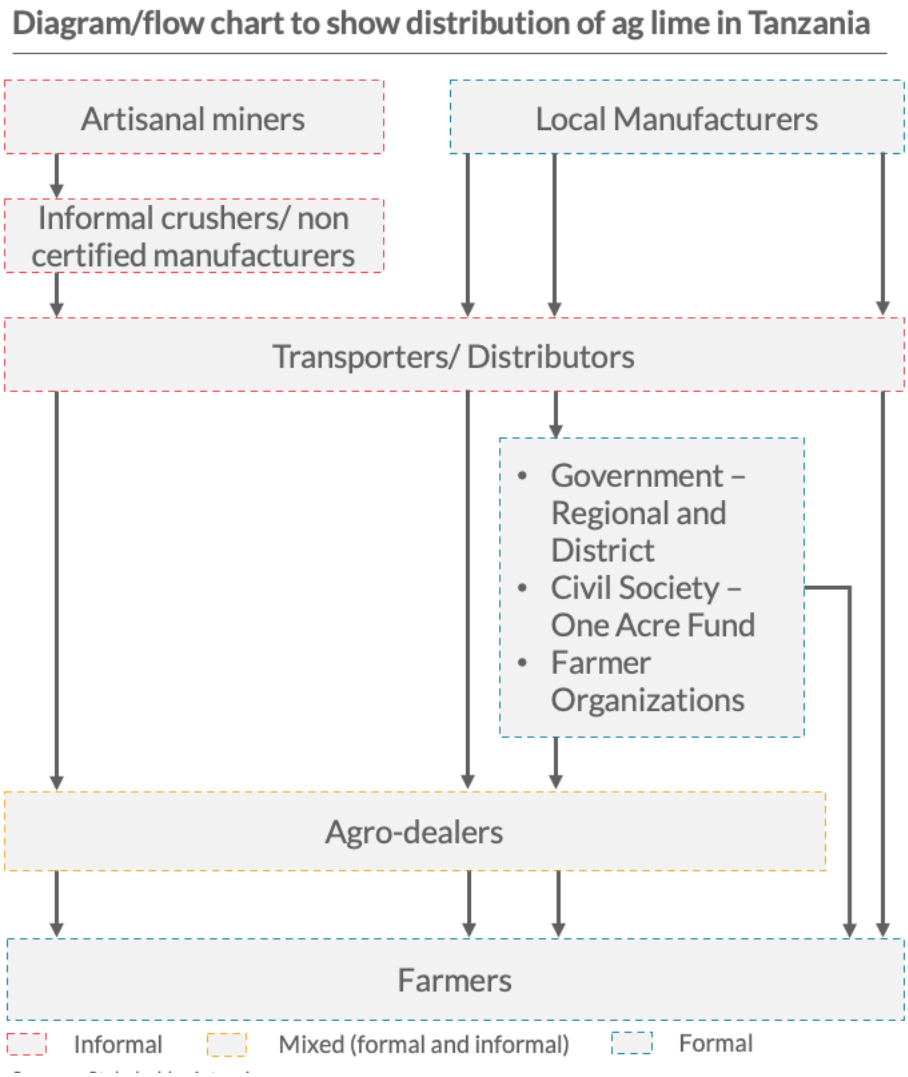
	Current practices	Best Practices
Timing	• Applied by farmers during the planting season, which leads to high demand for lime during the rainy season	• Applying lime two months before planting, during the dry season
Quantity	• Applied and purchased randomly, generally 1-2 tons per hectare, with limited understanding of the reasoning behind specific volumes	• Conducting soil tests to understand soil health and PH levels • Understanding the composition of lime being used with a focus on the % of CaCO3
Application method	• Micro-dosing/spot treatment application: lime is applied at the specific point of planting • Banding: lime is applied in bands where crops are planted across the field	• Broadcasting: lime is spread across the entire farm
Record keeping and monitoring	• No monitoring and evaluation conducted to understand the difference in yield from lime application (with varied application methods, timings, and quantities)	• Active record-keeping of lime amounts applied, application method, and the subsequent effect on yield

A lack of suitable financing options further aggravates the demand-side challenges for smallholder farmers' ability to purchase and use lime. Current financing options have shorter loan repayment period and are geared towards farmers using other inputs such as fertilizers, which are low cost and yield results and incomes within a shorter timeframe. Therefore, farmers are more confident in taking such loans (for fertilizers) as there is a high likelihood that they will be able to repay them. However, since lime is a longer-term investment and takes a long time to yield results, smallholder farmers are less likely to take on the risk of borrowing for lime, with fewer opportunities for timely repayment.

The supply side

The key components and interaction in Tanzania's lime supply chain are detailed as follows in **Error! Reference source not found.**. Tanzania's supply chain has high levels of informality that affect quality control and cost stability.

Figure 6: Diagram/flow chart to show the distribution of ag lime in Tanzania



- **Local manufacturers:** The leading ag lime producer is Dodoma Cement (incidentally only produces ag lime and gypsum and no cement). While there are other lime producers such as Tanga cement, the quality of their lime does not compare to Dodoma Cement's making it less suitable for agricultural use. Dodoma cement has a monopoly in agricultural lime production. Nevertheless, there are numerous other high quality lime deposits that can be used for ag lime in Tanzania that have not yet been exploited.

- **Distributors.** There are no established distribution networks for agricultural lime, Dodoma Cement supplies Free on Truck (FoT) ex works. However, there are well-established distribution networks for cement.

- **Government, Civil Society, and Farmer Based Organizations.** Given sufficient demand, and availability of warehouses or ability to deliver directly to farmers, these actors can order directly from Dodoma cement, bypassing some of the additional costs of using agro-dealers.

- **Agro-dealers.** These are critical players who serve as the interface between farmers and lime (along with other inputs). They also provide advisory support to farmers on the use of lime and other inputs.

Most of the current demand for lime is concentrated in the construction sector for cement manufacturing. In addition, there is high demand for hydrated lime, which is used for processing in sugar factories and gold mining. However, despite the country needing about 9.5 million tonnes of agricultural lime, there is low demand for it, as it is relatively new and unknown. As a result of low demand, there are few large-scale investments in agricultural lime mining, processing, and distribution. Lime producers and agro-dealers have ambitions for expanding manufacturing and retailing (including warehousing and storage capacity), however, low demand prevents their further investments in the sector. Consequently, there are very few ag lime supply side actors in Tanzania, with limited competition and incentive to address inefficiencies in the ag lime supply chain and reduce costs.

Table 4: Lime requirement estimates for Tanzania [21]

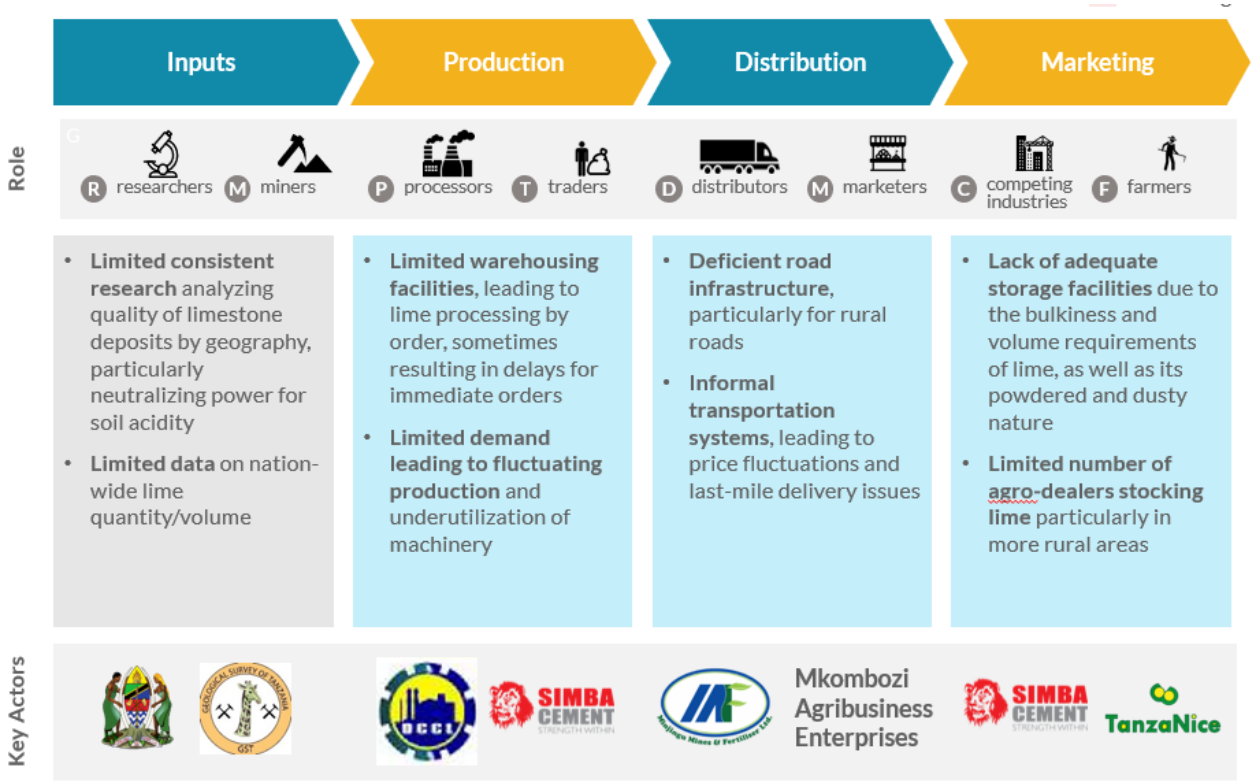
Agricultural zones	% Cover of total acidic cropland (4.7 million ha)	Acidic soil area in ha	Lime 0.5 MT/ha	Lime 2 MT/ha	Lime 3 MT/ha
Lake and Western zones	45	**2,115,000**	1,057,500	423,000	634,500
Southern Highlands and Southern Zones	35	**1,645,000**	822,500	329,000	493,500
Central, North, Eastern, and Zanzibar	20	**940,000**	470,000	188,000	282,000
Total	**100**	**4,700,000**	**1,880,000**	**940,000**	**2,220,480**
Total lime need (MT)	**9,481,440**		**940,000**	**1,880,000**	**6,661,440**

Across the supply chain, challenges with lime storage and distribution are the key bottlenecks to the growth of the sector

Error! Reference source not found. shows the key challenges across the lime supply chain.

[21] AFAP, Lime Scoping Study – Tanzania, 2018

Figure 6: Lime supply chain challenges

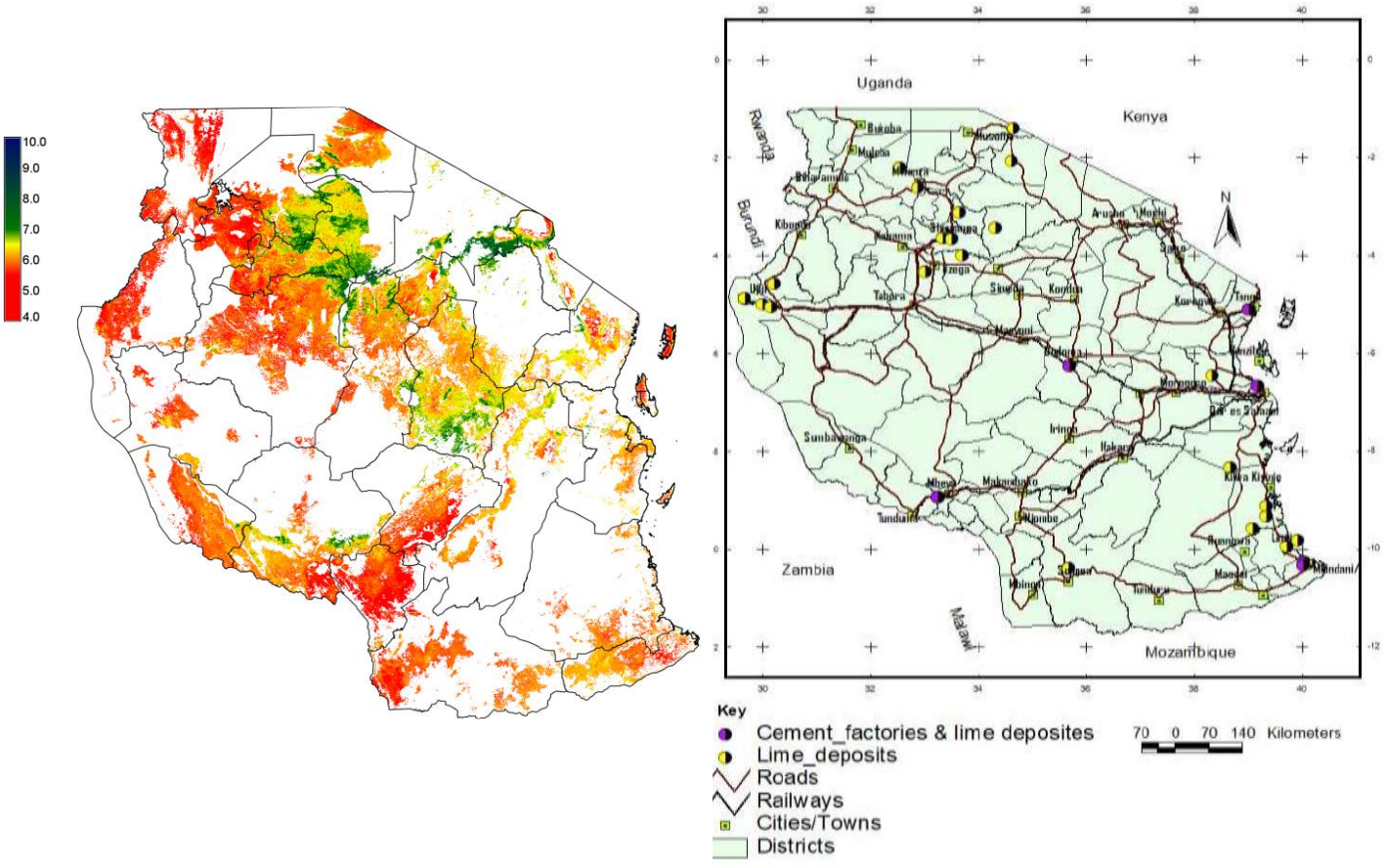


Limited warehousing facilities critically affect lime processors' ability to produce lime on time and ensure high utilization. Ag-lime processors are often unable to deliver large quantities of lime on demand due to limited warehousing facilities. Limited and sporadic demand means that processors are not incentivized to incur the cost of warehousing facilities. As a result, ag-lime processors require farmers to pre-order lime and order off-season to ensure timely delivery. However, this requires farmers to have sufficient and timely knowledge on their soil health and status and awareness of lime as a solution, which is often not the case. In addition, while lime can only be mined during the dry season, some farmers demand lime during the rainy season due to their erroneous belief that lime is better absorbed in wet soil. As a result, seasonal and low demand means that agricultural lime processors struggle with the effective utilization of capital and have limited appetite to grow their businesses and improve the quality of output. This also disincentivizes competition, which could further improve quality, storage, distribution, and lower costs.

Lack of adequate storage facilities further results in few agro-dealers stocking lime, and those that do tend to be based in urban and peri-urban areas. As lime is a bulk product, it requires sufficient storage facilities, which most agro-dealers do not have. As a result, the entire lime distribution and retail system is currently based on demand and orders from existing on-demand customers rather than new ones. Limited demand means that very few agro-dealers stock and sell lime, and those that do, are located in urban and peri-urban areas. Hub agro-dealers who are often larger and situated in towns are more likely to stock lime for commercial farmers. However, Village-Based Agro-dealers (VBAs) are unlikely to stock lime unless supported by civil society actors due to its cost and low selling prospects.

The cost of distribution is a binding constraint in the supply chain. As shown in Figure 4, while there are several lime deposits near areas of high soil acidity, most of these deposits have not been mined or used, and some are inactive. Limited demand for lime is a constraint to the additional investment required to develop lime deposits closer to areas of high soil acidity. The leading ag-lime supplier is Dodoma cement (at 90% market share), located in central Tanzania - a significant distance from farmers who need lime. As noted earlier, lime is transported using informal distribution systems, and distributors request trucks with a capacity of 30MT to deliver lime to their retail points. However, since demand is limited to a few commercial farmers able to bear transportation costs, the informality of the lime distribution systems and diseconomies of scale are perpetuated. For example, consistent demand could encourage the use of railway systems. If demand were high and distribution formalized, most of the distance lime is transported could be covered by rail, which can transport large volumes at lower costs (road freight is 40% more expensive than rail freight).[22] Trucks could then provide last-mile delivery. Distribution costs are further exacerbated by the poor condition of Tanzania's rural roads, through which lime is transported to farmers.

Figure 7: Tanzania soil acidity and limestone deposit maps



Limited consistent research and data limit the identification and mining of viable lime for agriculture. While the map above indicates lime deposit locations in Tanzania, information on the type of lime, quality, and quantity of lime is insufficient, particularly information on the lime's neutralizing power for soil acidity. Historically, very few lime deposits have been evaluated qualitatively, and the quantitative data collection was inconsistent (some lime deposits mention

[22] Dalberg, Stakeholder interviews, 2021

lime thickness, while other mention lime volumes in metric tons). With limited information on the suitability of lime for agriculture and low demand, investors are hesitant to invest heavily in lime for agriculture and are more likely to re-direct their investments in lime mining towards construction. Evaluating the existing lime deposits by the public sector, perhaps supported by development partners, is essential to identifying suitable agricultural lime for managing acid soils in Tanzania.

III. CHALLENGES IN THE ENABLING ECOSYSTEM

Inadequate policies and limited encouragement of lime use are key challenges to achieving sustainable demand and supply of lime in Tanzania

In the current regulatory and macro-economic environment, most supply side actors do not see a business case to extend their capacity to address the supply side challenges and drive demand by improving the quality of lime nor facilitating greater access to lime. Specifically, taxation on lime, lack of infrastructure and road networks, limited access to finance, and inadequate land rent policies are enabling environment constraints.

The classification of lime as a mineral has led to high taxes and royalty requirements from the government. Obtaining the rights to mine lime, particularly fulfilling environmental certification requirements (NEMC), is expensive (at about USD 10,000), limiting the emergence of small to medium-sized miners and processors in the value chain and restricting competition and growth. Furthermore, lime mining and excavation generate mining royalties (4% of limestone value), annually renewable licensing fees [23], and after processing, high VAT (18%), which is prohibitive for new entrants. These policies increase the cost of lime production and, ultimately, the end cost of lime.

Tanzania lacks critical road networks and infrastructure to lessen transportation and logistical complications and potentially lower distribution costs. The state of Tanzania's rural road network and infrastructure directly impacts the cost of lime distribution. For instance, Tanzania has 56,000 km of unpassable road networks by standard motorized vehicles during the rainy season, and 13% of its regional and 42% of its district roads are in poor condition.[24] A recent increase in fuel prices due to tax increases will likely worsen distribution costs for lime (distribution costs are a significantly high-cost contributor to final lime price) in Tanzania and pass along an even greater burden to farmers, further impacting demand.[25]

Access to capital from both commercial banks and private investors remains a challenge for lime suppliers and agro-dealers. Presently, low demand and inefficient supply combined with the lack of a plan to address challenges mean investing is too risky. In addition, financing options are inadequate due to high interest rates (17% and above) and because they do not cover feasibility studies and research required as part of due diligence. Finally, accessing financing is a lengthy process resulting in working capital constraints.

[23] Annual fees include retention license fees of USD 2,000 per sq km; https://www.de.tzembassy.go.tz/uploads/TANZANIA_Mining_Industry_Investor_Guide_-_June_2015_-1_sw.pdf
[24] The World Bank, Tanzania Roads to Inclusion and Socioeconomic Opportunities (RISE) Program (P164920), 2021
[25] The Citizen, Tanzania: Fuel Prices Hit All-Time Highs On Rising Demand, Taxation, 2021

Inadequate land rent policies[26] disincentivize farmers' investment in long-term soil health. Most smallholder farmers rent the land they farm on. While most inputs such as fertilizer generate results within the crop cycle or after the rains, lime has longer timelines of two to four years. However, land rent policies currently do not cover such long-term investments. As a result, smallholder farmers often lack the assurance that they can continue to rent the land to reap the full benefits of their investment. They have limited incentive to purchase lime in large volumes for effective soil treatment.

[26] For example, 80% of the land is village land and village govt authorities may select to reallocate land towards investment; https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Review_of_the_land_tenure_systems_-_Report_on_Tanzania.pdf, pg. 25; https://www.velmalaw.co.tz/national-land-policy-2016/#:~:text=A%20draft%20National%20Land%20Policy,land%20through%20PPPs%20(para%207.2; https://abcg.org/files/documents/20171213%20Lekaita%20TZ%20Policy%20Brief_FINAL.pdf

IV. RECOMMENDATIONS TO ADDRESS THE GAPS AND ADVANCE THE SUPPLY OF LIME

There is a need for the government to drive coordination between stakeholders, including the private sector, to optimize outcomes of soil acid management in Tanzania. Limited demand for lime is driven by a core set of interconnected factors, including lack of awareness, high cost of lime, limited access to lime when needed, lack of technical knowledge and capacity, and limited land ownership by smallholder farmers. As a result, our overarching recommendation is for the government to build demand by prioritizing activities and interventions that will increase awareness, reduce cost, improve lime availability and technical knowledge, and protect farming tenants' investments.

Figure 8: Opportunities and recommendations for ag lime development

Category	Binding constraints	Opportunities
Demand 	• **Limited awareness of the importance of soil health and little knowledge of soil acidity management** have contributed to low demand for lime • **Cost factors also influence demand for lime particularly for smallholder farmers (SHFs).** Existing demand is largely driven by commercial farmers • **The high cost of lime to the end consumer is driven by the cost of distribution** which accounts for more than 40% of the final price of lime	• **Create awareness for farmers** on soil health best practices and lime use by **incorporating soil testing and lime use in GAP training** • **Provide access to credit** and guarantees for SHFs wanting to purchase lime • **Explore and innovate subsidy models** to reduce final costs of lime • Create **favorable land renting policies** for farmers that **encourage the long-term liming investment requirements**
Supply 	• **Limited warehousing facilities** critically affect lime processors' ability to produce lime in a timely manner and ensure high utilization • **Distribution is a binding constraint in the supply chain,** driven by limited demand, diseconomies of scale, and informality • **Few agro-dealers stock lime,** and those who do are less rurally located. Generally, agro-dealers face a lack of adequate storage facilities for lime	• **Facilitate investment in infrastructure** including transport, rural road and warehouses to store lime • **Incentivize increased ag-lime production and distribution** as well as new entrants **through tax breaks and VAT exemptions, and reducing/eliminating fees for ag-lime mining**
Enabling environment 	• **Most smallholder farmers (SHFs) do not test their soil** before using inputs such as lime due to access and affordability issues • **Lime is currently taxed as a mineral** rather than an agricultural input in Tanzania, accumulating several royalties and fees • There has been **limited government encouragement of lime use,** arising from limited understanding of soil health and productivity challenges posed by soil acidity	• **Rehabilitate zonal labs** for soil testing • **Develop lower cost mobile soil testing labs** with experts and subsidies soil testing • **Revise tax policy** to classify lime as an agricultural input • **Create policies to differentiate between lime miners for agriculture and construction,** reducing fees for ag-lime mining to encourage production • **Develop consistent and clear messaging** on the benefits of lime

Demand side and awareness creation opportunities

To begin with, agriculture extension officers can bolster lime demand using Good Agricultural Practices (GAP) training to increase farmers' awareness through soil health knowledge and increasing demonstration plots. The government can spur farmer demand by incorporating soil health in GAP training, scaling GAP training, and increasing demonstration plots. A vital aspect of this intervention would be strong messaging from the government that generates awareness of the importance of soil health in agricultural productivity and encourages ag-lime use for acidic soils.

Furthermore, the government and civil society can elevate the business case of using lime for farmers. In Iringa and Manyara, trial and research use of lime resulted in yield improvements of 50%, 360%, and 220% with maize, beans, and barley, leading to comparable profit increases for farmers of USD 84.30, USD 589.70, and USD 2,268.60 respectively. Nevertheless, public sector

stakeholders are not the only actors that can demonstrate lime benefits, private sector commercial farmers are also well-positioned to demonstrate the effect of lime to neighboring smallholder farmers.

The government can also expedite soil testing to update the soil data and strengthen research infrastructure, through TARI (Tanzania Agricultural Research Institute), including improved soil laboratories or mobile soil testing labs. Due to the high cost of soil testing, particularly for kit purchase, there is a need for the government to facilitate soil testing on behalf of farmers.

Figure 9: Increasing demand through soil health emphasis

	1. Incorporate soil health in GAP training, increase demonstration plots	2. Explain the 'why'	3. Facilitate soil testing
Rationale	**Farmers are unlikely to simply use lime or invest in it without a strong evidence base** for it or reasons for its importance	**Farmers need to understand the productivity gains** and income losses from using fertilizer without using lime for acidic soil	**Soil testing is expensive and time consuming for farmers** with low incomes who already face time poverty
Description	• Currently, GAP training for farmers encourages fertilizer use with limited general soil health perspectives. As a result, most farmers use inputs to solve for productivity issues without testing their soil • There is a need to incorporate and emphasize the importance of soil health in GAP training. Adequate soil health understanding will lead to correct selection of and appropriate use of lime as needed on acidic soil	• In a previous study, some SHFs used fertilizers without seeing increased productivity and were not aware of their soil pH, nor did they understand the underlying barriers to fertilizer uptake posed by soil acidity • However, even with evidence of increased yields with lime use, some SHFs may not be incentivized enough to purchase and use lime appropriately unless the rationale and economics around effective fertilizer use and uptake are explained	• Soil testing is expensive and centers for accurate testing are often a significant distance away from farms • Soil testing requires additional monetary expenses and significant time investment from SHFs who are already resource-constrained and face time-poverty • Women SHFs would face a higher burden with soil testing as they have lower incomes and higher time poverty due to cultural norms and responsibilities

The government could adopt a dual approach to further soil testing efforts: rehabilitate zonal labs and develop mobile soil testing labs. Some zonal labs for soil testing exist in Tanzania; however, most are inactive and need rehabilitation and staffing so they can be used again. Once zonal labs are rehabilitated, awareness needs to be created on the importance of soil testing and locations of zonal labs, including incentives to smallholder farmers for soil testing is required. The government could also develop and fund mobile soil testing labs. These would have experts on board and offer the benefit of covering large geographic areas while ensuring that soil tests are promptly delivered and accurately interpreted. Mobile labs have the advantage of last-mile delivery, minimize time commitments from farmers, and reduce the costs of purchasing numerous soil test kits that may not be used efficiently. Beyond soil testing, mobile labs can offer additional agronomic recommendations. For instance, in areas with low to moderate acidity, suggestions for preventative measures against soil acidification could be provided (such as crop rotation and specific fertilizer use). Overall, these soil testing initiatives need to be refreshed after a set period (for instance, every two years) to provide reliable, up-to-date data to support regular agricultural review and decision-making for increased productivity.

While offering soil testing at a fee is not a viable business model for the private sector due to the initial high investment for purchasing soil testing kits, there may be an opportunity

for private sector involvement in implementation through public private partnerships. Soil testing kits cost USD 4,000 and with low farmer incomes it would be difficult for the private sector to make a return on investment. However, if the government procures soil testing kits and the private sector tests soils at a fee (to cover reagent and expert costs), this may be a workable approach. Thus, the Ministry of Agriculture's procurement of mobile soil testing kits may generate an understanding of Tanzania's soil health and raise awareness of soil acidity. However, while farmers may develop an awareness of their soil health, demand may not increase without accompanying initiatives that address farmers' ability to pay for lime.

Led by Tanzania Agricultural Development Bank, commercial banks can provide tailored financial products and services, including relevant access to credit and guarantees for farmers to purchase lime. To better support farmers, banks can develop new financial products and innovative delivery modes alongside financial sector stakeholders and farmers to increase lime uptake. These products would need to be tailored to factor in lime as a long-term investment, with longer lead times to improve productivity and income. Loans would also need to be flexible in terms of how funds are used- to cover the purchase of lime, lime application costs, or mechanization for efficient application of lime. To improve farmer awareness, banks can require evidence of sufficient GAP training (including soil health and analysis) for ag-lime-related loan applications. Banks can also make soil testing a prerequisite for ag-lime loan acceptance and encourage loans for only high soil acidity compared to moderate acidity. In one example, farmers received soil health cards similar to vaccination cards detailing the status of their soil. Besides banks, hub and Village-Based Agro-dealers (VBAs) can also design innovative models for providing lime on credit, perhaps bundling the lime offering with other inputs, enabling farmers to slowly pay for lime rather than to pay the full costs upfront. The recent introduction of a 10% ceiling on interest rates for agricultural lending may improve access to capital and lending rates in agriculture, down from previous interest rates of 17% and higher. However, whether this is sufficient to enable farmers to access additional agricultural inputs such as lime remains unclear. It is also unclear whether this interest rate ceiling will extend to processors and agro-dealers in the lime sector due to lime's potential dual use in both construction and agriculture.

Table 5: Access to finance challenges and opportunities

Actor	Current access to finance	Challenges	Opportunities
Smallholder farmer	• Through AMCOS, MFIs, and civil society programs • Need an input financing scheme	• Credit schemes have short tenors (i.e. for fertilizer and seed) and do not support long-term lime investments • Farmers still face many access to finance challenges in Tanzania (e.g need for collateral)	• Develop patient capital for farmers, such as One Acre Fund's (OAF) 9 month loan, potentially extend tenor to longer than a year to account for yield improvement delays • Explore digital-group lending to remove some barriers to finance

Commercial farmer	• Can access finance through commercial banks, or profits from agribusiness		• Can share best practice to anchor smallholder farmer demand for lime
Producer	• Established producers in ag-lime or cement have existing access to finance streams • SMEs and new investors obtain access to finance mostly through commercial banks • access to traditional bank finance (perhaps with someone sharing their risk)	• SMEs and new investors lack the operational model, management and growth plans and governance to qualify for loans • There is little existing sectoral research and due diligence • Credit schemes have short tenors	• Development partners can guarantee some private sector loans or provide support for due diligence and operational model development • Banks can provide patient capital
Distributor	• Can access commercial loans	• There is considerable lag time between loan approval and loan distribution	• Streamline processes so that collateral is checked during the loan approval process

The government can also consider designing and launching subsidies at different points in the lime supply chain, **which can help reduce the final costs of lime and hence, encourage uptake by smallholder farmers.** While there may be willingness and interest in using lime to increase yields, smallholders often lack the financial ability to purchase and use lime, particularly when it may take more than one crop cycle to yield significant improvements to increase incomes. Subsidies at different points in the lime supply chain, as detailed in **Error! Reference source not found.**, could lower the end cost of lime for farmers while also encouraging the production and supply of lime. The distribution (transporter) stage is an advantageous node of the value chain that the government can consider issuing a subsidy for. This node cuts across the supply chain and has the highest costs. Applying a subsidy at this stage. with select distributors may formalize actors and stabilize lime prices for farmers.

Table 6: Potential subsidy intervention points

Subsidy point	Description	Risks	Risk Mitigation
Manufacturing	• Issuing of subsidies to manufacturers who can then sell the lime at lower costs from the factory gate • This is **expected to lead to a lower trickle-down price that gets lime to farmers cheaply** • Alternatively, manufacturers can also be **issued with a subsidy based on the results of their lime use,** e.g., how	• The **subsidy issued to manufacturers does not trickle down to the farmer** as other players in the distribution chain add higher mark-ups	• Add a **price ceiling to factory gate prices,** ensuring that they do not exceed a certain amount • Add a **distribution clause for manufacturers** and **targets for smallholder farmer reach**

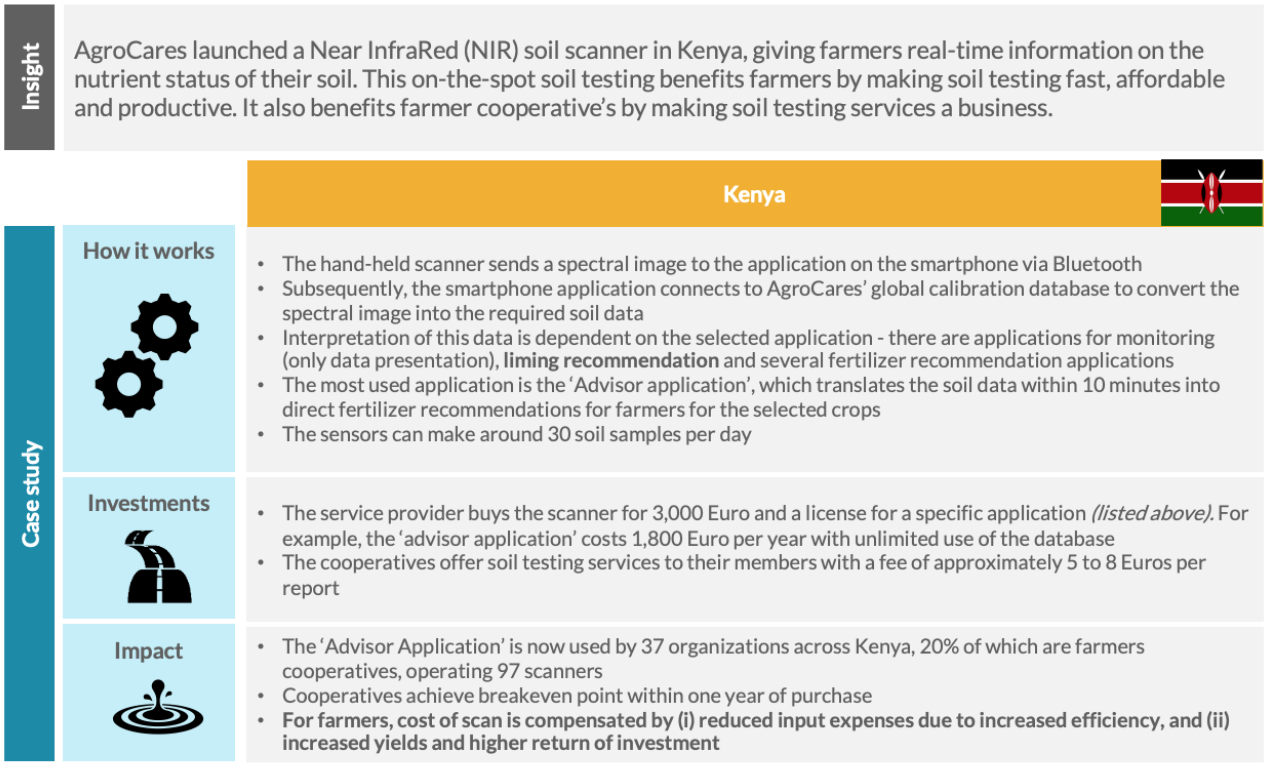
	much was the soil PH changed based on the lime		
Distribution, Retailer, and stockists	• Issuing of subsidies to distributors, agro-dealers, and village-based associations, particularly those who are closest to farmers or provide last-mile distribution services	• **Several distributors, retailers, and stockists are not tax registered** and therefore cannot be eligible for rolling out government or NGO subsidies	• Encourage registration and formalization of agricultural input distributors and stockists, such as by **offering tax exemptions for new registrants before offering the subsidy**
Farmer	• Provision of **direct subsidies to farmers through voucher systems dependent on soil pH or purchase at lower than market prices** from government or Farmer Based organizations	• Once accustomed to the subsidy, **farmers are not able to transition to higher regular market prices and** therefore **do not purchase lime once subsidies stop**	• **Careful design of the subsidy** including farmer contribution from the beginning, develop widespread and suitable credit schemes for when the subsidy is stopped

Favorable land rent policies are required to incentivize forward-looking agricultural practices and investments. As noted earlier, lime timelines for results, limited first-year crop responses, quantities, and costs required for effectiveness often disincentivize smallholder farmer investment in lime. This is compounded by the fact that most smallholder farmers rent their land and do not have the assurance that they can continue to farm the land in the coming years to reap the full benefits of their investment in liming. Moreover, given their lower incomes, making the significant investment required by lime may prove challenging. Therefore, it is essential to create favorable land rent policies for farmers that allow farming for longer lease terms and protect agricultural investments made by the farmer to encourage increased agricultural productivity.

To further drive demand, private sector actors can use technology and mechanization to drive awareness and encourage use of lime. Kenya displays a good example of private sector involvement in demand creation through AgroCares soil testing, which commercializes an essential service in the value chain. Correspondingly, Dodoma Cement can draw from lessons learnt from AgroCares and invest in a tech platform for farmers that can collate research conducted by various players on soil acidity by location. Alternatively, Dodoma Cement can use a USSD system to raise awareness of lime, communicate best practices and drive demand, however, due to farmer trust in government messaging, these efforts would need to be made in collaboration with government. In addition, agro-dealers can invest in purchasing agricultural machinery (such as tractors with lime-spreaders) and rent them out to farmers for more efficient lime application. For instance, HelloTractor in Kenya and Nigeria rents out tractors to groups of smallholder farmers and has

created a profitable model through its advisor and extension network for loaning agricultural machinery. Building capabilities for agricultural machinery renting would have two-fold benefits for agro-dealers: i.) expanding their product line and increasing profit, and ii) building a network of agro-dealers would give hub agro-dealers a deeper rural reach and simplify expansion.

Figure 10: Kenya private sector soil testing case study



Supply side and enabling environment opportunities

In parallel, on the supply side, fiscal incentives can facilitate and incentivize greater ag-lime production and distribution and address some of the challenges faced by businesses. There is currently limited appetite for private sector investment in lime. This is driven by the limited demand for lime and lack of supportive policies to encourage new entrants. The government can reduce or eliminate ag-lime mining and production fees and offer tax breaks and VAT exemptions for several years to catalyze ag-lime production and supply. To facilitate this, there is a need for specific policies that differentiate between lime produced for construction as compared to lime produced for agriculture (such as packaging or labeling requirements that adhere to quality standards), which would also encourage new entrants or cement manufacturer expansion into ag-lime production.

In addition, the government and development partners can continue to invest in transport and rural road infrastructure. TARURA, established in 2017, is the dedicated government arm that invests in and develops rural roads. The government can continue to invest in road and rural road infrastructure to address transportation roadblocks during the rainy season and reduce distribution costs. If lime demand radically increases, rail freight could be an important channel for the distribution of lime; thus, the government should move forward with its rail freight targets. Tanzania's National Transport Policy has set ambitious targets for major transport services, for which rail freight and road transport are most relevant for lime as a bulky product. Tanzania's goal

is to increase rail freight to 4 million tons by 2023; however, lime will continue to use informal and expensive distribution methods without sufficient demand. Finally, the government can invest in large-scale renewable energy projects to support lime-processing electricity needs and infrastructure warehousing projects to facilitate greater lime industry utilization and year-round lime production.

For lime suppliers, banks can improve internal processes and efficiency to reduce the time it takes to get loans. Banks can streamline loan application processes to ensure rapid loan approval and disbursement, with the time between application submission and loan disbursement taking a maximum of two weeks.

Supply-side actors can explore options for improving the commercial viability of supplying high-quality lime at a low cost. As a starting point, it would be helpful to understand whether current capacity constraints and scaling abilities could best be solved through a 'build, expand, or partner' approach to reduce costs. The expand and partner approaches could entail cement companies expanding into ag lime production (provided they have high – above 90% - calcium carbonate equivalents in their lime deposits) to use their economies of scale and existing distribution networks. To address storage challenges, private sector manufacturers and agro-dealers can engage village leaders to make use of the mostly vacant village warehouses, present in almost every village in Tanzania given the country's socialist history. Using existing facilities and partnering with village governments can lower costs of storage in comparison to greenfield investments for setting up storage or warehousing facilities.

While a few promising initiatives under development may effectively improve the supply of lime without increased demand, these interventions are unlikely to be viable or successful in the long term. Initiatives such as plans to improve road infrastructure and rail freight as well as policies on interest rate ceilings that encourage increased borrowing from manufacturers may help increase the supply of lime. Nevertheless, to best inform policy and practice, there is a need to conduct research and develop databases that track demand amongst other metrics in the lime sector.

V. NEXT STEPS

The agricultural sector accounts for 26.7% of Tanzania's Gross Domestic Product[27,28] provides a livelihood to 65% of the country's labor force,[29] accounts for about 30% of foreign exchange earnings, and contributes more than 65% of raw materials to the industrial sector.[30]

Acid soils threaten all the benefits derived from agriculture, and lime is a crucial and viable agricultural input to address soil acidity. The economic impact of yield impediment on primary crop outputs due to soil acidity is estimated to be more than USD 470 million per year. With sufficient lime reserves, lime presents a viable solution to address acid soils in Tanzania.

This study focused on identifying the critical challenges in the supply side of the lime sector and opportunities to address the challenges. Our analysis revealed that limited demand is a key binding constraint to the supply of lime in Tanzania, driven by limited awareness and the high cost of lime. In addition, the lack of demand and unfavorable policy environment are key constraints to investment appetite. Nevertheless, the demand challenge cannot be tackled singularly, as our study reveals that demand, supply, and the enabling environment are strongly interlinked.

As a first step, we recommend that stakeholders discuss and align on the outputs of all work packages. Tanzania faces considerable data issues and limited reliable databases; therefore, a reliable and up-to-date repository that can inform policy and practice would be helpful. Besides our work package, GAIA has commissioned different work packages focuses on i) alternative investments in soil acidity, ii) incentives to adopt soil management, iii) knowledge gaps on the impact of lime, iv) policies to support investment, v) multistakeholder collaboration, vi) access and use of data, etc. Engaging with different work package teams will ensure an adequate understanding of the core challenges and interlinkages between demand, supply, and policy. This will enable stakeholders to align and collaborate in developing tailored solutions and is a prerequisite to developing a national investment plan.

Recognizing the importance of agriculture, there is a need to build commitment to increase resource allocation to the sector- improving demand and supply (for example, through capacity-building and other interventions) to enable liming to deliver clear results and outcomes at a grassroots level.

As noted in this report, this requires supportive policies, informed by a diagnosis of the current situation and relevant financing mechanisms to enable private sector investment to achieve sustainability and growth in the sector. Expanding agricultural liming also requires effective multi-sectoral and multistakeholder coordination mechanisms to adequately understand and promptly respond to challenges.

Based on our findings on the supply side, the specific technical areas required to achieve growth of liming in Tanzania include:

- **Adopting a research-grounded, evidence-based approach to inform priorities and interventions for increasing agricultural productivity.** To ensure successful agricultural

[27] Statista, Tanzania: Share of economic sectors in the gross domestic product (GDP) from 2010 to 2020, 2021
[28] FAO, Tanzania at a glance, 2021
[29] Statista, Tanzania: Employment in the agriculture sector as a share of total employment in Tanzania from 2000 to 2020, 2021
[30] Oxford Business Group, Already Tanzania's largest sector, agriculture continues to post positive trends

transformation that is market-driven, the Government of Tanzania needs to demonstrate the analysis behind specific interventions and drives, including managing soil acidity. This involves developing a nationwide understanding of soil acidity levels with frequent sample testing and assessing the quality and composition of available limestone deposits, starting with those in close proximity to highly acidic areas.

- **Strengthening government capacity to provide relevant, market-oriented agricultural extension services and ensure last-mile delivery.** Incorporating soil health and lime use in GAP training, increasing demonstration plots, as well as facilitating soil testing for smallholder farmers are essential preliminary tools for providing compelling evidence to smallholder farmers of the importance of lime in improving yields.
- **Providing suitable agricultural finance, including guarantees and reasonably tenured credit access alongside innovative subsidy models that reduce lime final costs, is critical** to ensuring last-mile delivery for smallholders who may be willing to buy lime but cannot afford it. Access to finance can include improved access to and use of mechanization services through renting machinery. This can improve lime application and reduce health and safety concerns when applying lime.
- **Creating favorable land renting policies for farmers** that encourage long-term liming investment requirements may increase demand and elevate the economic viability of lime for farmers.
- **Strengthening the policy and regulatory environment to encourage investment and competition in ag lime to improve efficiency and reduce costs.** This can include fiscal incentives for investment such as tax breaks and VAT exemptions and reducing or eliminating ag-lime mining and production fees.
- **Improved and timely access to finance for processors and distributors** can encourage efficient supply chains by increasing mechanization in production, making use of economies of scale and lower costs, and enhancing demand by ensuring timely delivery to farmers.
- **Long-term multi-sectoral investments in infrastructure, including transport, rural roads, rail freight for distribution, and warehouses for storage,** benefit and advance not only the lime sector but all agricultural value chains in Tanzania.

VI. ANNEX

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Stakeholders consulted

Stakeholder Category	**Stakeholder**
Government	• TARI –Joel Meliyo
Private Sector	• Dodoma Cement – Theresia Numbi • Highlands Building Products/Songwe Lime works – Clara Diyami, Elias Diyami • Mkombozi Agribusiness – Elly Hongoli • YARA Tanzania – Peter Assey • OCP Tanzania - Msolla Mbette Mshindo
Development Partner/NGO/PPP	• SAGCOT • BriTEN – Josephine Miingi • One Acre Fund – Keith Mosirwa • BMGF AfSIS – Marcus Walsh • IFDC – John Wendt
Expert	• Paul Makepeace

Information on Lime Deposits and Quality in Tanzania[31]

ID	Lat.	Long.	Name	Description – origin, extent and quality
1	-5.10872	39.01542	Tanga Cement Factory	300 m thick, covering 80 sq.km, the limestone includes coralliferous, oolitic and porcellanous types. The exposure along the Tanga-Muheza road at Maweni-Kichangani area. Outlet – Tanga cement, Tanga city.
2			Tanga area	Near Tanga there is raised reef limestone, which are comparatively of small tonnage and were burned for local use at Kikokwe (6km south of Pangani), Kumbamtoni (3km NW of Pangani), Muhembo (3km north of Pangani), Nyanjani (4.8 km SSE of Tanga town).
3	-6.6625	39.1677	Wazo hill Factory	Located 20 km NNW of Dar, mainly capped by a layer of coral limestone. The deposit has been drilled, pitted and sampled and over 20 million tons of limestone has been measured. It is currently being utilized by Dar Twiga cement factory. Other areas are Mjimwema (6 km south of Dar), Kaole (8 km south of Bagamoyo), Mwambakuni (East of Bagamoyo), Bugi (Kundushi Island), Kimbiji etc.
4	-8.3333	38.67166	Mtumbi hills	Located in Mtumbi hills. Matumbi lime has variable thickness 600 m, up to 150 m composed of oolitic sandy limestone and calcareous sandstone (Mtumbei Beds), and up to 230 m of Basal Beds, consisting of coarse conglomeratic feldspathic sandstones and red mudstones, with two thin oolitic limestone.
5	-8.9432939	33.23809	Mbeya Cement Factory	In belt of Songwe limestone - high quality trevertine
6	-10.26029	40.0398394	Dangote Industries Mtwara	Limestone along Indian sea shore - Karoo formation
7	-6.4606565	38.329094	Lugoba	The Lugoba limestone deposit on the Coastal Region was drilled and estimated to contain about 9 million tons of suitable limestone. There is quarry at Lugoba, 9.6 km from Tanga-Dar railway line.
8	-9.130555	39.33333	Kiturika hills	The blocks of varied limestones hardly representing less than 60 m of beds, possibly much more. This is continuous thickness of limestone of its kind in Lindi district, that belong to Tertiary beds which are usually interleaved with marls, and the breccia that may represent a residue from a thick mixed clay and limestone series. Limestone estimated to be 150 m thick.
9	-9.58333	39.08333	Mtungi hills	These are limestones found south of Mbemkuru Rivers, at Mtungi hill, east of Kigombo and Niongala area.
10	-9.83333	39.91667	Moka area	Located south of Lindi town, is a limestone deposit of Jurassic age. The limestone at Moka area, Namguru Valley has a thickness of 500 m. Apart of being calcareous, it has pebble bands and patches of purple staining. Some siltstones, marlstones and black silty shale also occur.
11	-9.3333	39.33333	Mandawa Anticline	This is a white coralliferous limestone of 110 m thick occurring at the northern end of the Mandawa anticline and it appear to span the Jurassic to Cretaceous periods. The depositional trend from east of the Matumbi Hills, just south of the Rufiji River, to the Kitere area south of Lindi town.
12	-10.33333	40.016667	Dihimba area	Limestone occurs as local small knoll reefs of coral occur within the chalky limestone's, these are particularly common near Dihimba area, its thickness is about 1000 m near Mtwara town
13	-9.95	39.728056	Lower Miocene (Burdigalian)-Lindi Bay	Limestone blocks are dated as mainly Burdigalian and Aquitanian with varied limestone. It is variable thickness between 60 and 270 m of beds, possibly much more.
14	-4.994072	29.99579	The Karoo-Limestone, Western Tanzania (Kigoma)	Kigoma area has a significant dolomitic limestone of the Uha series, lying to the east of Kigoma-Kasulu-Kibondo road, extending from Kazuramimba and Lugufu to where the Malagarasi River crosses the Kasulu-Kibondo road. These dolomitic limestones of considerable extent have variable thickness ranging between 6 and 10 m to over 150 m in some places. The deposits include Nyakachacha, Lugufu, Nyamuri, Ulombola, Karema, Namwe and Mugondozi (Near Kugwe Bay) presented in rows below.
15	-4.573901	30.201165	Nyakachacha hills	The deposit is located 25 km east of Kasulu town (see Western Tanzania above)
16	-5.045888	30.159881	Lugufu lime works	Similar to Nyakachacha (see Western Tanzania above)
17	-4.891998	29.6703	West of Nyamuri-Kigoma	It is located 20 km east south east of Kigoma town (see Western Tanzania above)
18	-4.881998	29.6603	Ulombola Masaka Point	Located 24 km SE of Kigoma town (see Western Tanzania above).
19	-4.881998	29.6603	Karema Mission	There were lime activities before present. It is 14 km N of Karema and 350 m from shore of Lake Tanganyika. The lime of this source appears to be of quite exceptional purity and freedom from magnesia.
20	-4.881998	29.6603	Nsjukula hill	Other lime occurrence include: Nanwe, Mugondozi (near Kugwe Bay)
21	-3.558624	33.407868	Seseko limestone-Shinyanga	Found 9.6 km from Shinyanga along old-Shinyanga road; on both sides of Ningwa River to the south and less than 1 km from Ngonho River to the north. It is a thick deposit of marly limestone of up to 48 m thick in places. The Seseko limestone deposit longest axis in the north - east direction is around 3km while the shortest axis about 2 km, occupying a total area of 6 sq. km. The deposit is estimated to be a resource of 120 million tons of limestone with lime (CaO) content between 30-50%.
22	-3.653849	33.33787	Bed limestone	Found 18 km NW of Shinyanga. Geologically similar to Seseko.
23	-3.6461	33.509791	Ushora Shinyanga limestone	Located 9.6 km NE of Shinyanga town, close to Mhumbu River. It displays faint perceptible banding, and with considerable purity with 91% $CaCO_3$ content.
24	-3.6661	33.510791	Lukalanga Mwadui limestone	Similar to Ushora limestone above; located about 22 km NE of Shinyanga, probably continuous with the Ushora deposit.
25	-3.99999	33.7	Tinde limestone	Located 72 km East-north-east of Nzega town in Tinde village. The deposit of nodular limestone and tufa of Pleistocene age.

[31] AFAP (African Fertilizer and Agribusiness Partnership), Lime scoping study – Tanzania, 2018

ID	Lat.	Long.	Name	Description – origin, extent and quality
26	-4.33597	33.01049	Mansimba, Usongo-Nzega limestone	A good nodular travertine located 24 km NE of Nzega town. It is a very pale cream-coloured compact nodular limestone of high purity.
27	-4.3357714	33.010541	Other limestones near Nzega	Pangale, Kazimba Uyui
28	-2.614878	32.8739491	Iruruma limestone	Famous as Speke Gulf with stretch of limestone of about 8 km inland and about .9 to 1.8 m thick along the coast of Lake Victoria
29	-3.433333	34.3166667	Meatu, Maswa limestone	Not explored so far.
30	-3.116667	33.65	Gunguri, Mbwaraturu Nungdu	Not explored although it has been burned in the past.
31	-2.0691	34.615527	Ikoma-Robanda limestone	Dolomitic limestone with 7.58 % magnesia and other impurities like silica and insoluble silicates 13.41%; oxides (FE/Al) 1.87%, and lime 38.89%.
32	-1.399999	34.650009	Bwiregi limestone	Located 9 km east of Musoma town. Silica and insoluble silicates (34.83 %), oxides (Fe/Al (5.37%), lime (32.57%), and Magnesia (2.13%). It is rated the lime of poor quality.
33	-2.2083097	32.537274	Ngudu Kwimba limestone	It is trevertine formed from underlying crystalline rocks; Silica and insoluble silicates (3.33%); oxides (Fe/A/) 0.98%; lime 54.95%; magnesia 0.82%. There are other small limestone deposits around Mwanza area including Pambani or Misasi (West Mabuki), Mwanharanga, Nera (SE Ngudu) and Kanyelele, Usmao (NW Ngudu).
34	-8.93651	33.2446657	Songwe Trevertine deposit	Located 25 km SW of Mbeya city toward Tunduma. Deposits have 6 M tons of lime. The deposited rated as of high purity lime.
35	-	-	Igawa limestone deposits	Located in Mbeya region. formed from in situ weathering of calcite and dolomite marble. Exhibits different colours, extent and purity not explored.
36	-10.387076	35.6695453	Chokaa limestone deposits	Situated 19 km west of Luhimba village in Mtyangimbole ward along Njombe-Songea tarmac road. Luhimba village is 32 km north of Songea town. It cover 0.06 sq km.