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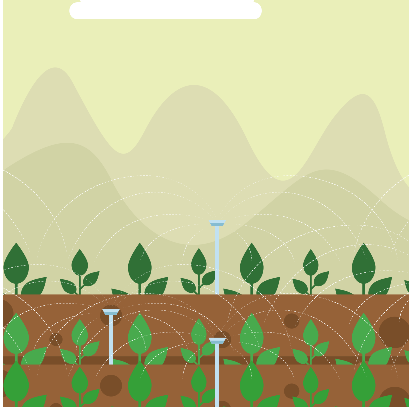

ENHANCING MARKET ACCESS AND USE OF AGRICULTURAL LIME AMONG SMALLHOLDER FARMERS IN WESTERN KENYA REGION

EARLY IMPACT ASSESSMENT REPORT

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Foreword

Kenya's Vision 2030 identifies agricultural sector as one of the key sectors to deliver the 10 per cent annual growth rate envisaged under the economic pillar. The Agricultural Sector Transformation and Growth Strategy 2019-2028 (ASTGS), focuses on the challenges of food security, poverty reduction, employment creation and transforming agriculture from subsistence to farming as a business. Yields at the smallholder level remain stagnant at 1.7 metric tonnes, well below average commercial production at 10-15 metric tonner per hectare. While crop management factors play into this yield gap, non-use or low rates of fertilizer application and blanket recommendations by smallholders are keeping yields stagnant. Soil acidity, due to inherent soil factors, fertilizer acidification, and lack of corrective liming, further suppress yields in many parts of Kenya.

Acidic soils (those with a pH lower than six) are becoming a significant issue in Kenya, especially in the maize growing areas that are traditionally regarded as the "bread basket" of Kenya. Soil acidity is associated with Aluminum toxicity and nutrient deficiency which affects crop growth and limits agricultural productivity. For instance, a national soil survey done in 2014, showed that about 50 per cent of the total samples taken from over 18 counties were acidic. Acidic soils cover about 18 million hectares (44 million acres) which maKES up about 13 per cent of Kenya's arable land, a key component towards transformation of Kenya's agriculture productivity thereby requiring an acceleration of adoption and appropriate use of agricultural lime by smallholder farmers.

Over the last five years, Kenya Markets Trust (KMT) has been engaging with a range of market players to promote agricultural lime use by smallholder farmers in Trans Nzoia, Bungoma, Kakamega and Uasin Gishu Counties. Through the private sector, KMT has intervened at multiple levels to drive commercial investments in promotions, marketing and distribution well as improvements in packaging. KMT's activities within this intervention have also included establishment of strategic partnerships between lime suppliers and soil testing services providers.

KMT commissioned this early impact assessment to establish the extent of adoption and uptake agricultural lime by smallholder farmers as a result of functioning market systems and inform our journey to scaling up use of agricultural lime across all the acidic-soil regions of the country. The study findings reveal that soil acidity remains a key constraint hindering farmers' productivity in the Western and Rift Valley regions. That, while the farmers who were reached by intervention reported improvements in farm productivity and increased yields from use of lime, concerted efforts are still required by multiple stakeholders to drive increased farmer education on the need for soil testing and corrective measures. The report recommends that in order to attain the desired transformation on the agricultural lime, it will involve concerted efforts in private sector-led agricultural extension and demonstrations to increase farmer awareness, develop efficient distribution networks, open up value chain financing for key investments that support manufacture, distribution and retail of lime products.

We invite you to absorb the findings of this report and utilise them to engage with the stakeholders who work towards improving smallholder agricultural productivity in Kenya, and together, contribute to solving the perennial food insecurity in the country.

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Kenya Markets Trust.

Acknowledgements

Abbreviations and Acronyms

AFAP	Africa Fertiliser Agribusiness Partnership
AGRA	Alliance for a Green Revolution in Africa
Al	Aluminium
ARMCARM	Cement (formerly Athi River Mining Ltd)
Ca	Calcium
CAPI	Computer Aided Personal Interviews
CBO	Community Based Organisations
CCE	Calcium carbonate equivalents
CSO	Civil Society Organisations
DAP	Di-Ammonium Phosphate
FBO	Faith Based Organisations
FGD	Focus Group Discussion
FIPS	Farm Input Promotions Africa Ltd
FYM	Farm yard manure
GIS	Geographical Information Systems
Ha	Hectares
HLCL	Homa Lime Co. Ltd.
IFDC	International Fertiliser Development Center
IPA	Innovations for Poverty Action
ISFM	Integrated Soil Fertility Management
KALRO	Kenya Agriculture and Livestock Research Organisation
KEPHIS	Kenya Plant Health Inspectorate Services
K	Potassium
Ke-Fert	Kenya Fertiliser Roundtable
KFA	Kenya Farmers Association; Kakamega Farmers Agency
Kg	Kilogram
KI	Key Informant
KII	Key Informant Interview
KMT	Kenya Markets Trust
KES	Kenya shilling
LR	Long rains
O_2	Oxygen
OAF	One Acre Fund
ODK	Open Data Kit
N	Nitrogen
NGO	Non-Governmental Organisation
Mg	Magnesium
Mn	Manganese
MSC	Mumias Sugar Company
MT	Metric tons
P	Phosphorus
PPE	Personal Protective Equipment
SCG	Silikon Consulting Group Ltd
SR	Short rains
TTFA	Toyota Tsusho Fertiliser Africa Limited

Definition of terms

Household: A house and its occupants regarded as a unit. The lowest sampling unit in the farmer interviews using questionnaires was a household. In everyday language, a household simply means a house and its occupants regarded as a unit. A challenge in sampling arises where a homestead houses several families. Hence the need for the definition requires to be nuanced depending on the purpose of the investigation. A common social-science research definition of the term "household" is about the people who share a common kitchen. This approach is able to deal with the issue of multiple families living in the same homestead.

Household size: By "household size" is meant the number of persons living in a household more or less permanently and who are dependent on farm resources; irrespective of familial relationships. In our case we used the following definition of household size: By "household size" is meant the number of persons living in a household more or less permanently and who are dependent on farm resources; irrespective of familial relationships. Thus, an employee who lived in a household is part of the household size

pH: A figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which seven (7) is neutral, lower values are more acid and higher values more alkaline.

Smallholder farmer: For the purposes of the study we defined smallholder farmers as those growing maize in a maximum/land size of 12 hectares. There were instances of farmers with large-scale farms but who were growing maize and other crops on only a small part of the farm.

Small farm versus large farm: According to the Agriculture Act (Cap.318), a "large-scale farm" means a farm which produces a gross income of not less than ten thousand shillings a year; and a "small-scale farm" means any farm which produces below this figure. From the Statistical Abstract (Kenya National Bureau of Statistics), small farms are between 0.2 and 12 hectares (ha) though there are some outside this range. In large-scale farming counties namely, Nakuru, Uasin Gishu, Trans-Nzoia, Kericho, Nandi and Laikipia, the average size of farms is around 700 hectares. Overall, 25% of the farms range between 20 and 50 hectares. The average farm size in Kakamega county is three hectares for small-scale holders while large-scale holders have an average of 10 hectares (ASDSP, 2014). With rapid increase in population, the size of land that qualifies a farm to be classified as "small" or "large" is bound to change. For the purposes of the current study, we defined smallholder farmers as those growing maize in a maximum of 12 hectares (or 30 acres). Our data was collected on that basis and two-thirds of the households had land holdings capped at only 1.2 hectares or three acres; 86 per cent of the households had land holdings capped at 2.8 ha or seven acres (see Figure 10). There were instances of farmers with large-scale farms but who were growing maize and other crops on only a small part of the farm. A particularly interesting example (though not part of the sampled farmers) was a farmer in Cherangany in Trans Nzoia county with hundreds of acres of land but reportedly he was only doing four acres of maize.

Executive Summary

Acidic soils (with pH lower than six) are becoming a significant issue in Kenya, especially in maize growing areas, traditionally regarded as the "bread basket" of Kenya. Soil acidity is associated with aluminium toxicity and nutrient deficiency which affects crop shows growth and limits agricultural productivity. The Kenysoil Survey (2014) showed that about 50 per cent of the total samples taken from over 18 counties were acidic. Acidic soils cover about 18 Million Hectares (44 Million acres) which maKES up about 13 per cent of Kenya's Arable land. Lime use, non-acidifying fertilisers and soil organic carbon build up formed part of recommendations. The most affected regions are in the Lake Basin, Western, North Rift, Mt Kenya, Aberdare and Coast. Application of agricultural lime provides multiple solutions, including reducing soil acidity, improving nutrients availability to plants, and enhancing root growth. Lime use, coupled with good agricultural practices, can therefore significantly improve crop productivity for smallholder farms in affected regions.

In 2015, Kenya Markets Trust (KMT) initiated an intervention to promote the use of agricultural lime by smallholder farmers in Kakamega, Vihiga and Uasin Gishu Counties, through a partnership with Homa Lime Co. Ltd. (HLCL), a lime manufacturing company based in Koru, Kisumu County. The intervention involved working with the company, agro-dealers and other stakeholders tocreate a sustainable supply of agricultural lime to smallholder farmers in western Kenya.

Key activities included;

Soil testing - boost understanding of the soil health status as a pre-cursor for liming. Soil acidity level tests provide information on the amount of lime to use and general knowledge on soil fertility;

Awareness Creation - boost knowledge on soil testing and lime use service which aids in counteracting soil acidity levels. Limited awareness could be a key constraint to use of lime among smallholder farmers;

Accessibility - creation of accessibility points to lime, soil testing services and markets could be a major constraint.

In order to ascertain the extent to which the agricultural lime market has grown and the resultant impact on farm productivity, KMT conducted an early impact assessment on market access and use of lime among smallholder farmers in Western Region, Kenya (Trans Nzoia, Bungoma, Kakamega and Uasin Gishu counties). The objectives of the study was to establish the existing knowledge levels, knowledge gaps and information awareness on lime and soil testing services among smallholder farmers in western region; uptake levels of the lime use and soil testing services among smallholder farmers in western region; the change in business performance, market share, sales and revenue for HomaLime Co. Ltd and its distribution networks through sales of lime and soil testing services; the impact of lime use and soil testing services on farm productivity, yields and farmer incomes in western region; and the impact on climate resilience and gender.

The key findings reveal that in line with Kenya's soil map, soil acidity and low fertility are widespread in soils in the western region and that to raise the productivity of these soils there is need to address the twin challenges. Since the levels of acidity and infertility differ from soil to soil, it is important to undertake soil analysis before undertaking corrective measures. Farmers employ different approaches in dealing with soil acidity challenges. This has enhanced micro-dosing promoted by Farm Input Promotions Africa Ltd. (FIPS), One Acre Fund and the use of granulated lime, all done without any form of soil testing. Over time, more farmers have increased their knowledge levels about soil acidity, soil testing and liming. For example, in all the four counties, 55% of the household respondents said they had heard of soil acidity; while 44% knew about soil testing. It appears that some farmers know about soil acidity and liming but not about soil testing. county government extension personnel arrange routine meetings with farmers' groups and in these forums, they are able to provide farmers with information and receive feedback from farmers.

Out of 518 households, 54 households (10.4%) had undertaken soil tests while 34 households (7%) had done liming. The introductory subsidised soil testing services and free lime provided by various stakeholders including county Governments were well received by farmers. This indicates that farmers are interested in addressing soil acidity. Unfortunately, however, in the promotion of these technologies there has not been sufficient demonstration to farmers on the cost-benefit ratio of soil liming.

Compared to 2013 baseline survey on adoption levels which found low levels of awareness and adoption at 5%, it can be concluded there has been an increase in adoption albeit at a low rate. The main reason why farmers do not adopt soil testing is the perception of high cost without a clear understanding of the inherent benefits. In terms of lime adoption, the low adoption is driven by perception of high cost (in terms of money, labour and inadequate impact on crop yield); inadequate information concerning types and application methods of lime; and distance to source of lime (related to cost of transportation of the bulky and dusty product). A few farmers paid commercial rates for soil testing; the majority of obtained services subsidised by the county government or the Equity Group Foundation. Similarly, only a minority of farmers have purchased lime as the same has also been subsidised in the past.

In terms of market penetration and business growth, the sales of lime by HLCL increased from about 4,000 MT in 2015 to about 9,200 MT in 2018. However, due to limited data, it is difficult to tell how much of the lime ended among smallholder farmers in the four study counties. Significant amounts of these sales were made by county governments who later provided them to farmers at no cost. HLCL have been able to get closer to the farmers through their linkages with distributors and stockists.

On impact of use of lime compared to unlimed plots, farmers who limed their plots, were able to notice changes in soil conditions as well as in crop conditions such as morphology. Farmers who in addition to lime used manures and/or fertilisers were able to keep their soils productive. Maize yield data from demo farmers (in Kakamega, Trans Nzoia and Uasin Gishu counties) indicate statistically significant differences in yields between limed and unlimed plots. Maize yields from limed plots were higher than those from unlimed plots. The difference was in the range of 6-20 bags per acre with an average difference of 10-11 bags per acre. It is estimated that the change in farm income on a maize farm would average at KES 21,000 per year (or about KES 1,900 per bag of maize). This implies that farmers stand to benefit significantly from applying lime to their crops. Soil testing would allow better targeting of lime use and appropriate use of fertilisers as recommended in precision agriculture; the impacts of such precision in crop nutrition would contribute to climate resilience.

In terms of gender impacts, unequal access to land and especially among the youth is a factor against climate resilience because socio-cultural norms keep the youth at the margin instead of at the center of agricultural development.

Some of the key challenges in the expansion of the lime market and use of lime by farmers included; that whereas farmers appreciate that lime is good for correcting soil acidity, they perceive it as a bulky, dusty commodity requiring a lot of labour for application; some farmers due to limited knowledge on liming, end up mixing lime and fertiliser during planting and also do not adhere to the recommended lime application rates; many farmers still expect government and donor agencies to help them acquire lime. They view the cost of lime as being prohibitive and so they do not perceive lime as a viable way to improve their farming business. On the side of promoters of lime, their messages lack convincing economic content; farmers get discouraged whenever they do not see instant results from lime application. Some farmers see the process of initial testing of soil before application of lime as tedious and expensive. This is exacerbated by the limited soil testing facilities, delays in the release of results, and lack of a policy to guide actors on the issue of lime.

Key recommendations from the study;

- Science-based policy guidelines are needed to address the situation of deteriorating soil health in Kenya. Such policy should also guide National and county Governments on what subsidies (if any) should be provided, on soil testing, lime or fertiliser or both lime and fertiliser.
- Farmers need to be provided with consistent information about the importance of soil testing prior to application of lime and fertilisers. This can be achieved by creating a forum where different actors and their research counterparts can share information and champion a consistent approach to communication about soil acidity, soil testing and liming to farmers.
- Training for farmers to understand the difference between lime and fertiliser, and promote soil testing as a basis for recommending appropriate levels of liming.
- Key stakeholders in lime and soil testing should support farmers in working out economics of promoting these technologies to demonstrate to them the benefit/cost ratio of adoption.
- Studies on the economics of lime application be encouraged to explicitly compare the costs and benefits of the technology. Such data should then be used in extension messages to assist farmers assess for themselves the value of liming to farming.
- To reduce opportunities for leakage, targeting of beneficiaries is critical. Therefore, there is need to develop an appropriate methodology for lime and soil testing subsidy with a clear exit strategy.

CHAPTER ONE

Introduction

Use of agricultural lime.

1.1 Manuring and soil acidity

Manuring is one of the most effective ways of improving soil fertility (Kihanda, F.M. et al. (2007). When manure is applied to soil, it impacts the chemical, physical and biological properties of the soil (including soil acidity); most of these effects are due to an increase in soil organic matter (Shirani et al., 2002; Liang et al., 2011; Bakayoko et al., 2009). Manure is an excellent source of Nitrogen (N), Phosphorus (P), Potassium (K) and many of the secondary nutrients. A major challenge for manure is its variability in composition of these nutrients on account of differences in type of animal, its food ration, manure collection, storage and application procedures, and climate (Risse et al., 2006). Manure effect on soil physical properties include increased infiltration (Risse et al., 2006), water holding capacity (Liang et al., 2011; Salahin et al., 2011, Rasoulzadeh, A. and A. Yaghoubi, 2010) and reduced compaction and erosion (Salahin et al., 2011).

In acidic soils, the effects of manure are more effective when lime is included due to its role in neutralising soil acidity, raising the soil pH, providing Ca2+, Mg2+ and decreasing aluminum (Al) and iron (Fe) toxicity. These positive effects on the soil stimulate microorganism's activity and crop growth (Kisinyo, P.O. et al., 2012; Kanyanjua, S.M. et al., 2002). Lime when applied in the soil reacts with water leading to the production of OH- ions and Ca2+ ions which displace H+ and Al3+ ions from soil adsorption sites resulting in an increase in soil pH (Kisinyo, P.O. et al., 2012).

Iyamuremye, F. et al. (1996) reported that of various materials, manure and lucerne residues raised soil pH the most within one month and also resulted in exchangeable Al reduction in soil. Pypers, P. et al. (2005) found that organic amendment significantly increased soil pH. Sharpley et al. (2004) compared soils with varying manure application histories and found that pH was significantly greater in manured soils than in untreated soils.

1.2 Use of organic materials to control acidity

Organic materials are known to reduce soil acidity, Al toxicity and increase soil available P in acid soils (Lungu, O.I., 1993). Decomposing organic materials release and synthesise organic compounds which interact with Al to result in reduction of Al solubility (Tang, Y. et. al., 2007). Organic materials also interact with P in soils in ways that influence P sorption and release reactions (Guppy, C.N., et al. 2005).

In a study in western Kenya, Opala et al. (2010) noted that wild Mexican sunflower (*Tithoniadiversifolia)* green manure increased maize yield due to its ability to form complex with Al and reduce exchangeable Al in soils without necessarily increasing the soil pH. The same study observed that although manure increased the soil pH, it was not as effective as *Tithoniadiversifolia*in decreasing the exchangeable Al3+. It was thus concluded that the ability of an organic material to reduce Al toxicity was related to its ability to complex the Al through organic acids produced during its decomposition process.

The *Tithoniadiversifolia* green manure was therefore more effective because of its ability to release larger quantities of organic acids compared to the well rotten manure which had lost most of the organic acids. Iyamuremye, F. et al. (1996b) reported malic, malonic, maleic, succinic, formic, citric and acetic acids in soil solution samples amended with organic residues; however, it was the citric acid that affected the speciation of the metals Al, Fe and P by forming complexes with them.

Photo 3.1: Tithonia [Taken on 24 December, 2018]

1.3 Effects of lime on crop productivity

Soil acidity has a big effect on the solubility of nutrients given that 14 of the 17 essential plant nutrients are obtained from the soil (Mahler, Robert L., 2004.). Most nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils. While phosphorus is never readily soluble in the soil, it is most available in soils with a pH around 6.5. A pH range of six to seven promotes availability of plant nutrients. Soil pH of four to five (strongly acid) promotes high concentrations of soluble aluminum, iron and manganese and these are toxic to the growth of some crops. In addition to such toxicity, such acidity also leads to deficiencies of calcium (Ca), magnesium (Mg) and potassium (K). Toxicity and deficiencies lead to reduced soil fertility and hence lower crop productivity ((Mahler, Robert L., 2004.).

Crop productivity is linked closely to the organic matter in the soil (Bauer and Black, 1994). Organic matter or organic carbon promotes soil aeration in the soil and this in turn permits the roots of crops to penetrate and flourish more readily. In contrast, soils with low levels of organic carbon tend to be compact and plant roots growing in them tend to be stressed by drought or excess water. High organic matter increases productivity and, in turn, high productivity increases organic matter.

Experimental results in Kenya have shown that soil acidity decreases with increasing levels of organic carbon (e.g. as contained in manure) and lime. In one experiment in maize, "a treatment with 12.5 Mg ha-1 of lime and 10 Mg ha-1 of manure had the best reducing effect on soil acidity and better maize yield performances reflected in the highest pH (6.3), highest root length (41.3 cm), plant height (150.3 cm) and dry biomass weight (755.4 kg ha-1)" (Gitari, et. al. 2015). Soil acidification is a natural process accelerated by agriculture. Ammonium-based fertilisers like DAP are major contributors to soil acidification. In a liming trial involving maize in Embu, the research found that maize growth parameters (root length, height and biomass dry weight) increased significantly as levels of manure and lime increased (Gitari Harun Ireri 2013).

1.4 Background to the study

One of Kenya's current Big Four Agenda (2018-2022) is the improvement of food and nutritional security. Farming is not optimal on account of high risks associated with dependence on rain-fed agriculture, high input prices, and low farm-gate prices. Agricultural productivity is low because of low utilisation of yield-raising inputs (improved seeds, fertilisers and other agro-chemicals, and irrigation low soil fertility and high acidity), and reliance on manual labour for farm production.

It is estimated that 13 per cent of arable land in Kenya(mainly in Western, Nyanza, Rift Valley, Central, Eastern and Coastal regions) has acidic soils (Kanyanjua, S.M. et al., 2002).

The Ministry of Agriculture estimates that around 50 per cent of smallholders in western Kenya may be farming soils with pH below 5.5. For many crops, their optimum soil pH for plant growth is 5.5 to 6.5 (One Acre Fund, 2015).

On account of soil acidity, farmers experience low crop response to fertilisers and hence low crop yields. The result is continued food insecurity and poverty. Maize yields grown in these acidic areas has been documented to be as low as one ton per hectare, way below the potential of six tons per hectare.

Lime is one of the major solutions to soil acidity. The application of agricultural lime, a calcium-containing product processed from limestone, gypsum or dolomite, increases the soil pH, reduces the solubility of the toxic elements and increases availability of nutrients to plant roots. Lime also helps in biological nitrogen fixation in legumes and general microbial activity.

Although agricultural lime is produced in Kenya and used by large-scale farmers, historically, its use by small-scale farmers has been low.

In 2015, Kenya Markets Trust (KMT) initiated an intervention to increase use of agricultural lime by smallholder farmers in three pilot counties (Kakamega, Vihiga and Uasin Gishu) in the western part of Kenya. This was to be realized through pro-actively seeking and managing relationships with agro-dealers willing to sell lime to farmers; agro-dealers giving more information to farmers about agricultural lime and lime use; lime suppliers improving their marketing; and greater collaboration between lime suppliers and soil testing firms.

KMT's intervention partner, Homa Lime Co. Ltd. (HLCL) is a lime manufacturing company based in Koru, Kisumu County. KMT and HLCL sought to develop a model that could ensure sustainable supply of agricultural lime to smallholder farmers in western Kenya.

The model involved working with the lime manufacturers, agro-dealers and other stakeholders with the key interventional strategic activities being;

- **Soil testing** – To boost understanding of the soil health status as a pre-cursor for liming. Soil acidity level tests provide information on the amount of lime to use and general knowledge on soil fertility.
- **Awareness Creation** – To boost knowledge on soil testing and lime use service which will aid in counteracting soil acidity levels.

Limited awareness could be a key constrain to use of lime among smallholder farmers.

- **Accessibility** – Creation of accessibility points to lime, soil testing services and markets could be a major constraint. KMT is working with HLCL and its distribution networks of agro-dealers as a key intervention strategy.

The KMT/HLCL pilot study sought to address identified constrains such as; agricultural lime use by smallholder farmers, limited awareness on the levels of soil acidity, lack of access to lime and limited access to soil fertility testing services.

KMT applies a market systems approach to private sector development. Through the model, KMT seeks to improve the factors of production in the agricultural sector by removal of market constraints that hinder optimal productivity. For markets intervention to be effective in addressing the systemic agricultural productivity constraints, they must be based on evidence. The KMT model seeks to unleash large scale, sustainable growth by changing the underlying incentives, capacities and rules that shape the functioning of markets.

HLCL was willing to adopt new business strategies, and commit their own resources and time to implement change and apply business ethics.

The pilot relationship was underpinned by two hypotheses. The first hypothesis was that a private-sector distribution model for lime could significantly improve access to lime by smallholder farmers. In other words, it was assumed that as a result of KMT facilitation, HLCL would expand the number, skills and reach of its distributors and stockists and hence significantly increase farmers' access to lime. In this context, the current study sought to find out if this model has worked. The second hypothesis was that application of lime to acidic soils would improve productivity; thus when farmers apply lime to their fields, they should increase their crop yields. Thisstudy looked for evidence to show whether or not lime use leads to crop productivity.

1.5 Objectives of the study

1. To establish the existing knowledge levels, knowledge gaps and information awareness on lime and soil testing services among smallholder farmers in western Kenya region.
2. To establish uptake levels of lime use and soil testing services among smallholder farmers in western Kenya region.
3. To establish the change in business performance, market share, sales and revenue for Homa Lime Co. Ltd and its distribution networks through sales of lime and soil testing services.
4. To demonstrate the impact of lime use and soil testing services on farm productivity, yields and farmer incomes in western region.
5. To demonstrate the intervention's impact on cross-cutting issues, including climate resilience and gender.

1.6 Scope of work

This study was conducted in Uasin Gishu, Trans Nzoia, Kakamega and Bungoma Counties and incorporated an interaction with a cross-section of stakeholders including public officials.

CHAPTER TWO

Literature Review

2.1 Soil pH and acidity

Soil acidity in western Kenya is not a new phenomenon. Agricultural researchers had done studies on liming as far back as the 1960s and established the presence of soil acidity in the western region (see for example Mehlich, A., Bellis, E. and Gitau, J.K., 1964).

Soil fertility management includes maintaining the soil pH at the proper range for the crops grown. Soil pH is a critical factor in soil because it influences many of the chemical and biological functions of a soil. Soil pH is a parameter used in soil chemistry; it is a measure of the activity or concentration of hydrogen ions (H+).

In mathematical symbols, $pH = -\log[H^+]$. This equation points to the fact that the more hydrogen ions are present in soil solution, the lower the pH value. Soil pH values below seven are considered acidic and values above seven are considered alkaline or basic. The Kenya Agriculture and Livestock Research Organisation (KALRO) formerly known as the Kenya Agricultural Research Institute (KARI) classifies soil acidity as shown in Table one below (Kanyanjua, S.M. et al., 2002).

Table 1: Classification of soil acidity

Degree of acidity	pH range
Extremely acidic	Below 4.5
Strongly acidic	4.5 – 5.0
Moderately acidic	5.0 – 6.0
Slightly acidic	6.0 – 6.5
Near neutral	6.5 - 7.0

Source: Kanyanjua, S.M., Ireri, L., Wambua, S. and Nandwa,S.M. Acidic soils in Kenya: Constraints and remedial options KARI Technical Note No. 11 June 2002

While grain crops like maize, small grains and soybeans tolerate soil acidity in the medium pH range of 5.5-6.0, crops like potatoes (both Irish and sweet) and chillies can do well in soils with pH values below 5.5. Vegetable crops like beans, peas, peppers, onions, spinach, carrots, cabbages and cauliflower must have soils with a pH value above six since they do not tolerate acidity (Kanyanjua, S.M, et. al., 2002).

Soil pH test is needed to confirm soil's acidity problem. However, there are some general symptoms that could point a farmer to suspect soil acidity problem. These include: poor plant vigour, uneven crop growth, poor nodulation of legumes, stunted root growth, increased disease incidence, abnormal leaf colours, and reduced crop yields (Michigan State University, n.d.).

Natural development of acidity: Acid ic soils have excess Al ions, which are toxic to plants and which also make other plant nutrients unavailable. Acidic soils tend to have a low pH, low P, high P fixation and Al toxicity. Soil acidity is found naturally in some rocks, for example, non-calcareous rocks produce inherently acidic soils. The high rainfall in humid regions promotes leaching of basic cations mainly Ca, Mg and K in climatic conditions characterised by excessive rainfall (r) relative to evapotranspiration and leads to acidic soils. Under conditions of poor drainage, reclaimed swamps (peats) can become acidic with time (Soilquality.org.au).

Acidifying fertilisers: In addition to natural sources of acidity, when farmers use acidifying fertilisers such as those with ammonia (DAP, Urea), the soils become acidic over time, particularly when these soils are low in organic matter. Nitrogen (N) fertilisers that contain urea or ammonium (NH_4^+) contribute to soil acidity when NH_4^+ is converted to nitrate (NO_3^-), releasing many H^+ ions into the soil solution (Fertiliser Technology Research Centre, n.d.).

2.2 Neutralising soil acidity

Soil acidity can be effectively neutralised by either liming or application of farm yard manure (Kanyanjua, S.M.et. al., 2002). Calcium can be obtained from calcitic or dolomitic limestones while Magnesium (Mg) can be obtained from dolomitic limestones. Phosphorous can be obtained from readily soluble sources (including super phosphates) or slowly soluble forms (including rock phosphates). If a farmer applies higher quantities of lime than what is recommended from soil test, there is a possibility of creating micronutrient deficiencies in the soil and also phosphorous deficiency.

Liming recommendations are based on adding that amount of lime which just neutralises the exchangeable Al^{3+} to avoid toxicity (Kanyanjua, S.M.et. al., 2002). But what in lime is responsible for neutralising the acidity?

Although the application of limestone with calcium and/or magnesium serves as a source of these macronutrients to growing plants, the calcium and magnesium cations do nothing to reduce soil acidity. What is responsible for the reduction in acidity are the oxides (O^{2-}), hydroxides (OH^-), carbonates (CO_3^{2-}) or silicates (SiO_4^{4-}) of calcium (Ca) or magnesium (Mg) in the limestone (North Carolina State University Extension, n.d.). Calcitic lime is calcium carbonate ($CaCO_3$) while dolomitic lime contains calcium carbonate and magnesium ($CaMg(CO_3)_2$); quick lime is calcium oxide (CaO), and slaked/hydrated lime is calcium hydroxide ($Ca(OH)_2$). The oxide, hydroxide, carbonate, or silicate anions in these materials are the active liming agents. Therefore, the reason these materials neutralise acidity is not due to the calcium or magnesium in the material. When these liming materials dissolve in water, the acidity (H^+) reacts with the negatively charged anions (O^{2-}, OH^-, CO_3^{2-}, or SiO_4^{4-}), thereby reducing the concentration of acid (H^+) in the soil solution (North Carolina State University Extension, n.d.)

In a 2010-2012 field experiment to evaluate response to lime on cultivars of ricebean (*Vigna umbellata*) in India, increasing levels of lime in planting furrows from zero to 0.6 tonnes per hectare significantly increased growth, yield attributes and yield. Quality parameters of ricebean were also influenced significantly by lime. Maximum gross return (INR 39,098 ha^{-1}), net return (INR 27,281 ha^{-1}), benefit to cost (BCR) ratio (2.29), production efficiency, and economic efficiency were realized with the application of lime at 0.6 tonnes per hectare (RaKES h Kumar et. al., 2014).

Crop production can increase significantly as a consequence of better management practices which include P and N fertilisation and, occasionally, S fertilisation .

Grain crops use up nutrients intensively and common rates of fertiliser application may not be sufficient to replace and balance the nutrients taken out of the soil, and this is particularly so with respect to meso-nutrients (Ca^{+2} and Mg^{+2}) which are not normally applied by farmers (Barbieri Pablo A. et. al. 2015).

In an Argentinian experiment, designed to determine the effect of lime over a four-year period on soybean, one-year period on wheat, and on a one-year double cropped wheat/ soybean combination on no-till, the results showed that

(1) soil bulk density and penetration resistance were not affected by lime application;

(2) soil structure stability was significantly affected by lime application;

(3) Lime application increased soil pH, Ca^{+2} content, base saturation and Ca^{+2} saturation;

(4) Lime application increased only soybean grain yield; and

(5) Soil Ca^{+2} content could limit soybean grain yield as a consequence of cation imbalance in intensive agriculture. (Barbieri Pablo A. et. al. 2015).

Application of lime tends to raise the soil pH by displacement of H+, Fe2+, Al3+, Mn4+ and Cu2+ ions from soil adsorption site (Onwonga, R.N. et. al., 2010). More than increasing soil pH, it also supplies significant amounts of Ca and Mg, depending on the type. Indirect effects of lime include increased availability of P, Mo and B, and more favourable conditions for microbially mediated reactions such as nitrogen fixation and nitrification, and in some cases improved soil structure (Crawford, T.W. et al., 2008).

Available information indicates that there are only two main manufacturers of agricultural lime, ARM Cement (ARMC), formerly known as Athi River Mining Ltd and Homa Lime Co. Ltd. (HLCL). ARMC is primarily a cement manufacturer and supplies dolomitic lime, i.e. lime with magnesium. On the other hand, HLCL is the major supplier of calcitic lime. New players are introducing granulated lime; these include Toyota Tsusho Fertiliser Ltd, Omnia Group and Mavuno Fertiliser Ltd (a subsidiary of ARMC).

It so happens that the soils in western region have adequate levels of magnesium and so correction of their acidity requires calcitic lime rather than dolomitic lime (Homa Lime Co. Ltd., personal communication).

The lime manufacturers supply lime to their distributors who in turn sell to stockists who serve farmers at local level. However, distributors also retail their products.

According to farmer responses, the major crops to which lime is applied in the region include maize, sugarcane and coffee.

A recent study by One Acre Fund on 'Managing Soil Acidity with Lime,' showed that lime interventions to smallholder farmers can slow down the process of soil acidification with positive impact on yield (One Acre Fund, 2015). Soil acidity has contributed to low crop productivity leading to reduced income per household, decline in food and nutritional security. Research indicates that many soils in western region of Kenya are acidic and deficient in nitrogen and phosphorus (Opala, P. et. al., 2018).

The impact of soil acidity is felt in the maize growing regions.The main types of soil in this region are the red clay soils (FAO: Acrisols, US Soil Taxonomy: Utisols) and red and yellow weathered soils (FAO: Ferralsols, US Soil Taxonomy:Oxisols). Acrisols are naturally acidic and the acidity hinders crop responses to fertilisers applied to remedy nutrient deficiencies.

2.3 History of liming by smallholder farmers in western region

A number of Organisations participated at different times in the creation of awareness among the smallholder farmers about the role of soil testing and lime use.

The Soil Fertility Initiative project implemented in Kakamega North District and Khwisero District between 2005 and 2008 by the then Kenya Agricultural Research Institute (KARI) had the aim of improving soil fertility status and crop yield in the region to arrest the declining yields of maize.

The low yields were attributed to factors such as low soil fertility, use of unimproved seed varieties, poor agronomic practices and Striga weed.

A study conducted by KARI Kakamega showed that soil acidity was also contributing to the low yields. It was demonstrated that when agricultural lime was added to the fields with multi nutrient fertilisers, the yields of maize increased from less than one ton per hectare to 4-6 tons per hectare (Mbakaya et al., 2004).

One outcome of the encouraging yields was the bringing on board of the Alliance of Green Revolution in Africa (AGRA) with a view of scaling up the use of agricultural lime to other areas of western Kenya (Onyango, E. et. al., 2013).

KARI researchers from Kakamega wrote a

research proposal to AGRA in 2009 aimed at creating awareness about the use of agricultural lime with the expectation that farmers would increase demand for lime application on acidic soils.

On its part, AGRA wanted to promote local solutions for soil health. Accordingly, AGRA through its Soil Health Programme[1], provided a joint research grant to KARI and Moi University to train extension workers and agro-dealers, purchase vehicles and buy lime for sale at subsidised prices. It was hoped that the research would lead to an increase in the use of lime and other soil acidity management technologies on smallholder farms.

There were two phases of the project between 2009 and 2017. In phase one (2009-2012), major on-farm demos were established in Kakamega North and South, Emuhaya, Gem and Siaya; the approach was to use individual farmers. The project gave each farmer 10 bags (500kg) of lime free and the application of lime led to maize yields increasing up to 1.5 tonnes per hectare. Where farmers applied the lime to sugarcane, the yields also increased (the use of urea in sugarcane had depressed yields through soil acidity).

Towards the end of Phase one, Kakamega county Government supported soil testing for the whole county and the results showed that acidity was a major problem. This was the basis for the decision by the county government to introduce a fertiliser subsidy and the introduction of the blended fertiliser, Mavuno.

AGRA supported phase two (2014-2017) under the Integrated Soil Fertility Management (ISFM) project; the approach this time was group approach, to reach more farmers. In this phase covering the whole of Kakamega County, the project identified stockists and supported them to stock lime from HLCL.

Farmers bought lime at a subsidised price, however, it was noted that fewer farmers applied the lime unlike in Phase one when lime was provided. Stockists were left with huge stocks at no cost the end of the project which were later turned over to the county government.

KALRO and university researchers continue to undertake research on lime use in the region. Kisinyo et.al. (2015) reported on their results of testing micro-dosing of fertiliser and lime in maize in Busia. They concluded that when fertilisers were applied to supply 37.5 kg N per hectare, 13 kg P per hectare and 1.55 tons of lime per hectare (these rates were 50 per cent of the recommended rates), grain yield increased above the control by 134% for N, 39% for P and 22% for lime. These results showed that response was not only to lime but to fertiliser, indicating that soil fertility was poor. Micro-dosing of these inputs can increase maize production on Kenya's acid soils.

2.4 Available liming materials

Common liming materials are available in solid form. Some materials are more effective at Neutralising acidity than others. The liming ability of any material is expressed as calcium carbonate equivalents (CCE). Table two shows the CCE of common liming materials.

Table 2: The calcium carbonate equivalents (CCE) of common liming materials

Liming Material	CCE
Pure calcitic lime (CaCO3)	100
Pure dolomitic lime CaCO3*MgCO3	108
Quicklime / burned lime (CaO)	179
Hydrated lime CaOH2	136
Slag (CaSiO3)	86

Source: https://www.smart-fertiliser.com/articles/liming-materials

Pelletised limestone or Pelletised lime, is created when limestone rock is crushed into a powder (applied with specialised lime applicators) or granulated into small pellets for broadcasting with conventional fertiliser equipment. Pelletised lime is relatively expensive per ton; it is applied at lower rates compared to recommended rates of agricultural lime. A "1:10 ratio" rule of thumb has been promoted for comparing the short-term Neutralising effectiveness of Pelletised lime to agricultural lime (Stevens G. and D. Dunn, n.d.).

Calcitic versus dolomitic lime: Soil that has no magnesium deficiency should be limed with calcitic lime which is derived from deposits of primarily calcium carbonate. Soil with magnesium deficiency should be limed with dolomitic lime which is derived from deposits of calcium carbonate combined with magnesium carbonate (Michigan State University Extension. N.d.).

2.5 Results of trial with lime and fertiliser

Scientists from Maseno University, Masinde Muliro University of Science and Technology and KALRO studied the effects of lime and fertiliser on soil properties and maize yields in acid soils of Western Kenya in the 2015 and 2016 seasons (Opala, P.A., et. al. 2018).

They tested the effects of lime on maize yield at four sites, Butere, Emuhaya, Mumias and Kakamega North, over three seasons, 2015 long rains (LR), 2015 short rains (SR) and 2016 LR. All the test sites had soil pH above 5.0 but below 5.5. They used $CaCO3$, CaO and granulated lime, applied alone or in combination with fertiliser [Di-Ammonium phosphate (DAP) + calcium ammonium nitrate (CAN)]. The rates of application for $CaCO3$ and CaO were two tons per hectare once in the 2015 LR season; while for DAP and CAN the rates were 26 kg P and 60 kg N per hectare per season. Granular lime was applied at a ratio of 1:1 with DAP per season. To get 26 kg P from DAP one requires to apply 26*2.17 = 56 kg of DAP. Thus the amount of granular lime applied was 56 kg per hectare.

The results were interesting in that without fertiliser, maize did not respond to lime. The only exception was at Butere in the 2015 LR where the application of CaO and $CaCO3$ with fertiliser gave significantly higher maize yield than fertiliser applied alone.

These results indicate that the impact of liming for maize production may not be significant if the acidity levels are not extreme and especially where farmers are applying N and P. And while in a sense, the results also highlight the importance of detailed soil tests that show precise requirements of soil for specific nutrients, they do indicate that perhaps what many farmers need are quick and cheap soil tests to show if the acidity of their soils is below five.

2.6 Blended fertilisers

There are two new fertiliser blends that are involved in the lime and fertiliser debate. These are Mavuno and Baraka fertilisers.

ARM Cement Ltd, formerly Athi River Cement Ltd, is the mother company of the Mavuno Fertiliser division that manufactures Mavuno fertilisers.

Based on field research between 2000 and 2003, ARM found that many soils were acidic and decided that they would manufacture fertilisers mixed with lime to neutralise soil acidity. Their fertiliser contains 12 essential plant nutrients such as nitrogen, phosphorous and potassium, among others key nutrients. The fertilisers are packed in one, 10, 25 and 50 kg bags.

Mavuno fertiliser sells its products directly to smallholder farmers and also reaches them through their distributors located in various parts of the county. They manufacture fertilisers specific to particular soil need of given areas. Soil in Kakamega is, for instance, different from soil in Bungoma, therefore they consider such variables when formulating fertilisers.

Conventional fertilisers provide plants with three main nutrients, nitrogen, potassium, and phosphorus; but soils are often deficient in secondary or micronutrients such as zinc or boron. Baraka fertiliser contains boron and zinc in addition to the standard NPK.

In 2015, Toyota Tsusho established Toyota Tsusho Fertiliser Africa Limited ("TTFA"), a wholly owned subsidiary, and proceeded to construct a fertiliser blending plant at Ngeria, Eldoret.

Production capacity is 150,000 tons per year. The plant began operating in 2016. It produces 50 metric tonnes of the commodity per hour.

In 2017, farmers purchased more than 10,000 bags, rice yields increased by 30%.

In 2018, Baraka was being scaled out countrywide. Nearly 2,000 bags of blended fertiliser were distributed to stockists at multiple locations in western Kenya, available at subsidised prices, thanks to a partnership between the county government, IFDC and Toyota.

The fertiliser company produces 10 different Baraka fertiliser brands which are all specific to different crops and agro-ecological zones. Currently fertilisers are available for potatoes, rice, onions, vegetables and legumes. The firm is planning to develop fertilisers for sugarcane. The fertilisers are available in 10, 25 and 50 kg packs. The price of baraka fertiliser (unsubsidised) is KES 3,000 per 50 kg bag to the farmer; retailers buy at KES 2800 per bag and enjoy a KES 200 margin per bag.

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1 AGRA's Soil Health Program was launched in January 2008 supported by the Gates and Rockefeller Foundations. It was aimed at fostering widespread adoption of Integrated Soil Fertility Management (ISFM) which involved assessing local soil and water resources and considering how organic matter, fertilisers, farmer cropping systems, and farmer knowledge could work in concert to create highly productive and environmentally sustainable approaches to soil revitalization (AGRA.https://www.sourcewatch.org/index.php/AGRA%27s_Soil_Health_Program.

(Source: IFDC. Blended fertilisers – Baraka is better. IFDC Perspectives, Project Updates. September 27,2018. https://ifdc.org/2018/09/27/blended-fertilisers-baraka-is-better/).

CHAPTER THREE

Methodology

3.1 Introduction

The study was conducted using both qualitative and quantitative methods. An inception meeting between KMT and the Silikon Consulting Group Ltd was held at the beginning and an inception report presented by the consultants. At inception, timelines and data collection tools were deliberated upon and were agreed upon. To comprehensively cover different sources of information on the early impact assessment on enhancing access and use of lime among smallholder farmers in Western region, Kenya and triangulate it, three interview modules were adopted. The modules included: -

i. Individual farmers (household) interviews
ii. Key Informant interviews (KII)
iii. Focus Group Discussions (FGDs) and
iv. Observations

Consequently, interview tools and FGD checklist were developed, revised and adopted. The final survey tools are annexed to this report.

To objectively address the objectives of the study which revolved around the assessment of:

1. knowledge levels and gaps and information awareness on lime and soil testing services among farmers in western region;
2. uptake levels of the lime use and soil testing services among smallholder farmers;
3. change in business performance for Homa Lime Co. Ltd. and its distribution networks;
4. impact of lime use and soil testing services on farm productivity, yields and farmer incomes; and
5. impact on cross cutting issues including climate resilience and gender, the study used mixed methods.

3.2 Data Collection

Data for this study came from both primary and secondary sources. Secondary information was obtained from literature review and interviews of key informants while primary data was obtained through household interviews and focus group discussions.

Observation also came in handy to complement the other methods for primary data collection, especially at the level of the beneficiaries. GIS tools and digitized maps of the target area assisted in the collection of data as well as in reporting. Attention was given to the quality of data collected by focusing on the following;

(i) Selection and training of research assistants and enumerators;

(ii) Guided and supervised data collection;

(iii) Triangulating of information sources;

(iv) Data cleaning and coding;

(v) Focused analysis based on the terms of reference; and

(vi) Review of study tools and outputs.

3.2.1 Secondary data collection

Secondary information was obtained from literature review. The secondary information mainly related to experimental results on the use of liming as well as information on fertiliser companies and their products. Most of the information reviewed was generated in Kenya by research scientists working for the Kenya Agriculture and Livestock Research Organisation (KALRO) as well as local universities.

3.2.2 Primary data collection

Primary data was collected through a mix of methods, utilising both qualitative and quantitative approaches. Quantitative data was collected through the household survey while qualitative data was collected through Focused Group Discussions and Key Informant Interviews.

3.2.2.1 Quantitative data

A household questionnaire was developed to collect primary data from farmers (see Inception Report). The questionnaire was programmed using Open Data Kit (ODK) software to conduct Computer Aided Personal Interviews (CAPI).

ODK Collect is an open source Android app that replaces paper forms used in survey-based data gathering.

3.2.2.2 Sampling design for quantitative data

This study focused on four counties (Bungoma, Kakamega, Uasin Gishu and Trans Nzoia). This was because, these counties were targets of our intervention through Homa Lime Co. Ltd. in creating awareness about the benefits of lime, branding, and training agro-dealers. Part of the awareness creation was done through demonstrations, field days and radio messaging.

Statistical analysis presupposes the use of a statistically significant sampling strategy based on the Central Limit Theorem. The study sample was a random sample. We resorted to cluster sampling because, there was no list of names of all the farmers in each of the four counties. The clusters were formed by administrative units, sub-counties in the first round and wards in the second round.

For each county, a research assistant and two enumerators were assigned and they were tasked with random sampling of sub-counties followed by random sampling of wards from the sampled sub-counties. It was purposively decided to identify only four sub-counties from each county, and only four wards from each of the sampled sub-counties. The random sampling was done from the numbers of the sub-counties and wards shown in Table 3.

Table 3: Number of sub-counties and wards in the target counties

County	Number of sub-counties	Number of wards
Bungoma	9	45
Kakamega	12	61
Trans Nzoia	5	25
Uasin Gishu	6	30
Total	**32**	**161**

A total of 16 wards were identified in each county giving rise to 64 wards in the four counties. However, due to difficulties of knowing the exact ward boundaries, some interviews were conducted in neighbouring wards and in total, 74 wards were covered which translated to 46% of the total number of wards in the four counties. A complete list of all sub-counties and wards in the four targeted counties is shown in Annex two (separate volume of annexes). Out of these 74 wards, a total of 518 farmers were interviewed in the study through individual questionnaires against a planned 494 farmers distributed as follows (see table 4) in the four counties.

Table 4: Distribution of household respondents

County	Number of respondents	Percentage of total
Bungoma	127	24.5%
Kakamega	134	26.0%
Trans Nzoia	130	25.0%
Uasin Gishu	127	24.5%
Total	**518**	**100%**

3.2.2.3 Before and after comparison with opinion

In an impact assessment, counterfactuals or control groups play an important role in the issue of attribution. Given the distribution of lime sellers in the four counties, it was practically difficult to isolate areas that could have provided realistic control groups. The approach adopted was that of a "Before" and "After" Comparison with Opinion (BACO). Although this non-experimental design has certain drawbacks, it was the best that could be used in the circumstances.

Respondents (HLCL, Distributors, Stockists, Farmers, NGOs, etc.) were asked time-based questions to bring out the differences between the pre 2015 situation and post 2015. These questions were contained in the Household Questionnaire and some Checklists (Annex 'X').

3.2.2.4 Qualitative data

Qualitative data was gathered from review of relevant literature (discussed in Chapter 2), key informant interviews, focus group discussions, and observations. For qualitative data collection (through key informant interviews and focus group discussions), information/data was collected through respondents whose selection was done by finding out through personal visits or making telephone calls to find out who was available for interview. Potential respondents were contacted as individuals or through their Organisations identified based on the role, they play in lime use and soil testing services.

Key Informant Interviews (KII) were held with two personnel from KMT (Agricultural inputs/Monitoring evaluation/Policy and climate);

two personnel from HLCL (General Manager, Sales Manager);

two National government officers (Ministry of Agriculture - Inputs Officers) and 10 lime distributors/ stockists.

The lime sellers were distributed as follows across the four counties:

two from Bungoma, two from Kakamega, three from Trans Nzoia and three from Uasin Gishu (see volume on annexes).

The interviewed distributors and stockists were sampled from the list of 17 HLCL approved distributors (see volume on annexes).

In the distribution of inputs such as fertilisers and seeds, sometimes the terms "distributor" and "stockist" are used to mean the same thing. At other times, the term "stockist" is used to denote a retailer, one who sells inputs to the final consumer while the term "distributor" is applied to wholesalers.

In this study, it was found that such a distinction between "distributor" and "stockist" (also referred to as "agrovet") was blurred in the case of lime business because nearly all the enterprises were selling retail, even those that were also wholesaling.

Focus Group Discussions (FGD): In each county FGDs were organised with mixed participants. This involved bringing together farmers and actors involved with lime for a common Discussions to hear the views of different stakeholders in an open forum. Farmers were able to voice their concerns directly to the concerned parties who in turn were able to respond directly.

In addition to farmers, other participants included county CECs in charge of Agriculture and agricultural extension officers.

In addition, in specific FGDs there were representatives from various other Organisations such as KALRO, KEPHIS, Soil Care, One Acre Fund, Farm Africa, Farm Concern International, Innovations for Poverty Action, Welt Hunger Hilfe (Action against Hunger) and Equity Group Foundation (EGF).

Table 5 shows that a total of six focus group discussions were held. The number of participants varied between 14 and 19 per Discussions and in total the number of participants was 95. The names of the participants and their institutional affiliation are given in the volume on annexes.

Table 5: Focus group discussions and locations where they were held

County	Sub-County	Location of FGD	Number of Participants				Date of FGD
			Men >35	*Women >35*	*Youth (19-35)*	*Total*	
Kakamega	Lurambi Sub-County	Sheywe Guest House, Kakamega	7	6	1 (M=0; F=1)	14	30 October 2018
	Marama/ Butere Central-Sabatia	Deputy Commissioner's Office	9	5	0	14	31 October 2018
Bungoma	Kimilili	Kimilili town	6	7	5 (M=2; F=3)	18	1 November 2018
	Bungoma Town/South	Bungoma Town/ South (Midtown Hotel)	7	5	3 (M=1;F=2)	15	31 October 2018
Uasin Gishu	KES ses Sub-County	Comfy Inn Hotel, Eldoret	8	5	6 (M=	19	2 November 2018
Trans Nzoia	Kiminini	Elgon View Hotel, Kitale	8	3	4 (M=	15	1 November 2018
	TOTAL		**45**	**31**	**19**	**95**	

Observation was an important method. For example, on one farm it was observed that the farmer was practicing "Push-pull" biological method of pest control on maize and relevant questions were raised accordingly. While interviewing stockists, the interviewers also made observations of any lime on display and any customers that were asking for the product.

3.3 Data Processing and Analysis

The data obtained from the field was downloaded from the central server cleaned, and coded, entered then analysed. Data cleaning and debugging was done continuously during the data collection stage. The CAPI system was set up in a manner that any errors detected in the course of data collection were fed to the supervisors and correction made in liaison with the concerned field interviewers. The process of the data analysis was done by pre-analysis of the data where by the mass of the raw data collected was systematically organised to facilitate the analysis. Table 6 below shows a summary of the study objectives and the related data collected, tools used and the analysis methods applied.

Table 6: Objectives of study, types of data collected, tools and analysis methods used

Objective	Type of data collected	Methods/Tools used in data collection	Analysis methods used
To determine the demographic features of households	Age, sex, household size, marital status, etc.	Household questionnaire	Descriptive statistics-
To establish the current knowledge levels, knowledge gaps and information awareness on lime and soil testing services among smallholder farmers in western region.	Information and knowledge about lime and soil testing; sources of information about lime and soil testing service providers	Review of documents Key informant interview Household interviews using questionnaire	Descriptive statistics-frequencies; percentage of farmers who were aware Qualitative analysis
To establish uptake levels of the lime use and soil testing services among smallholder farmers in western region.	Adopters and non-adopters of lime	Review of literature Household interviews using questionnaire	Descriptive statistics-frequencies; percentage of farmers using lime and soil testing services
To establish the change in business performance, market share, sales and revenue for Homa Lime Co. Ltd and its distribution networks through sales of lime and soil testing services.	Changes in HLCL business performance and sales over the period 2015-2018 Suppliers of lime in western Kenya Change in distribution network over the period 2015-2018	Key informant interview checklists (covering Homa Lime Co. Ltd, Agro-dealers and soil testing service providers)	Qualitative analysis
To demonstrate the impact of lime use and soil testing services on farm productivity, yields and farmer incomes in western region.	Lime application rates Crop yields Crop prices	Review of literature Household questionnaire Focus group interviews Case study (interviews, reports, documents and observations)	Qualitative analysis Descriptive statistics

Objective	Type of data collected	Methods/Tools used in data collection	Analysis methods used
To demonstrate the intervention's impact on cross cutting issues including climate resilience and gender.	Views of stakeholders on impact on climate resilience and gender	Focus group interviews Case study (interviews, reports, documents and observations)	Qualitative analysis

The focus of the analysis was on finding answers to the two key research questions:

(i) Did HLCL/KMT intervention result in a significant increase in access to lime by farmers? and

(ii) Does lime lead to increased productivity?

A comparison was made between the main characteristics of farmers who have adopted the use of lime and those of non-users.

3.3.1 Quantitative data analysis

Statistical Package for Social Scientists (SPSS) was used in the analysis of the household survey data to generate the descriptive statistics.

3.3.2 Qualitative data analysis

The information/data analysed came from key informant interviews and focus group discussions.

The data was recorded manually in notebooks in the process of the interviews but based on some Discussions topics.

The topics became a framework/basis for categorisation of the data into themes or patterns that consisted of ideas, phrases, concepts, behaviors or interactions.

To illustrate, in FGDs, participants (farmers in particular) were asked to explain what they knew about why soils needed liming, soil acidity and soil PH. Soil acidity/soil PH was considered one of the important themes in the study. The responses to this question were varied as different participants had different views about the issue.

The further analysis of the data involved (a) finding the different views interviewees expressed with regard to a specific issue; and

(b) deciding whether a view was expressed by the majority of interviewees or a minority of them. In general, ideas expressed by many interviewees were given more weight compared to those expressed by one or only a few people.

However, in some instances, the minority views carried the day because the individuals expressing them had unique qualities such as technical skills or experience that the majority may have lacked.

Another example was the case of agro-dealers; they were asked to assess the level of awareness liming and soil testing among

(i) county government extension workers,

(ii) staff of CSOs active in agriculture,

(iii) researchers,

(iv) input distributors/stockists, and

(v) smallholder farmers.

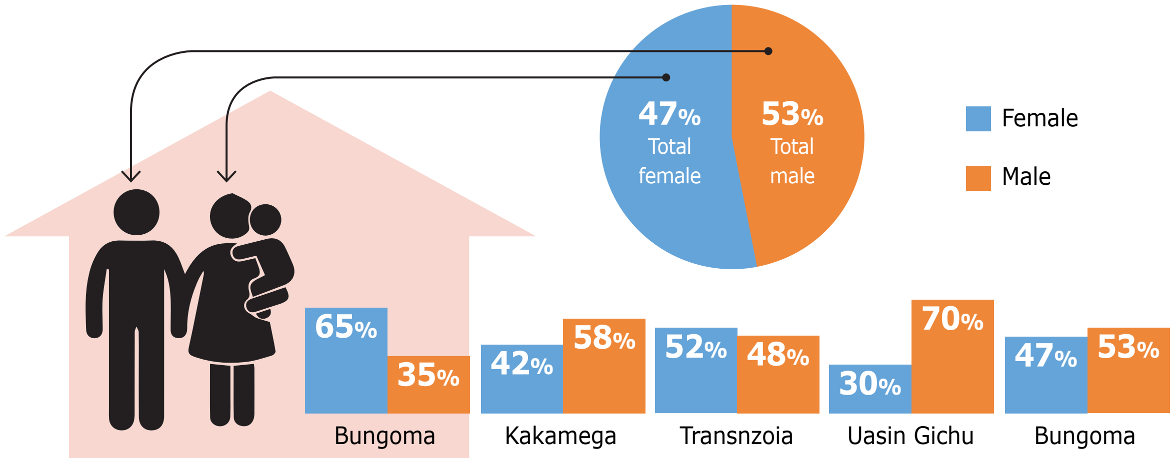
They were to rank the awareness as being either low, medium or high. The responses from the respondents in each county were recorded on templates and county patterns emerged. The responses from all four counties were consolidated in one template and an overall pattern emerged.

CHAPTER FOUR

Discussion of Findings

4.1 Household Demographics

Figure 1: Distribution of respondents by gender



A total of 518 farmers participated in this survey.

Out of the total 518 farmers interviewed, 53% of them were male while 47% were female. In terms of counties, Uasin Gishu had more male respondents (70%) than all other counties followed by Kakamega county (58%). On the other hand, Bungoma county had the highest female respondents (65%) followed by Trans Nzoia (52%).

Age Distribution

Figure 2: Age distribution of respondents

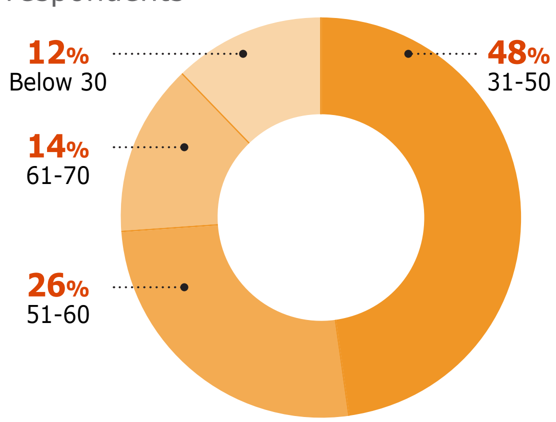


Figure 2 shows the distribution of respondents in different age groups. 48% of the respondents are aged between 31-50. 26% of the respondents fall within the ages 51-60 years. 14 per cent were between 61-70 years of age while 12 per cent of the respondents were below 30 years of age. The average age therefore falls within the 41-50 age group.

Household Headship

From the responses received, all the households were adult-headed (>18 years) with 85 per cent of the households being male-headed while 15 per cent were female-headed, indicating a male-controlled community.

Figure three shows the proportion of female-headed households in different counties; the figure varied between 10% and 20%.

As depicted in the above graph, Trans Nzoia county had the highest number of female-headed households (20%) followed by Bungoma (17.5%). Uasin Gishu county had the lowest female-headed households (10%) followed by Kakamega (12%).

Marital Status of the Respondents

Figure 3: Marital status of married household heads

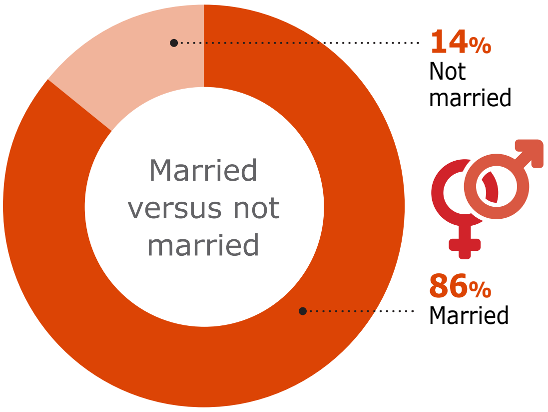
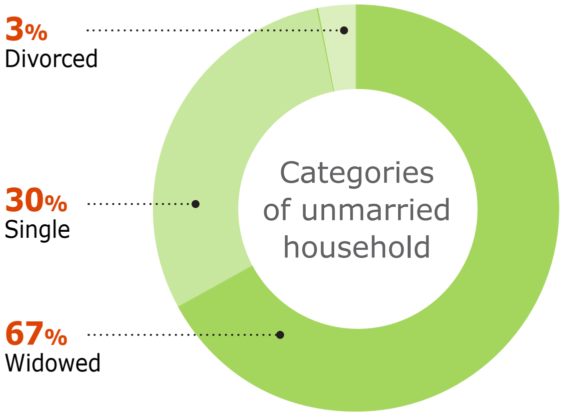


Figure 4: Marital status of unmarried household heads



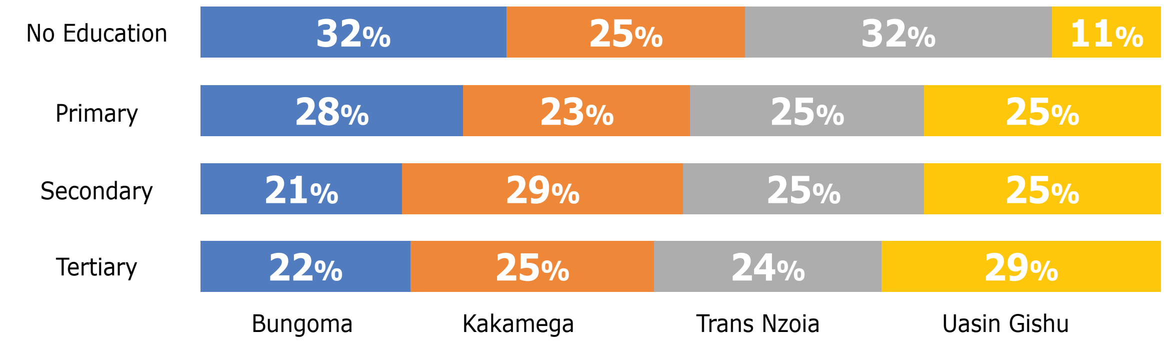
Majority of the respondents were found to be married (86%) while 14% were single. Of the single, majority of them were widowed (67%), 30% were single while only 3% were single as a result of divorce. It can be concluded that the family is a high consideration in the Western region of Kenya.

Respondents' Education

The education level analysis was intended to find out the potential of engaging the farmers and related communities in educational and extension services in terms of adoption of new technology and livelihoods. Results indicated that more than 90 per cent of the household heads were literate; with 30.7 per cent having attained primary school education; 36.2% having attained secondary education; and 24.5% tertiary levels of education.Only 8.5% were considered illiterate; these were mostly over 60 years, with only one such person reported to be in the 31-40 years age bracket. Household heads within the age bracket of 31-50 years constituted 52% of those who had attained tertiary education compared to 26% of those in the 51- 60 years age bracket.

Based on these results, it can be concluded that the younger people tended to have higher chances of being engaged in technical matters of lime and soil testing requiring some level of education.

Figure 5: Comparison of education achievement of household heads in the four counties



Looking at the educational achievement among household heads in the four different counties (figure 5), Bungoma had the smallest proportion of respondents who had achieved tertiary education (22%) followed by Trans Nzoia county.

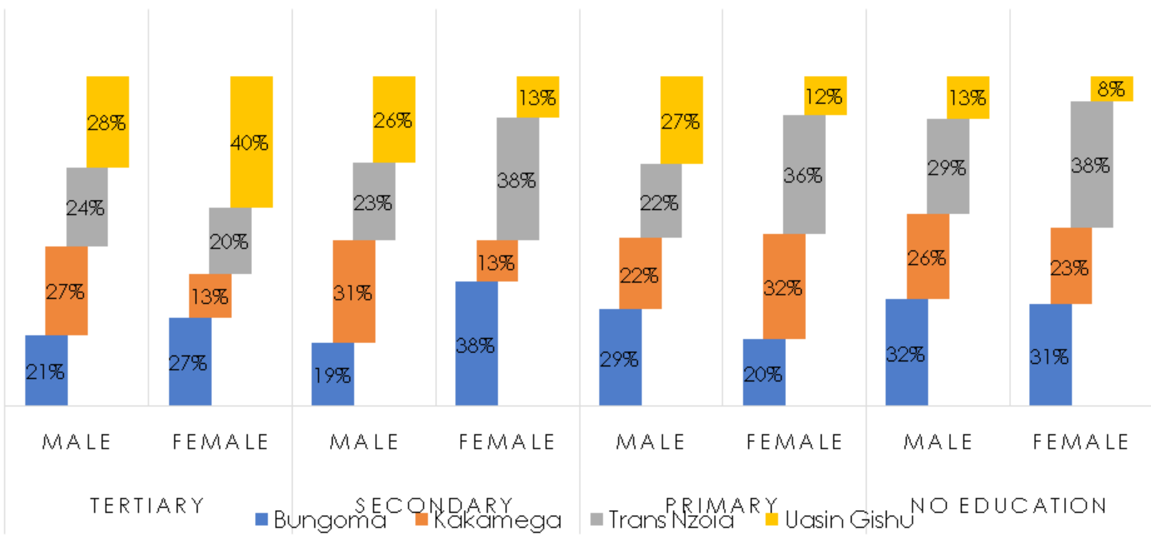
The county with the highest number of household heads with tertiary education was Uasin Gishu county at 29% followed by Kakamega county at 25%. Similarly, Uasin Gishu had the smallest proportion of respondents without education (11%). Bungoma and Trans Nzoia counties had the highest number of household heads with no education (32%). Kakamega had the highest proportion of respondents with secondary education (29%).

Gender differences in education achievement are shown in Figure six below. The figure shows that Bungoma had the smallest proportion of male respondents (21%) who had achieved tertiary education than the other counties but with slightly higher number of women with tertiary education (27%) only second to Uasin Gishu with the highest number of females with tertiary education.

In terms of those with no education, Uasin Gishu had the smallest proportion of female respondents without education (8%) followed by Kakamega (23%). Similarly, the county also had the lowest number of males with no education at 13 per cent followed far off by Kakamega county at 26%.

Kakamega had the highest proportion of respondents with secondary education (31%) but also with the lowest number of females with secondary education (13 per cent). More female in Bungoma and Trans Nzoia counties had the highest proportion of female respondents with secondary education (38%).

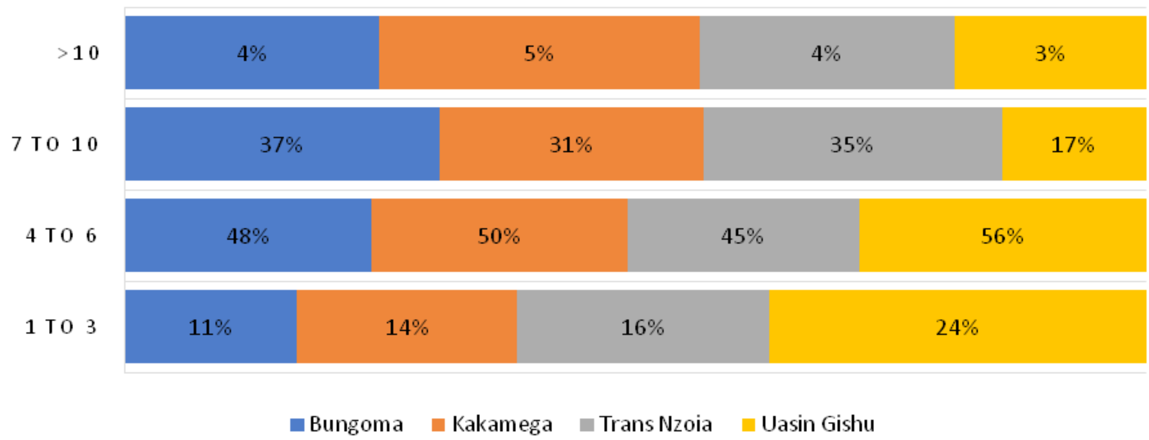
Figure 6: Educational levels across different counties and gender



4.2 Household size

Figure seven below presents the proportion of households within a given range of members. From the figure, majority of the respondents in all counties had a household size of 4-6 with Uasin Gishu county having the highest number under this category (56%). All counties had 5% or below household size of more than 10. Bungoma had the highest number of households between seven and 10 (37%) followed by Trans Nzoia county (35%) while Uasin Gishu county had the lowest household size under this category (17%). In Uasin Gishu county 24% of the respondents had the smallest household of one to three.

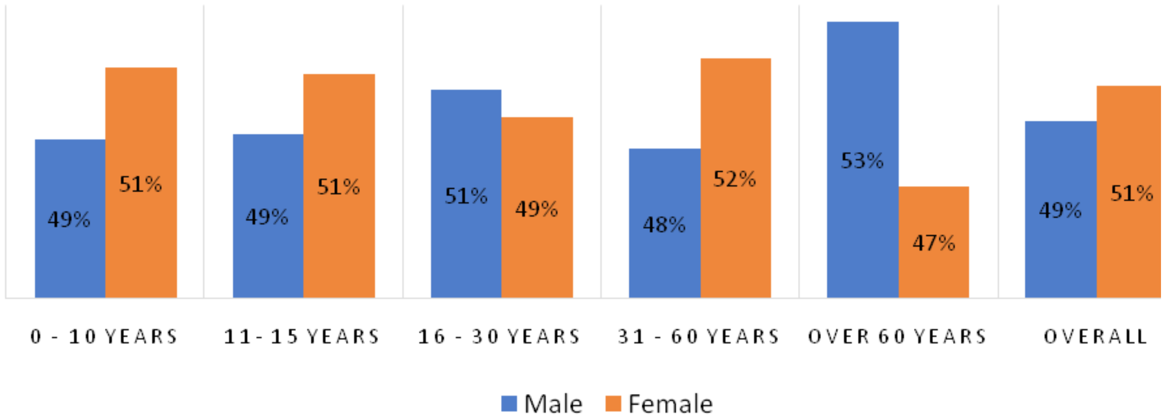
Figure 7: Proportion of households (%) with a given range of members



On further probing, it was revealed that the households in this region is female dominated (51% against 49%). There are more female than men under each age category except for 16-30 years of age and over 60 years where male are 51% and 53% respectively. These data show a growing household population potentially exerting adverse pressure on land and other resources in future especially land parcel sizes could diminish through subdivisions.

Besides, given 73% of the households had sizes of 4-10 members, depicting large family sizes, a significant proportion of farm produce would be consumed at home rather than be sold, reducing household income. This is supported by the finding that 55% of the household members were in the 16-60 age groups with the overall gender ratio for the study population more or less 1:1. i.e.49.2%: 50.7%.

Figure 8: Distribution of household members by age and gender (%)



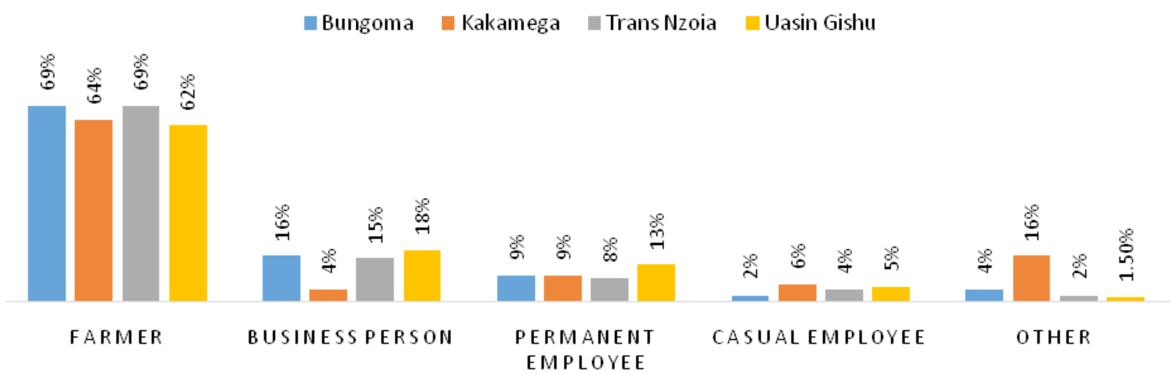
Occupation of the respondents

The area residents were predominantly engaged in farming with about 66% of the respondents reporting that household heads were farmers. This high proportion was not unexpected given that snowballing was used with farmers referring researchers to fellow farmers. Other occupations were business (13 per cent), permanent employment (10%), and casual employment (4%).

Figure 9 below shows the county proportions of respondents in the different occupations. The low diversity of economic activities diminishes the capacity to mobilise financial resources to diversify the economic platform.

This increases dependence on the land and natural resources for economic production, making the communities and especially low-income households highly vulnerable to multiple adverse environmental impacts. The other categories of occupation by household heads did not exclude them from engaging in farming since at any rate, their household members would be involved. In view of the high level of dependenceon the land resource, environmental degradation and natural resources depletion, a large proportion of the community will be adversely affected by climate change impacts and outcomes. Moreover, this dependence should also be a compelling reason for households to manage their soils well, including liming acidic soils.

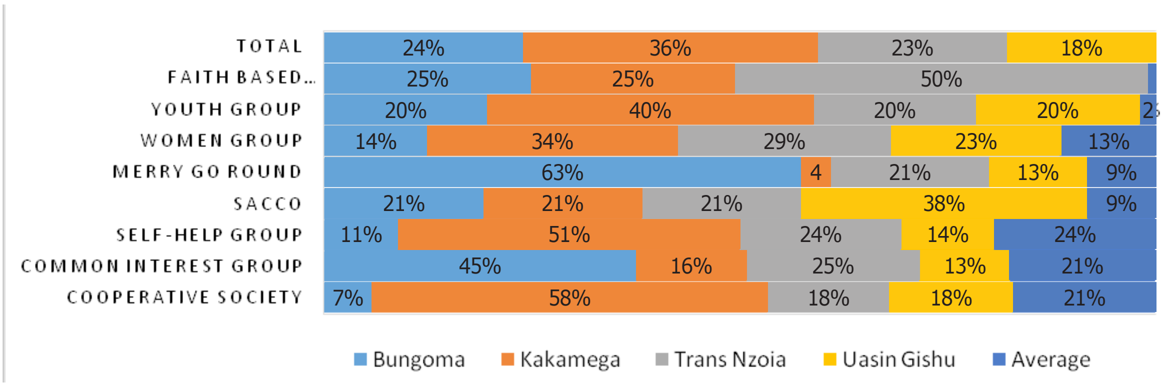
Figure 9: Occupation of household head in target counties



Community Organisation

Information was sought about the types and level of existing community Organisations, organised groups' activitiesand the potential for channeling soil testing and lime use awareness. While 299 respondents (58%) did not subscribe to any organised group, 219 respondents (42%) indicated that they at least belonged to a type of an organised group.

Figure 10: Types and number of community groups in the target counties

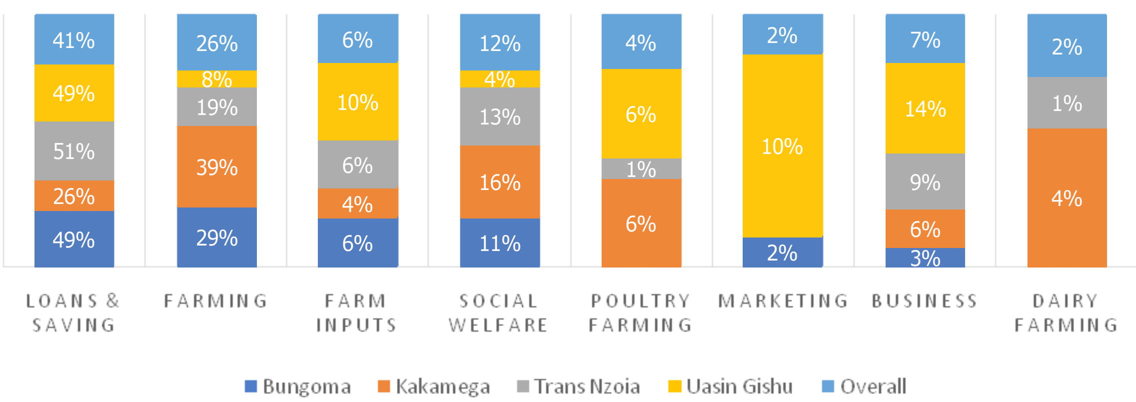


The leading types of community groups in terms of membership were self-help groups, (24% of households), cooperative society (21% of households), and common interest groups (21% of households). Faith based Organisations had the least membership at one per cent followed by youth groups at two per cent.

Overall, Kakamega county had the highest number of memberships in the formal Organisations (36%) while Uasin Gishu county had the lowest membership (18%). In general, the communities in these counties had a low level of engagement with formal organisations, which would hinder rapid deployment of intervention measures.

The activities undertaken by the groups were diverse; out of 287 recorded activities, 118 of the recorded activities (41% of total) were in relation to loans and saving; 75 were in relation to agriculture (26% of total); 35 were related to social welfare (12.2% of total) while 21 were business oriented (7.3% of total). The groups active in the four counties potentially provide nexus for intervention and platforms for launching project activities. The groups in Kakamega and Bungoma counties were mostly oriented to farming, financial and social welfare activities while those in Uasin Gishu were financially and business aligned. In Kakamega and Trans Nzoia there was no group that was involved in marketing.

Figure 11: Group activities and proportion of households engaged in them (%)



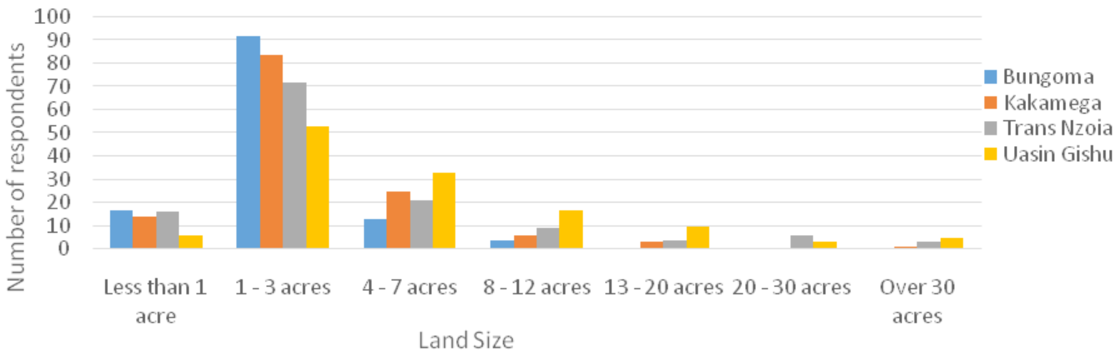
The respondents indicated they received the following benefits from group membership: financial support, boosting farming, access to inputs, home improvements and school fees. Out of the households that had members in organised groups, the proportion of the respondents who had implemented group activities on their farms was 63%. The lack of implementation was due to the group activities being unrelated to agriculture.

4.3 Land tenure and land size

Land tenure was important to determine livelihood sustainability and consequently adoption of land based technology. Majority of the land ownership in the target area was inherited/titled land (90% of households) while others had certificates (7% of households), leases (2% of households) and squatters (0.4% of households). In the households headed by females, 84% had inherited/titled land and 12% had certificate for their land while those led by males were predominantly inherited/title land (91% of households).

Most of the respondents had parcels between zero and three acres (68% of households) and a small proportion had 4-7 acres (18% of households) as shown in Figure 12. Few respondents possessed large parcels indicating that land size a crucial factor in the target areas. There were no significant differences in the land size owned by female-headed and male-headed households.

Figure 12: Land parcel holdings



4.4 Main land uses and trends

The land use in the four counties was varied and reflected climatic conditions prevailing in the different zones. The predominant land useswere mixed farming (43% of respondents), mixed cropping (30% of respondents) and mono cropping (22% of households). In Kakamega, the main land uses were mixed farming (62% of respondents) and mixed cropping (25% of respondents).

In Bungoma and Trans Nzoia, mixed farming and mono cropping were the dominant land use types. Uasin Gishu had more varied land use types with those practicing mono cropping and mixed cropping as the major land use types (34.6% of households for each). Other land use types reported were settlement and commercial reported in Kakamega and Uasin Gishu counties, while pasture and irrigation were only reported in Uasin Gishu County.

Respondents suggested a variety of potential land use practices they would adopt if they had the finances. Dairy cattle rearing, soil conservation and commercial agriculture practices were the most desired alternatives (Table 7).

Table 7: Alternative land uses respondents would want to adopt

County	Alternative land use	Reasons for suggestion
Bungoma	Cash crops	Climate change, marketable and profitable
	Adopt new technology	Profitable, conserve soil and climate change
	Mixed farming	Profitable, low maize prices and food security
	Soil conservation	Improve land fertility profitable and climate change
Kakamega	Soil conservation	Conserve soil and profitable
	Adopt new technology	Profitable, Improve land fertility and food security
	Cash crops	Profitable and food security
Trans Nzoia	Horticulture	Profitable, marketable and matures fast
	Dairy farming	More profitable, good market, good prices and small land size
	Livestock farming	Marketable, low maize prices and low maintenance
	Poultry farming	Profitable, not affected by weather and low maize prices
Uasin Gishu	Horticulture	Good market and prices, matures fast and low maintenance
	Adopt new technology	Profitable and improve soil fertility
	Food crops	Food security and profitable
	Dairy farming	Profitable and continuous production

Queried on reasons driving the need for change in land use, increased income was the most frequently proffered reason, falling in tandem with finances as the major constraint to change in land use. Lack of skills and information was mentioned as a constraint to change in land use practices. These responses suggest that interventions on additional training and capacity building will be critical for getting farmers to adopt soil testing and liming.

When respondents were asked about who has access to new technology in the household, they said husband/father (48% of households); wife/mother (33% of households) and children (12% of households).Respondents also mentioned that husband/father had the highest access and input on new technology adoption (50 per cent of households); but wife/mother was also mentioned (34% of households). The respondents stated they consider mostly cost, benefits and knowledge and skills required before adopting new technology. Additional considerations mentioned were: Accessibility and availability of technology; rate of adoption; and if the technology was an answer to a current s

The major land use and management trends observed by the respondents in the last five to 10 years were changes in crops and varieties, mechanization, increased use of fertiliser, adoption of new technology and reduced yields (Table 8). It is noteworthy that use of lime was not considered a significant trend by the respondents.

Table 8: Main trends in land use and management in past five to 10 years

County	Main trends in land use
Bungoma	Changes in crops grown and varieties of crop
	Mechanization
	Increased use of fertiliser
	Changes in planting season
Kakamega	Changes in crops grown and varieties of crop
	Adoption of new technology
	Sugarcane planting
	Reduced yields
Trans Nzoia	Introduction of mixed farming
	Changes in crops grown and varieties of crop
	Increased use of fertiliser
	Increased use of pesticides and herbicides
Uasin Gishu	Changes in crops grown and varieties of crop
	Change from crop to livestock farming
	Increased use of pesticides and herbicides
	Reduced yield

4.5 Crops grown

The crops grown in the target counties included maize, beans, sugarcane, vegetables, bananas, wheat and potatoes. However, the overall picture is one of limited diversification.

Maize was the most widely cultivated crop, grown by 485 households (94% of the respondents); beans were planted by177 households (34% of the respondents) and sugarcane was grown by 38 households (7% of the respondents). Other crops grown by smaller proportions of farmers were vegetables (5%), bananas (4%)) and wheat (2.5%).

Bungoma had higher diversity of crops grown compared to the other counties. Maize was grown by 75% of respondents in Uasin Gishu, followed by horticulture (fruits/vegetables) by 10% and tubers by 5% of the respondents. Wormer, et. al. (2016) in their study on characterisation of small farms in Western Kenya also observed the dominance of maize-based farming systems.

The major production technologies used by the respondents were disc ploughing, fertiliser application, use of organic manure, use of pesticides and use of herbicides. The major crops and the associated production technologies are shown in Table 9. It is noteworthy that liming was not mentioned very often as one of the main technologies used by farmers.

Table 9: Crops, production technology, purpose of production, yield and acreage

County	Main crops grown	Main production technology used	Purpose of production	Average quantity harvested (90kg bags/ acre)	Average acreage (acres)
Uasin Gishu	Maize	Fertiliser application Use of pesticides & herbicides Disc plough	Consumption & sale (85%) Consumption (13 per cent)	17	3.6
	Vegetables	Use of pesticides & herbicides Fertiliser application, Manure	Consumption & sale (64%) Consumption (36%)		0.28
	Wheat	Fertiliser application Use of pesticides &herbicides Disc plough	Consumption & sale (61%) Consumption (39%)	14	3.8
Trans Nzoia	Maize	Fertiliser application Manure Use of pesticides & herbicides Liming	Consumption & sale (73%) Consumption (26%)	18	3
	Beans	Fertiliser application Manure Use of pesticides & herbicides	Consumption & sale (74%) Consumption (23%)	4	1.7
	Bananas	Fertiliser application Manure	Consumption & sale (67%) Consumption (33%)		0.47
Bungoma	Maize	Fertiliser application Manure Use of pesticides	Consumption & sale (58%) Consumption (38%)	12	1.3
	Beans	Use of herbicides Manure Fertiliser application	Consumption & sale (68%) Consumption (32%)	9	1.2
	Bananas	Manure Use of pesticides Liming	Consumption & sale (43%) Consumption (43%)		0.3

County	Main crops grown	Main production technology used	Purpose of production	Average quantity harvested (90kg bags/ acre)	Average acreage (acres)
Kakamega	Maize	Fertiliser application Manure Liming	Consumption & sale (47%) Consumption (47%)	12.5	1.6
	Beans	Fertiliser application Liming Minimum tillage	Consumption & sale (58%) Consumption (37%)	2	1.2
	Sugarcane	Fertiliser application Manure Minimum tillage	Sale (83%) Consumption & sale (17%)	19.8 tonnes/ acre	3.5

In crop production, the distribution of labour across gender categories was variable.

> In Uasin Gishu, labour was mostly supplied by hired labour (55% of households) and men (21% of households), while in Trans Nzoia, it was supplied by hired labour (34% of households), and women (30% of households).

Hired labor, men and women were more involved in manual work in Kakamega, while in Bungoma both men and women contributed equally. A considerable number of households (114) indicated children offered farm labour while only 10 stated youth were involved in farm work. The low involvement of youth in labour issues needs to be addressed for long term sustainability considering that 29% of household members(nearly a third) are between 16 and 30 years (821 persons out of 2952).

Households were asked to state the maize production technologies they use. Nearly a third (29%) of the respondents mentioned use of fertiliser; 20% mentioned lime use; 13 per cent mentioned improved seeds; and 12% mentioned use of organic manure. Other technologies used included use of herbicides by 8%, use of pesticides by 7%, push – pull by 7% and conservation tillage by 4% of the respondents. The remaining responses by respondents undertook irrigation agriculture. Respondents in Uasin Gishu indicated they used fertiliser and organic manure, while in Trans Nzoia, Bungoma and Kakamega, they reported using fertiliser and lime. Although the data does have some inconsistencies (e.g. although 20% of the respondents mentioned using lime in this part, in another part the figure was closer to 10%), the data nevertheless shows the general trends.

4.6 Farmers' historical crop production

When households were asked to assess their own historical trend in crop production with choices of high, medium or low; 8% of households said it was high; 48% said it was medium or average and 44% of the households said it was low. There were differences between counties (Table 10).

Table 10: Households' assessment of own historical production (Low, Medium or High)

	Assessment (% of households)		
County	**High**	**Medium**	**Low**
Bungoma	6	67	27
Kakamega	13	36	51
Trans Nzoia	2	42	57
Uasin Gishu	11	47	41
All four counties	8	48	44

In response to a question about general crop production trends, 57% of households said crop production has been decreasing; 23% of households said the trend was increasing; and 20% said it was constant.

In terms of the factors contributing to the trend, declining crop production was attributed to climate variability (21% of households), soil fertility (15% of households), pests and diseases (13 per cent of households), and low rainfall (9% of households) amongst other causes.

Given that climate variability includes low rainfall, it means that 30% of the households believed the crop production decline was related to weather-related causes.

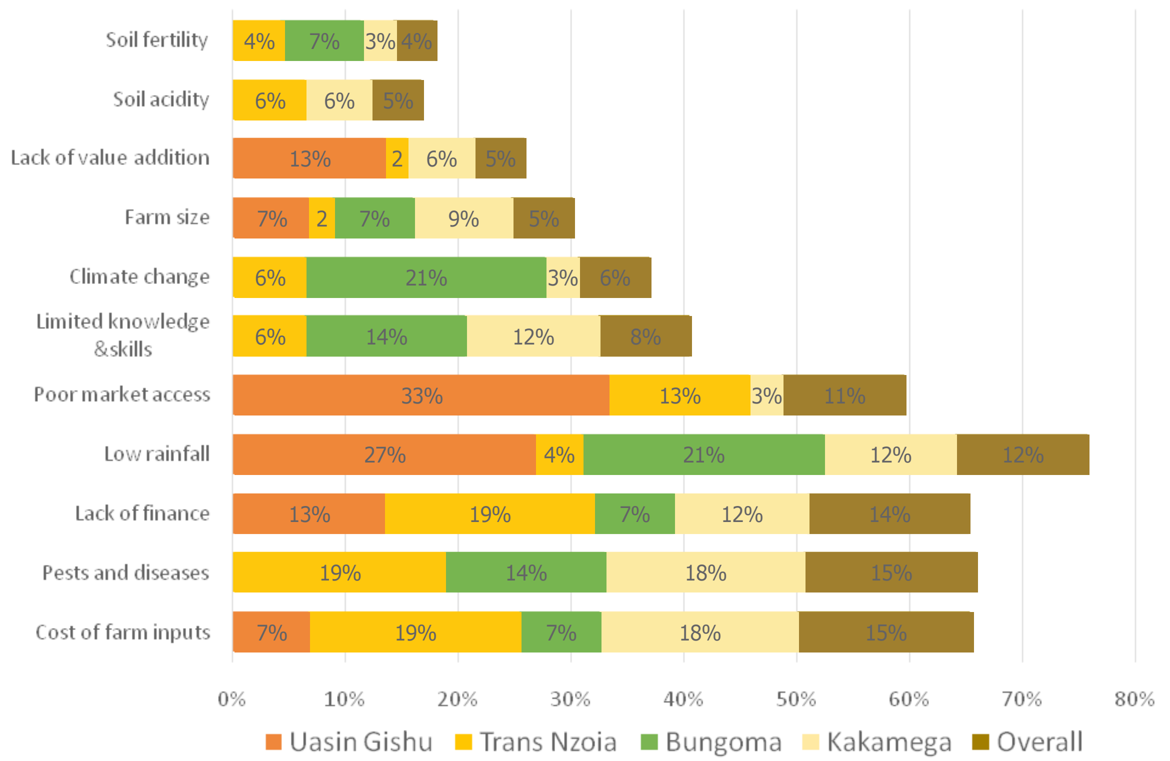
> Only one out of seven households perceived soil fertility as a major factor in the crop production decline.

This may be an indication that the majority of farmers have not prioritised this issue and it may explain why there is little progress in tackling soil issues, including soil acidity. Improved crop production was attributed to high rainfall (14% of households), use of fertiliser (10% of households), improved production technology (6% of households) and use of organic manure (6% of households). The major pest that has led to decreased crop production was given as fall army worm; minor pests were cut worms, aphids, green worms and stalk borers.

4.7 Constraints in maize farming

Respondents indicated that in maize production, cost of farm inputs, pests and diseases, lack of finances, low rainfall and poor market access were themost critical challenges in decreasing magnitude,while soil acidity and soil fertility were the least mentioned constraints (Figure 13). Cost of farm inputs and pests and diseases were reported mainly in Trans Nzoia and Kakamega while climate change was indicated in Trans Nzoia and Bungoma. In Uasin Gishu, the major constraints were poor market access, low rainfall, lack of finance and value addition. The challenges in maize marketing were compounded by lack of market information, delay in payment, post-harvest losses and lack of produce value addition technology leading to waste and poor returns on investment. It is imperative that marketing challenges are addressed as better returns would reduce the need to change crops grown/land use for livelihood assurance and supplementation.

Figure 13: Major constraints in maize farming (% of households)



Limited knowledge and skills, cost of farm inputs, lack of information access and lack of finances are some challenges that the respondents would like to be sorted out in the target counties (Figure 13). Other limiting factors mentioned by the respondents were, pest and diseases, ineffective fertilisers and pesticides, farm size and climate change.

The other constraint represents poor farming methods, inadequate labor, weeds, low yields, flooding and low rainfall.

Theconstraints that farmers face haveserious implicationson crop production, adoption of new technology, as well as farmers' livelihoods and resilience.

Farmers in different counties identified different sets of priority constraints that should be removed.

Cost of farm inputs was prioritised across all four counties while limited knowledge and skills was prioritised in three counties. Interestingly soil acidity and poor market access were only prioritised in Uasin Gishu while lack of information access was prioritised only in Kakamega.

The respondents also had views on the actions that should be taken to address constraints and who should do it (Table 11).

Table 11: Farmers' constraints, proposed actions and preferred actor

County	Constraint to be improved	Action to be taken	By whom
Uasin Gishu	Cost of farm inputs	Subsidize farm inputs	Government
	Poor market access	Better prices	Self, Government
	Soil acidity	Soil testing	Self, Private sector
Trans Nzoia	Limited access to knowledge and skills	Training and awareness Avail information	Extension officer, Self, Government
	Cost of farm inputs	Subsidize farm inputs Timely provision of fertiliser and seeds	Government
	Lack of finances	Subsidize of finances Lend loans	Government, NGO, Private sector
Bungoma	Limited access to knowledge and skills	Training and awareness, Avail information	Self, Government Extension officer
	Lack of finances	Subsidize farm inputs, Training and awareness	Government NGO
	Cost of farm inputs	Training and awareness, Effective pesticides/ herbicides	Extension officer, Self Government
Kakamega	Limited access to knowledge and skills	Training &awareness, Avail information	Extension officer, self, Government
	Cost of farm inputs	Subsidize farm inputs, Better prices	Government
	Information access	Training & awareness, Employ extension officers	Government, Self, Government, NGO

CHAPTER FIVE

Discussion: Liming and Soil Testing

5.1 Farmers' knowledge about soil health, soil acidity, soil testing and lime

About 80% of the households believed that their farms were not producing at maximum yield while 91% believed that crop yield could be improved by monitoring soil health in their farms. Respondents stated they considered soil health when crop yield is low (31% of households);

- when appearance of crop is abnormal (25% of households);
- when choosing crop to plant (13 per cent of households); and
- when choosing fertiliser to apply (12% of households).

Smaller proportions of households also mentioned they also considered soil health when making crop management decisions, choosing technology and when soil is hard. However, 12% of households stated they did not consider it at all. The use of organic manure (51%), soil conservation (14%), use of lime (7%), soil testing (6%) and minimum tillage (4%) were some of the measures undertaken by the households to improve soil health but 12% had not done anything to ameliorate soil health. Practices such as strip farming, soil sterilization and adding new soil were rarely mentioned by respondents. Soil conservation measures adopted were mainly crop rotation, minimum tillage, agroforestry and terraces.

In all four counties only 55% of the respondents in household interviews said they had heard of soil acidity; while 44% knew about soil testing. Asked about what they knew about soil testing, majority stated: "It measures soil acidity and soil fertility; it is a basis for recommending crops to grow and the fertiliser to apply during planting." The respondents indicated as sources of this information: NGOs (31.4%), extension officers (20%), fellow farmers (18%), radio (13 per cent), and TV (6%). The NGO, One Acre Fund, was indicated by majority of the households as the source of soil testing information followed by Equity Group Foundation (EGF), KALRO and HLCL. Households mentioned soil testing service providers as Soil Cares, KALRO, KEPHIS, Crop Nut Ltd and Moi University but also sugar companies. A good number of households (110 out of 518 or 21%) stated they were not aware of soil acidity and for those that were they did nothing to reduce the acidity of their soils; liming was mentioned by 34 households (7%).

In focus group discussions, when asked what "soil acidity" was, farmers who knew about acidity and lime use explained that acidic soils bind nutrients and these therefore are not released to the plant. They also mentioned that other than through soil testing, decreasing yields were an indicator of acidity.

In one FGD, those farmers who had not tested their soils indicated the reasons to be lack of information and high cost. Only one farmer in that group of 18 mentioned a radio programme as having been the source of information on soil testing and liming. Farmers knew that DAP and Urea were acidifying fertilisers which should only be applied on an acidic soil if the recommendations from soil test allowed it.

Box 1: Bungoma Farmers Speak

"Wakati walipima udongo wangu mara ya kwanza mwaka wa 2016, udongo ulikuwa mbaya sana. Walisema udongo unalia, waliniambia pH ilikuwa 4.7 ilihali ilifaa isipungue 5. Nilianza kutumia chokaa ya shamba na pia kuzuia mmomonyoko wa udongo."

"In 2016, I harvested 6-8 bags of maize from my one acre piece of land. I then started applying lime in 2017 and I got 16bags. This year (2018), I want to say lime has really worked on my farm. I got 22 bags of maize from the same one acre piece of land."

"I used to farm casually until the extension officer visited me and did soil testing courtesy of the county Government of Bungoma. I cannot recall the exact pH but my soil was bad. I took a section of the land and started practicing conservation agriculture and also applied lime. My yields have been above average all through."

"For me I have not used agricultural lime before. Soil samples were taken from my farm in 2015 but to date I am yet to receive the results. But I am seeing that productivity on my land has been on a downward trend. This year, I harvested only four bags in an acre."

Farmers' statements in a focus group Discussions held in Kimilili, Bungoma on 1st November 2018.

When asked about soil tests and the relationship with the amount of lime recommended for application, farmers in FGDs who had undertaken soil tests and liming were able to explain that the lower the soil pH, the higher the amount of lime that was needed to reduce the acidity. Only when the pH was below 5.5 did the soil test recommend application of lime to the soil. Some farmers gave specific examples of how much lime they had received to apply to one acre of land where they intended to plant maize and the amounts of lime varied depending on the pH of their soils. A farmer who had soil pH of 4.5 had received 38 bags of lime (1,900 kg or 1.9 tonnes). In comparison a farmer with soil pH of 4.8 had received 20 bags of lime (1,000 kg or one tonne).

In household interviews, 70% of 67 households who knew about liming said that liming soils reduced acidity, improved soil health and increased yields. Lime was considered to be a fertiliser by 11% of households mostly from Bungoma with lime application and its advantages on improving soil structure being some of the things they knew about liming.

According to households in Bungoma, lime was sold by One Acre Fund, and lime was also used in construction. When asked about calcitic and dolomitic lime, some farmers in FGDs knew the fact that calcitic lime contains calcium but no magnesium while dolomitic lime contains both. They were able to link the choice of which lime to use to the recommendations of the soil test.

Use of organic manure and soil conservation were the main strategies used by the households to reduce soil acidity. Soil and water conservation are paramount undertakings if sustainable land management is to be attained in western region. Their conservation confers resilience on the ecosystem and continued productivity of the agro ecosystems. Overall, there is poor soil and water conservation undertaking in these areas resulting in soil erosion during the wet season. The lack of soil and water conservation was cited as one of the key challenges in agricultural production. Some of the soil conservation measures adopted are crop rotation, terraces, intercropping and minimum tillage.

Some farmers in FGDs were aware about Mavuno and Baraka fertilisers, introduced to them by One Acre Fund, Equity Group Foundation or the country governments. They admired fertilisers for their rapid action in improving soil fertility and wondered why lime cannot perform faster. It was this temptation to see quick results that led many to One Acre Fund and DAP.

In household interviews, only one farmer (from Sinyerere Ward in Trans Nzoia) indicated that he had used Mavuno fertiliser and he had obtained good results with maize.

Pelletised Lime: Some farmers in FGDs were aware about granulated lime which they compared to fertiliser in terms of ease of handling, preferring it to powder forms of lime.

What they did not appreciate was the significant cost implications of granulation. Given the fact that farmers mentioned cost as a factor in deciding to apply or not to apply lime, firms that may consider granulated lime products will need to take into account the fact that poor farmers might be attracted to the granulated product but might shy away when confronted with the higher price.

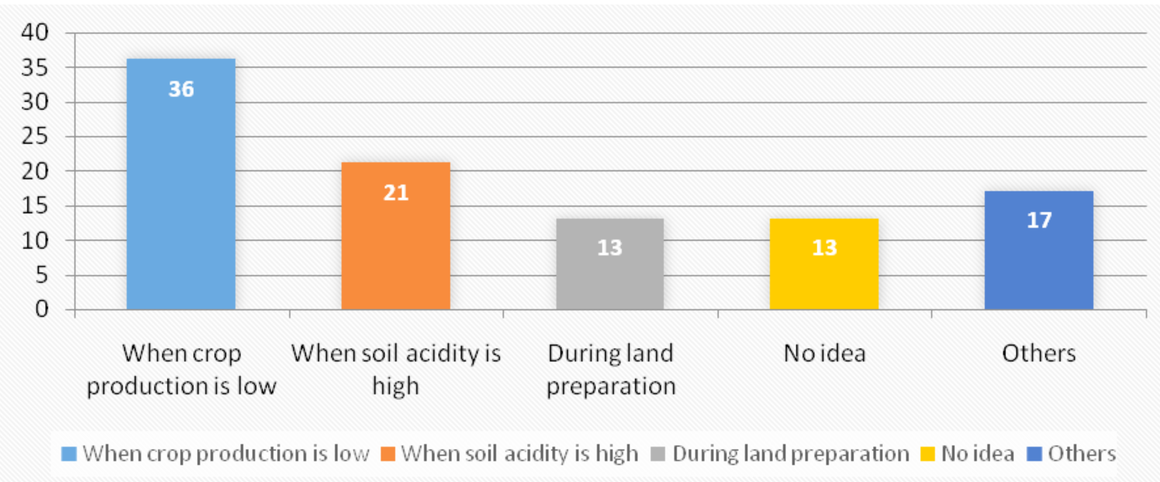
Impostor products: Unscrupulous salesmen can take advantage of farmer ignorance to sell fake products. In the USA, an example of such a product marketed as an "alternative" liquid lime product, turned out to be calcium chloride ($CaCl_2$). $CaCl_2$ cannot be used to neutralise soil acidity and is not a viable alternative to agricultural lime. Neither is it "liquid lime". It is true that $CaCl_2$ can provide plant available Ca to the soil, but Ca cannot reduce acidity.

Farmers in FGDs and in household interviews were not asked about $CaCl_2$. None of them mentioned it, giving the impression they were not aware about the issue. It is important that in future, trainers of farmers should make them aware about the possibility of rogue lime products. This is also an issue that should be addressed in the proposed lime policy.

When to lime soils: Lack of clarity on when soils require liming was demonstrated by responses from households. They were asked to say when soils required lime. There were three major responses (Figure 14). "When there is low crop production"; "when soil acidity is high"; and "during land preparation"

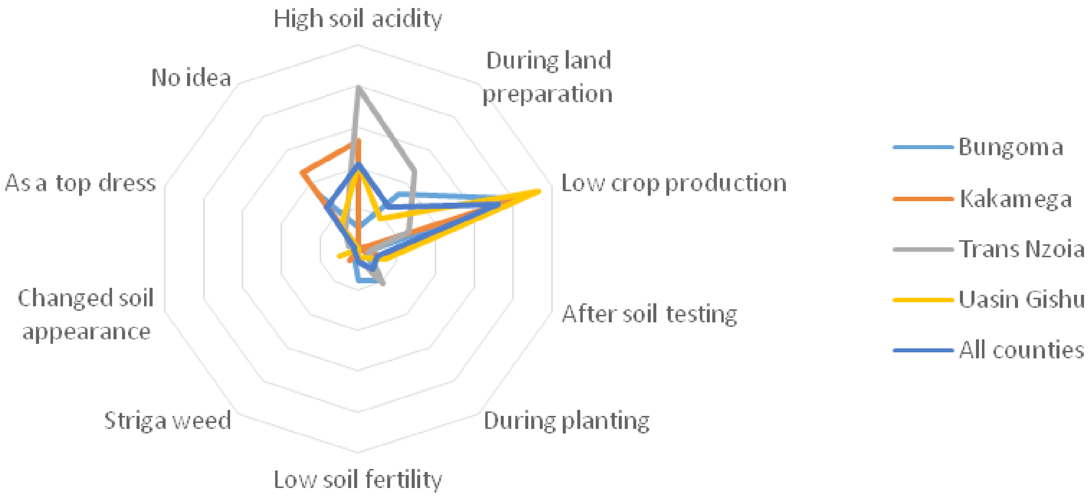
These responses accounted for 70% of the responses. Some respondents had no idea when soils require lime raised. Other responses included: "during planting", "when there is low soil fertility", "after soil testing", "when there is Striga weed", and "when top dressing".

Figure 14: When soils required liming



"Low crop production" was given as the time when soil required liming by 46% of households in in Uasin Gishu; 41% of households in Bungoma and 40% of households in Kakamega. These and other responses are summarized in figure 15.

Figure15: When households think soils require lime (% of households)



Maize and beans were the main crops that were grown in lime applied soils with beans being reported in Trans Nzoia and Kakamega. Tomatoes and wheat were stated in Uasin Gishu and French beans and bananas in Trans Nzoia (Table 12).

Table 12: Crops grown on limed soil, acreage and quantity of lime applied in target counties

Crop grown	Number of farmers with limed plots	Total acreage planted	Amount of lime applied (kg)
Maize	48	57.25	13,555
Beans	16	18.5	1,508
Tomatoes	1	1	50
Wheat	1	1	1,500
Bananas	1	0.25	50
French beans	1	1	125
Total		**79**	**16,788**
Average per acre (kg of lime)		*212.5*	

Of the farmers applying lime, 14 did so in February and 15 in March; these farmers mainly planted maize and beans. Lime was applied in April for fields planted with French beans and wheat; also in banana fields lime was applied lime in April. Farmers planting tomatoes applied lime in November. It was in the years 2016, 2017 and 2018 that most of the farmers applied lime. Of the maize farmers, nine applied lime in 2016 while 22 applied lime in 2017 and 12 did so in 2018. Farmers planting beans applied lime in 2017 and 2018. It was only in 2016 when farmers applied lime to the other crops.

Changes from liming: Perception of soil acidity changes was reported by 34 of the 46 households (74%) who used lime. Of the thirty four who reported changes in soil acidity only four tested their soils (for the second time) and had applied lime for the first time in 2017, nine relied on improved crop morphology and eight on better yields as an indicator of decreased soil acidity.

The main differences observed between limed and unlimed fields by 46 households (5 from Bungoma, 20 from Kakamega, 15 from Trans Nzoia and six from Uasin Gishu), that had used lime on their farm, were: increased crop yield (56% of households) and improved crop morphology (38% of households). Healthier crops, fast growth and increased yield were the main changes in crop growth habits observed by the respondents. Some also observed that crops planted in limed soil had better resistance to pests and diseases such as Striga. These changes were mainly reported in maize.

Changes in soil structure and color were mentioned by respondents; 37.5% of them mentioned limed soils were soft and light; 25% mentioned improved soil structure; and 19% mentioned reduced water logging.

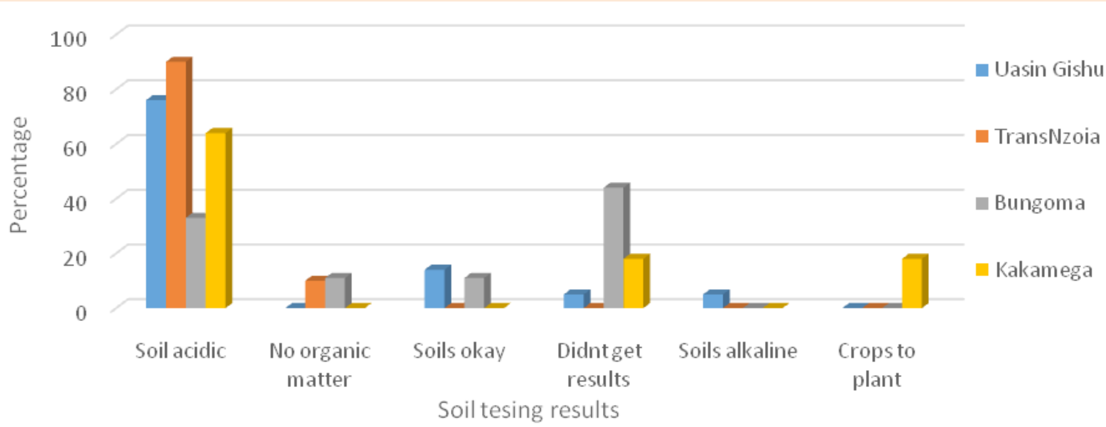
5.2 Farmers' experience with soil testing services

Only 54 respondents (10.4% of households) had undertaken soil testing on their farms and 46 had taken this service in 2014 to 2018 with majority undertaking it in 2015 (10) and 2016 (18). January (9), March (9), October (9) and August (8) was when soil testing was done by most of the households. Reasons for soil testing were given as to improve crop production (37%), because it was offered (24%), know soil pH (11%), know crop to plant (11%), know soil health (11%) and know fertiliser to use (6%).

Of the households that had done soil testing, 47% accessed soil testing service as a common interest group and individuals through One Acre Fund, Equity Group Foundation and county Government. Of those who tested, 28 households did not pay for the service while 18 paid KES 1,000 to KES 1,200 per sample.

Most of the households that had tested their soils reported that the soil test results indicated their soil to be acidic (35 out of 54 farmers) and seven households did not get results. In Trans Nzoia, the tested soils were found either to be acidic 90% or to be low in organic matter. In Bungoma where the county Government had soil testing initiatives, 44% of households did not get their results; while 34% had acidic soils. The farmers who did not get soil test results did not know the reasons why the testers withheld the results. There were four households from Uasin Gishu (3) and Bungoma (1) that indicated their soils were found to be okay (Figure 16).

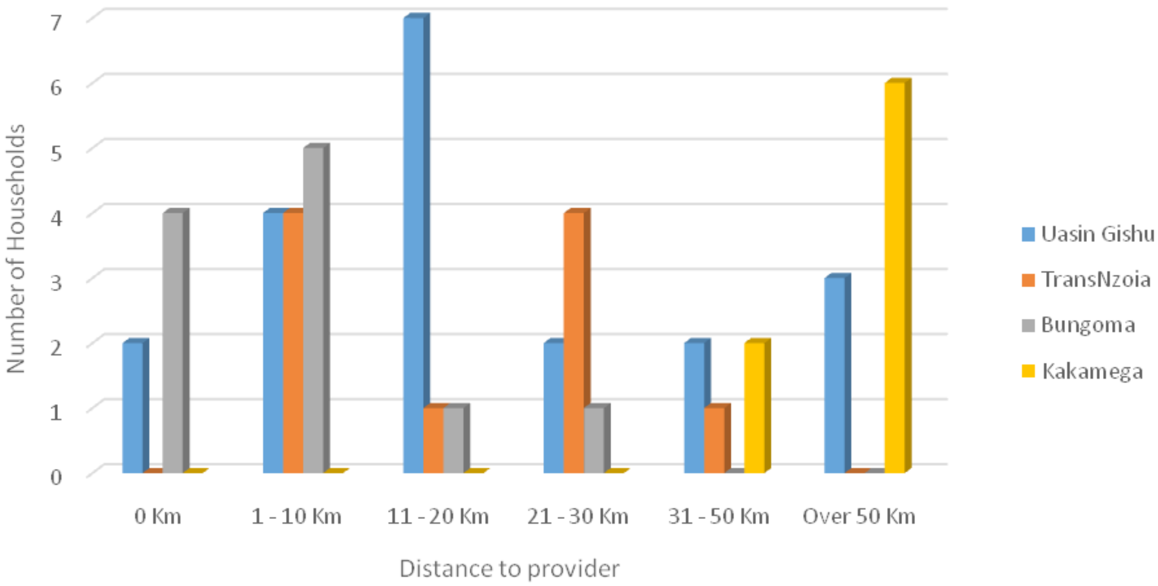
Figure 16: Results of soil tests



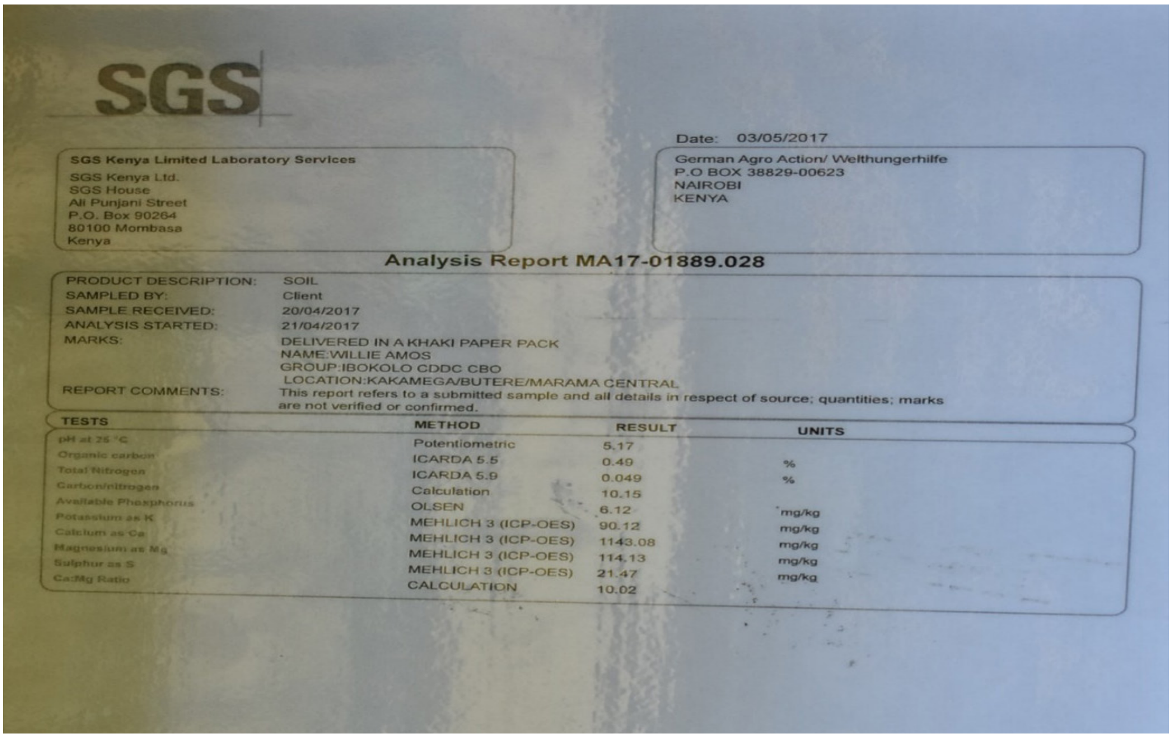
Use of lime, change of fertiliser and use of organic manure were highly recommended based on the soil test results. Out of the 54 households that tested their soils, two thirds (66%) implemented the recommendations to reduce acidity and to improve their yields. Those who did not implement the given recommendations stated high cost of lime and manure as the reason for their non-action. Only two households had redone soil testing. The reasons for not retesting soil were reported to be: lack of service providers; it was less than three years since the last test; financial constraints; and the crops were still doing well. Among the households that had not redone the soil test, some indicated they were planning to and had changed land use and thus there was no need for retesting. Soil testing was argued to be important by the households who had undertaken it because it determines soil health and pH and helps them make farm decisions like which crop to plant and which fertilisers to use.

According to 12% of the respondents, the service providers were available at zero distance; perhaps this was because the service providers were collecting soil samples from the farm. According to 39% of the respondents the soil testing providers were within 10km distance from their farms. This suggests that 61% of the respondents could only access the service beyond 10 km from their farms (Figure 17). For households in Bungoma, most of them were able to access the service within 20 km from their homes and the same pattern was true for Uasin Gishu. For Trans Nzoia about half of the farmers could access the service within 20 km from their homes. But for Kakamega, the majority could access the service beyond 50 km from home.

Figure 17: Distance of soil testing service provider from the farmer



Soil sample collection and time taken to receive test results: Respondents were asked about which method was used to deliver the soil samples. The majority of householders (87%) who had their soils tested indicated that soil testing service providers collected the soil samples from their farms; 9% of those farmers received their results in less than a week; 41% of those farmers received their results in one to two weeks; while 32% received their results in 3-4 weeks; and 15% with received their results after more than four weeks. Some of those households that collected and delivered the soil samples to the service provider (12%) got their results within a week and some in three to four weeks.



SGS

Date: 03/05/2017

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Analysis Report MA17-01889.028

PRODUCT DESCRIPTION: SOIL
SAMPLED BY: Client
SAMPLE RECEIVED: 20/04/2017
ANALYSIS STARTED: 21/04/2017
MARKS: DELIVERED IN A KHAKI PAPER PACK
NAME:WILLIE AMOS
GROUP:IBOKOLO CDDC CBO
LOCATION:KAKAMEGA/BUTERE/MARAMA CENTRAL
REPORT COMMENTS: This report refers to a submitted sample and all details in respect of source; quantities; marks are not verified or confirmed.

TESTS	METHOD	RESULT	UNITS
pH at 25 °C	Potentiometric	5.17	
Organic carbon	ICARDA 5.5	0.49	%
Total Nitrogen	ICARDA 5.9	0.049	%
Carbon/nitrogen	Calculation	10.15	
Available Phosphorus	OLSEN	6.12	mg/kg
Potassium as K	MEHLICH 3 (ICP-OES)	90.12	mg/kg
Calcium as Ca	MEHLICH 3 (ICP-OES)	1143.08	mg/kg
Magnesium as Mg	MEHLICH 3 (ICP-OES)	114.13	mg/kg
Sulphur as S	MEHLICH 3 (ICP-OES)	21.47	mg/kg
Ca:Mg Ratio	CALCULATION	10.02	

Photo 5.1: Soil test certificate. [Taken 29 October 2018].

Understanding soil test results: The results given by the soil testing providers were understood by 66% of the households. The most cited reasons for comprehension was that a proper explanation was given and they were convinced by the low pH that their soils were acidic and unhealthy and required to be improved. Those who did not understand attribute not getting the soil testing results as a major culprit while others did not get a proper explanation of terms and factors affecting their soil. Sufficient training, detailed explanation and elaboration of the results with increased awareness and sensitization of soil testing are some of the ways that understanding by the households about soil test results could be improved.

Satisfaction with soil testing services: Increase in yields and helpful results were some of the reasons that 68% of the households gave for their satisfaction with the soil testing service. Those that were not satisfied stated not getting results for their soil test, lack of follow up and duration taken to get results as the factors for their dissatisfaction.

Soil testing services in the target counties have several challenges: Distance to service providers, lack of knowledge, cost of service and duration taken to get results were cited as the most critical challenges in decreasing magnitude, while quality of service was the least mentioned constraint.

Constraints of soil testing service: Distance to service provider was reported by households in Kakamega and Uasin Gishuas a constraint to using soil testing service. Cost of service was mentioned as the major impediment in Trans Nzoia and Uasin Gishu with lack of knowledge being mentioned to be an issue in all the four target counties. Asked about which actions they would like to be undertaken to address these constraints most of the households stated capacity building and awareness creation. The actors they would like to address these constraints are shown in Table 13. County Government extension officers were the preferred actor to address (i) the high cost of service; (ii) lack of knowledge; and (iii) long duration taken to get soil test results. Government was the preferred actor to address the issue of few soil test service providers. NGOs were the second best preferred actor to address lack of knowledge.

The private sector was preferred second to Government in addressing the issue of few service providers. Generally, farmers seemed to have confidence in Government and agricultural extension officers in their ability to address some of the issues. It seems farmers were not too sure who should address the issue of quality of service.

Table 13: Actors suggested by households to address constraints in soil testing

	Number of households mentioning who should address constraint				
Constraint in soil testing	Community	County Extension officers	Government (National & County)	NGOs	Private Secto
Cost of service		11	3		3
Few number of providers	2	2	13	1	5
Quality of service		2	3		
Lack of knowledge	1	13	3	7	
Duration taken to get results		6	2	1	1

5.3 Location of farmers applying lime

The two maps below show the location of farmers who were interviewed at the household level; some who had tested their soils and were using lime and those who were not using lime. Out of 518 farmers, 54 reported that they had been made aware about lime but only 34 had applied it. The number of farmers who had adopted soil testing and lime use was very small compared to the number of farmers who had not done so.

Thus, despite the fact that many farmers have been made aware about the advantages of using lime to correct soil acidity, and the importance of soil testing, comparatively few have adopted one or both of these technologies. It is true that more farmers have tested their soils than have applied lime. Uptake of lime use has been slow for a number of reasons as mentioned by farmers in both household interviews and FGDs.

The main reasons advanced included:

(i) inadequate information about where to get the lime and how to apply it;

(ii) lack of money to purchase the lime;

(iii) distance to the location of supplies of lime; and

(iv) some farmers did not find any improvement in crop yield following their initial lime application.

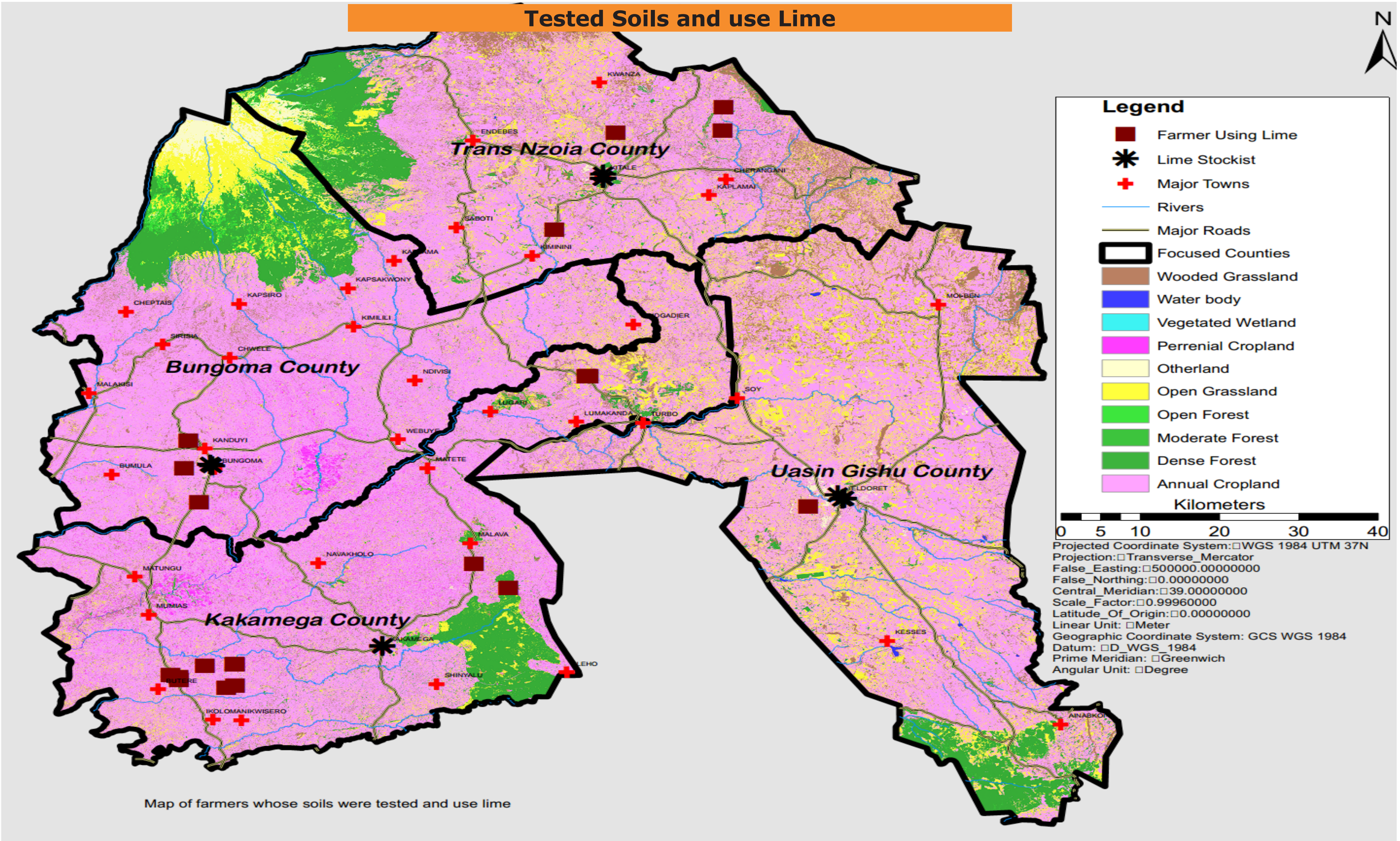
They blamed the extension services for lack of contact with extension staff. However, it appears they were unaware of the change in approach to extension services provision to "demand-driven" services or they were unwilling to seek out the extension staff and this begs the question of how committed to farmers such people are. Figure 15 shows the location of farmers who had tested and limed their soils.

Findings of a 2013 survey on liming: A farmer survey undertaken in October/ December, 2013 using a single - visit survey approach in nine counties (including Turbo in Uasin Gishu) found that the proportion of farmers who had used lime was about 5% in Turbo and Siaya.

On average, < 4% of all the interviewed farmers were aware of soil acidity and less than 8% had carried out nutrient analysis on their soils (Muindi, et. al., 2016). It is interesting to note that the current assessment carried out five years down the road carries very similar findings to those of the 2013 survey.

Feedback from FGDs and household interviews confirmed the finding that relatively few farmers have adopted soil testing and lime use among the general population of smallholder farmers in the western region.

Figure 18: Location of farmers who tested soils and use lime



While distance from lime distributors may be given by some farmers as a reason for not applying lime, as shown in Figure 19, there are many farmers who are very close to lime supply are not applying lime.

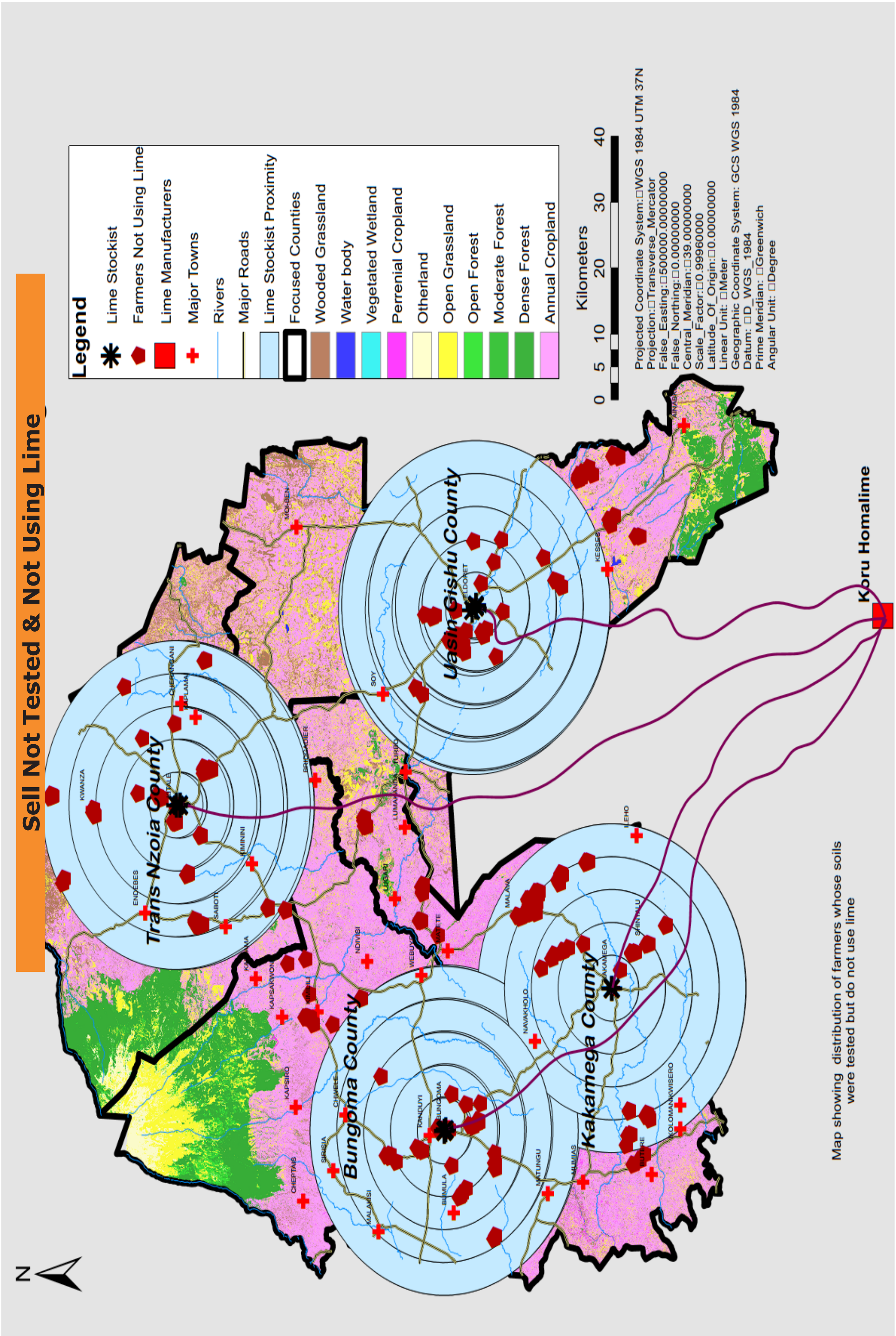


Figure 19: Location of farmers who have not tested soils, do not use lime

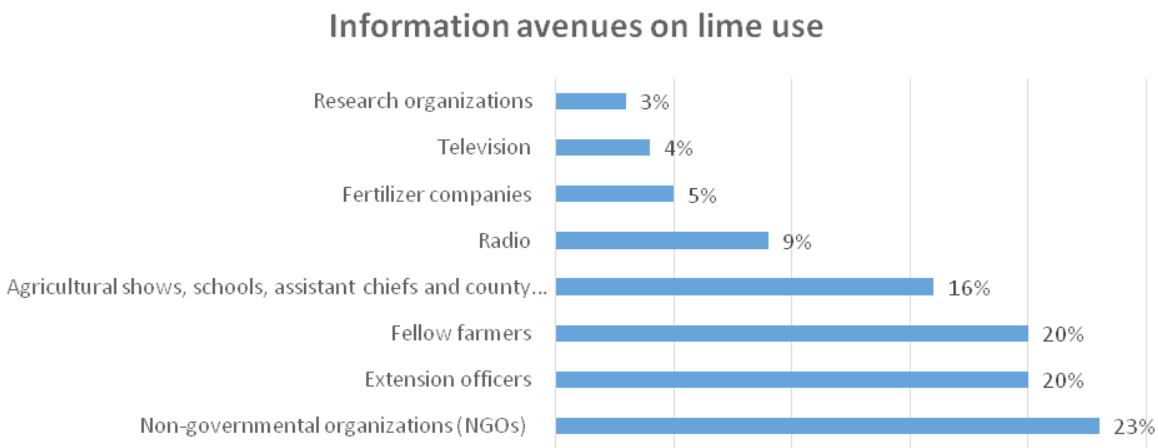
Box 2: Poor access to lime

"We were helped by Equity Group Foundation to carry out soil tests and the results indicated that our soils were very acidic. We look forward to apply lime. However, it has not been easy to get lime and we would appreciate if efforts were made to make lime more accessible." – *Farmer, member of Talatany Cooperative, Uasin Gishu.*

5.4 Sources of information about lime and training on liming

Farmers had several **sources of information** on lime. The three major sources were NGOs, extension officers and fellow farmers. In Trans Nzoia, 37% of households learnt about lime from extension officers; while 22% of households got the information from school, agricultural shows and government administrative officials. Stockists, TV and research Organisations were reported by a few households with stockists being indicated in Bungoma by one household. Radio, TV and research Organisations were not reported as sources of information on lime in Trans Nzoia, Kakamega, and Bungoma respectively. One Acre Fund, an NGO operating in western region, was the main source of information on lime especially in Kakamega and Bungoma counties while in Uasin Gishu most households got their information from fellow farmers (Figure 20). Across all four counties, stockists were mentioned as the least important sources of information about lime.

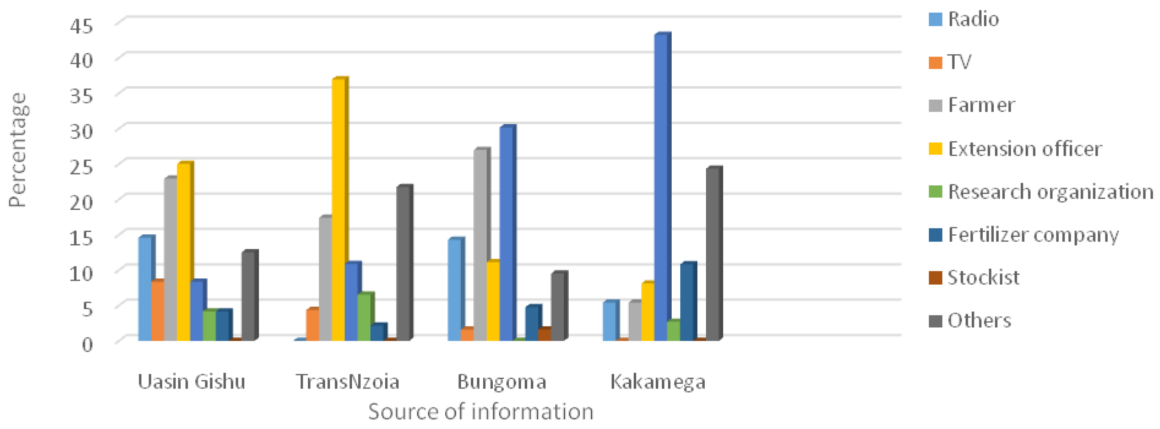
Figure 20: Proportion of farmers using various sources of information on lime



Farmer participants in FGDs identified county Government (administration) officials and extension personnel; NGOs such as German Agro-Action, IPA and, One Acre Fund; and input distributors and stockists (agrovets) as sources of information about soil testing and lime.

One Acre Fund (OAF)'s information to smallholder farmers on liming was to use micro-dosing of the soil with fertiliser (including a little lime) as well as apply compost with the objective of slowing down acidification. They also recommend application of lime just prior to planting instead of the 2-3 months before planting that is recommended by the Ministry of Agriculture. According to OAF their methods are simpler for the farmer to understand and less labour demanding than the alternatives suggested by other stakeholders (One Acre Fund, 2016).

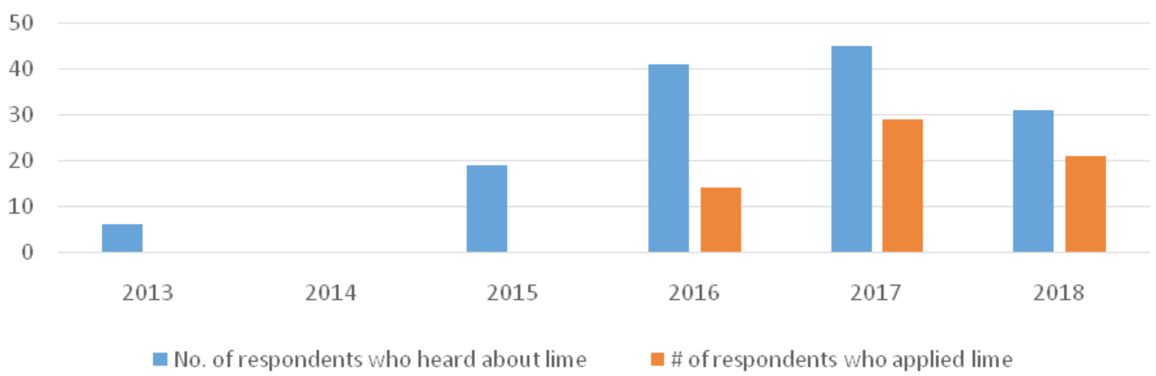
Figure 21: Sources of information about lime in different counties



The diversity of sources of information about lime is encouraging. Different stakeholders play different roles in information dissemination. Diversification of information sources was envisaged in the **National Agricultural Sector Extension Policy (NASEP)** (Republic of Kenya, 2012) and**Guidelines and standards for agricultural extension & advisory services** prepared by the Ministry of Agriculture, Livestock and Fisheries (Republic of Kenya, 2017). These documents provide the rationale for a multi-stakeholder approach to extension service delivery. Feedback from farmers indicated that the quality of information provided by different stakeholders on liming and soil testing was not guaranteed because the information was not packaged or standardized. For example, when politicians and local administration officials speak in public meetings, they provide basic awareness about the need to use lime but without technical content. It is difficult to tell which source of information is working well and which is not working well. What is not in doubt is the need for standardized information, e.g. in pamphlets, about lime made available widely through the different avenues.Another point worth noting is that the majority of farmers and other stakeholders appeared unaware of the government's policy stance on extension. This was clear from their repeated complaints about the low number of extension staff and their wish to have supply-driven extension services.

Some households indicated that they heard about liming as early as 1978 but majority learnt about it between 2015 and 2018 with 2016 and 2017 having the highest number of households learning about lime. During the years 2016 to 2018 some of the farmers who had learned about lime took the next step of applying the lime to their fields.

Figure 22: Years when households first learned and applied lime



Most of the respondents indicated that they learnt about lime in the months of October (33 households), January (27 households), March (20 households), February (19 households) and November (18 households) with June, July, April, May, September and December being the months in which only a few households learnt about liming. Thus it appears that information about liming was provided in good time before the planting season (March-April). The following section shows who was active in training of farmers.

Training of farmers on liming: Only four zero respondents were trained on liming; half of them were trained by NGO, 10 by extension officers; four by fertiliser companies and four by research Organisations. The training Organisations named were One Acre Fund (15), Equity Group Foundation (5), HLCL (2) and Kitale KFA (1). Most of them were trained in the four-years 2015 to 2018 when the KMT-HLCL partnership was operational and their training took place during January to March. Demonstration farms were the locations of choice. The training took mostly a day or less.

Table 14: Content of training as recollected by respondents

Topic	Percent of respondents*
Soil acidity	40
Importance of liming	24
Lime application rates and price of lime	15
Source of lime	10
Types of lime	8

*This is % of respondents indicating they were trained.

Training on different types of lime and source of lime was indicated by respondents in Kakamega and Trans Nzoia while lime application rates was mainly reported in Trans Nzoia but not in Bungoma. Uasin Gishu had only six respondents trained in liming with most being demonstration farmers. The respondents indicated they did not pay for the training and 88% of them were satisfied with the training they received.

For the minority dissatisfied farmers, the areas that were not clear to them were soil acidity, methods of applying/handling lime, cost of lime, and health effects/risks associated with lime. To address these areas the respondents recommended further training on lime by reliable qualified personnel who will give the correct information.

Demonstration farms and field days: Information from HLCL shows that following the KMT/HLCL partnership in 2015, HLCL supported a total of 79 demo farms distributed in the four counties of Kakamega, Uasin Gishu, Trans Nzoia and Vihiga. Demonstrations were not organised by the project in Bungoma County. However, there were other actors that organised demonstrations there. The demo farms were spread across the various sub-counties/wards in the above counties].

Table 15: Distribution of HLCL supported demo farms in four counties 2015/16

	Name of County	No. of demo farms
1	Kakamega	16
2	Trans Nzoia	16
3	Uasin Gishu	35
4	Vihiga	12
	Total	**79**

Source: HLCL.

Five **field days** were held in three counties in August 2016. A total of 576 farmers attended the field days. This high level of attendance is testament to the fact that many farmers have had opportunity to learn about lime use though few have adopted the practice.

Table 16: Field days and farmer attendance

	Name of County	Where field day was held	No. of farmers attending
1	Kakamega	Malava	132
2	Trans Nzoia	Chematich	90
3	Trans Nzoia	Kiungani	130
4	Uasin Gishu	Kaptagat	86
5	Uasin Gishu	Kiplombe	138
	Total		**576**

Source: HLCL.

5.5 Types and sources of lime used by farmers

When asked about the types of lime the farmers knew, very few were able to mention anything beyond agricultural lime. Very few farmers were able to tell that in addition to agricultural lime, there are other types of lime used for purposes such as stabilizer in building and road construction, in livestock feeds, in sugarcane processing (for cane juice clarification), as a softener in leather processing, and to clean gold in gold mines. However, those who knew about agricultural lime knew that it is used to correct soil acidity in the soil. A few farmers knew that agricultural lime is available in two forms, crushed rock which is in powder form and is largely calcium carbonate ($CaCO_3$) and calcium oxide (CaO).

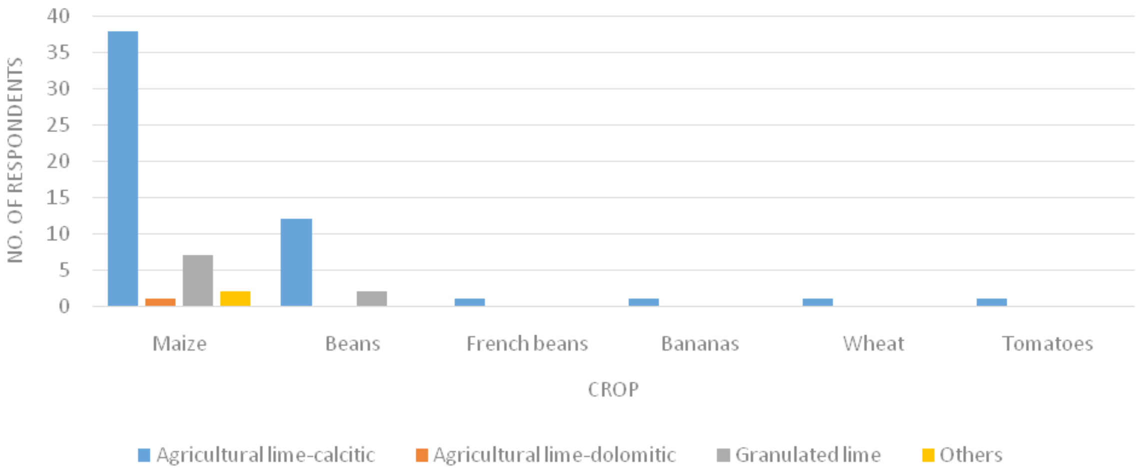
The only "local" name for lime farmers knew was *chokaa* (chalk). Those who had applied the powder form complained of its dustiness and effect on hands when manually applied.

They expressed desire to have the product in granulated form "like fertiliser"; they were not aware that granulated form is much more expensive than the powder form.Farmers knew Homa Lime Co. Ltd. as the source of lime. In Bungoma one farmer mentioned that there was a local producer of industrial lime.

Photo 5.2: Packaging material for Homa Lime Co. Ltd Super Calcium Fertiliser brand of lime. (Taken Sunday 28 October 2018).

Figure 23 shows the types of lime farmers used and the crops they grew. Maize and beans were the main crops grown on limed plots. The main type of lime applied was agricultural lime-calcitic (48 households in the case of maize and 12 households in the case of beans) and granulated lime (7 households in the case of maize and two households in the case of beans).

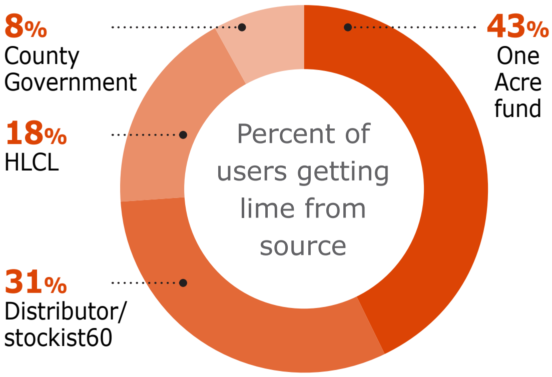
Figure 23: Type of lime used by crops grown



Calcitic lime went by various names: super calcium fertiliser, crushed lime, agricultural lime-calcitic) and granulated lime. Super Calcium Fertiliser, a Homa Lime Co. Ltd brand, was reported mainly in Kakamega (14 farmers) with no farmer in Uasin Gishu indicating its use. Agricultural lime-calcitic, most likely the Homa Lime Co. Ltd brand (Super Calcium Fertiliser), was mentioned in Uasin Gishu (6 farmers), Kakamega (5 farmers) and Trans Nzoia (3 farmers). Granulated lime was mainly used in Trans Nzoia (7 farmers) and Kakamega (2 farmers).

Out of 39 farmers indicating the sources of lime, the proportions attributed to different sources were as shown in Figure 24.It is noteworthy that 43% obtained their lime from OAF (on credit) and a further 31% from distributors and stockists. HLCL and the county governments provided the rest. Even though the overall numbers are small, nevertheless, these percentages do show that the market model is functioning.

Figure 24: Important sources of lime



Most respondents (47% of households using lime) stated that the distance from their farm to the lime source was less than one km. This could be explained by the observation that most of these households had their lime delivered to them by Organisations including the county Government. This actually means that the majority of lime users (53%) obtained their supplies from one km and beyond; and had therefore to bear the additional cost of transportation, typically by motorcycle taxi. Of these households, only 14% obtained their lime within 1-6 km while 39% of the households had to go beyond six km.

Lime is typically made available in 25kg and 50 kg bags; 49% of the respondents using lime reported the available unit sizes as falling between 21 and 50 kg category while 43% indicated unit sizes above 50kg. They indicated that for super calcium fertiliser 50 kg bag was the largest unit size. It was possible to get bulk volumes for the other types of lime.

The **quality of lime** was rated as good (30 farmers) with a moderate number saying it was very good (12 farmers). Super calcium fertiliser/crushed lime/agricultural lime-calcitic was rated as of good quality while granulated lime was rated as very good by four respondents out of the seven that used it. Respondents in Bungoma, Uasin Gishu and Trans Nzoia rated the lime they used as either good or very good. Users in Kakamega rated the lime from good, medium to poor.

The **price of lime** was rated as very high by 11% of users; high by 24% of users; medium by 50 per cent of users; and low by 13 per cent of users. Those stating it was very high and high had bought their lime mainly from One Acre Fund (on credit), fellow farmers and agrovets. Those reporting the price to be low were from Trans Nzoia and they had bought the lime from the same sources. Three out of the five respondents using lime in Bungoma considered the price to be either very high or high. The price in stockists' shops was around KES 500 per 50 kg bag but farmers considered a fair price to be about KES 200 per 50kg bag, lower than the wholesale price at HLCL putting into question their preparedness to undertake commercial purchases of the product.

Recommended **application rates** for lime depend on the crop to be grown and the level of the soil acidity or soil pH.To establish the acidity status of a soil, a farmer needs to undertake soil testing. This includes the water pH and the lime requirement (buffer pH) test run to obtain an accurate estimate of the quantity of lime needed to raise the pH back to the pH range of the target crop (E. Ernest, 2015). Organisations that undertook detailed **soil tests** in the target region include KALRO, Crop Nut Ltd, KEPHIS, SoilCares, Eldoret University and Bungoma county Government. Trans Nzoia county Government does not have soil testing equipment but collects samples from farmers as an agent of some of the soil testing labs.

Farmers who "microdosed" their soils did not establish through soil testing the appropriate application rate. The approach of One Acre Fund which promotes "microdosing" is to use low application rates. In 2015 they evaluated lime application rates in maize from 0.5 tonnes/ha to 2.0 tonnes per hectare (One Acre Fund, 2015). Other actors in the lime intervention gave to maize farmers or advisedthem to apply 10 bags (500 kg) per acre when the pH was not low and 20 bags per acre (1,000 kg) when the pH was low; implying a cost outlay of between KES 5,000 and 10,000 per acre on buying of lime.

In general, soils in Western Kenya are not only acidic but they also suffer from soil nutrient depletion. If a farmer applies fertilisers but fails to apply lime to correct the acidity, he may not get the higher crop yields he expects because acidity hinders crop responses to fertilisers. Normally applied in powder (dust) form, on smallholder farms, liming materials are typically broadcast by hand and soon thereafter, they are incorporated into the soil by being ploughed in or through preparation of furrows. Farmers detest the process of application which they say is laborious but also unhealthy due to the impact the dust has on breathing. An alternative form of lime which is easier to apply is granular lime, which is applied like an ordinary fertiliser. However, the latter is much more expensive than the powder formulation, although one needs to appreciate that the application rates are different.If we apply the "1:10 ratio" rule of thumb for comparing the short-term Neutralising effectiveness of Pelletised lime to agricultural lime (Stevens G. and D. Dunn, n.d.), then an application rate of 1,000kg per acre of agricultural lime would be the equivalent of 100 kg of granulated or Pelletised lime. A ton of lime in form of powder sells for about KES 7-10,000; when granulated the cost goes to KES 20-50,000 (Personal communication, Joseph Abubakar, HLCL)[2]. For 100 kg, the granulated lime would cost KES 2-5,000 which is lower than the cost of lime in powder form. Farmers may therefore be justified in asking for granulated lime. An effort by a combined team of researchers and extension personnel could make an important contribution by preparing a simple manual/guide for farmers with information on different options in liming and the associated costs for guiding farmers.

Box 3: Farmer confesses relapsing back to non-use of lime

"The extension officers testing my soil and recommended lime application. I did the broadcast a week before planting but I did not notice any change in yields…..a year later, it was bumper hectarervest. Lime really worked on the subsequent crops. Unfortunately I stopped using it again. This year….it has been worse. I got nothing at all" - *Farmer from Bumula, Bungoma*.

5.6 Does micro-dosing work?

There was widespread criticism by some farmers of the fact that One Acre Fund does not insist on farmers testing their soils for acidity before they apply lime and that they promote micro-dosing, a practice that was also frowned upon by soil and crop experts. All the same, OAF had managed to recruit thousands of farmers as members of its programme and, farmers were paying for the lime through a credit arrangement. One farmer reported that he received 12.5 kg of lime and paid over nine months KES 400 for the lime and was ready to take such a loan again even when shown that buying lime cash was much cheaper, since a 50 kg bag was being retailed for KES 350 to 500 by some of the stockists.

Micro-dosing is supposed to be a precision technique in which small quantities of inorganic inputs are applied to a hole in the ground prior to planting; about 10g or no more than a bottle cap-full of a fertiliser is applied to each plant. It is suggested that this approach is affordable to poor farmers. An AGRA/ICRISAT partnership in West Africa's Burkina Faso, Mali and Niger aimed to reach at least 295,000 farmers on 150,000 hectares of land through micro-dosing combined with conservation agriculture techniques, such as crop rotations with legumes to further build soil health. (AGRA. https://www.sourcewatch.org/index.php/AGRA%27s_Soil_Health_Program).

In an FGD in Bungoma, a representative of One Acre Fund answered critics of micro-dosing as follows:

"We did research and established that soils in this region are very acidic. Our goal was to positively impact upon productivity of the farms. We encouraged spot application of lime because it is not very tedious…we deal with very poor and smallholder farmers with an average of ¼ acre to three acres most of whom cannot afford even one bag of agricultural lime. This is why we advocate for spot application even though we know that broadcast application is the best."

Then he gave the following example. In 2015, One Acre Fund: Nathan did an experiment using lime on 0.125 acres of a farmer's land. The mode of application was spot treatment i.e. micro dosing: by adding 10grams of lime in the hole then adding some soil to avoid lime coming into contact with the fertiliser and seeds and to let lime react with soil acidity before the plants start accessing the nutrients. Next was added the fertiliser and then the seeds. For spot treatment; 25kg of lime was applied on 0.125 acre for a cost of KES 330. For a quarter of an acre (0.25 acres), 50 kg lime would have been applied at a cost of KES 660. There was a leaflet on lime use especially on protection. One Acre Fund trains their farmers on lime use. The farmer started by soil sampling and testing and receiving appropriate recommendations. The yield: increased from 8-12 bags per acre in 2015 to 30bags per acre in 2018.

In the same meeting, a farmer reported that he was trained by One Acre Fund and an agricultural officer on soil testing, liming and integrated soil management in 2016. Soil pH in 2016 was 4.8 pH; he has not retested the soil yet. In the first season of planting after application of lime, there was no increase in yield. In the second planting he noted that the maize crop height increased and the general morphology of the crop was good (green leaves, heathier stalks, bigger combs). He reapplied lime in 2017 and 2018 through micro dosing. While his initial yield in 2015 and 2016 was less than 8bags per acre, in 2017, the yield increased to 16bags per acre while in 2018 it increased further to 22 bags per acre. The farmer undertook other measures such as soil erosion control, sporadic manure application and intercropping.

Another farmer related that he tested his soil in 2016 through Bungoma county soil unit. He was given results and recommendations in a week. He did two experiments. In the first one he used micro-dosing as the mode of lime application. He said the results were poor as "the crop struggled" In his second experiment, he broadcast the lime and then ploughed it in to mix with the soil. The result was better yields. Other measures he adopted were smart agriculture and cover cropping. In 2018 harvested 18 bags of Dolichos beans from 0.5 acres. In the second season he has planted cow peas. This farmer had obtained his lime from the Bungoma county Government's Ministry of agriculture.

[2] **Interviews held on 17th and 29th October 2018.**

CHAPTER SIX

Early Impacts of Liming and Soil Testing Services on Farm Productivity, Yields and Farmer Incomes, Gender and Climate

To demonstrate impact requires sound empirical data. HLCL provided through KMT maize yield data for 26 farmers in Kakamega, Trans Nzoia and Uasin Gishu counties for demo plots in 2015 (baseline), 2016, 2017 and 2018. The ANOVA for the data is discussed in section 6.2 below. Only a small fraction of the 518 farmers interviewed through household questionnaires had tested their soils and limed their land and this they had done on diverse years.

6.1 Impact on farm productivity

Plants and crops are unique in their ability to thrive in acidic or alkaline environments. Each crop has its soil pH range in which it grows. The soil pH strongly influences the availability of nutrients and the presence of microorganisms and plants in the soil. Although some species prefer more acidic or more alkaline environments than others, most crops and plants survive within soil pH range of 5.5 to 7.5. Nitrogen (N), phosphorus (P), and potassium (K) are the most critical macronutrients that are needed by plants. Microelements, are needed in smaller amounts by plants. Fortunately, they are generally present in sufficient quantities in the soil.

Notwithstanding the fact that out of 518 respondents in household interviews, fewer than 10% had applied lime, the study did demonstrate a positive impact of liming on factors that affect farm productivity. For example, as discussed in Chapter five above, some farmers reported a positive impact of liming on soil structure. Many had not observed any change perhaps because they did not look for such change. Some farmers were aware that liming without undertaking soil conservation measures was counterproductive since the lime would be taken away by water through soil erosion. Farmers reported improved crop growth when the soil was limed and mentioned maize, potatoes, bananas, sugarcane and vegetables as examples of crops whose improved growth they had witnessed. Besides, some farmers undertook liming in addition to manuring and/or conservation tillage, further enhancing the technical capacity of the soil to be productive.

6.2 Impact on crop yields

Most of the farmers who applied lime reported varying levels of increased maize yields. However, some reported no change in the initial season after lime application while many reports yield increases in the second and third seasons. However, some farmers reported negative experiences with lime but it turned out these had applied the lime in the wrong way. For example, some farmers were given lime by relatives or local officials without going through soil testing and the associated technical expertise. In one case it was reported that a farmer top-dressed his maize with lime. Some farmers were also reported to have mixed the lime with fertiliser leading to poor germination of seeds.

A data set obtained from HLCL on maize yields from demo farms for the four seasons of 2015, 2016, 2017 and 2018 is summarized. The 2015 season crop formed the unlimed control. Liming was done in 2016 and its effects were expected to last 3-4 years. The number of farmers captured per county ranged between four and 11 farmers in the years 2015, 2016, 2017 and 2018 for the three counties of Kakamega, Trans Nzoia and Uasin Gishu. These were small samples. The range in the increase in yields for all the three counties taken together was nine bags per acre from 2015 to 2016; 12 bags per acre between 2015 and 2017; and 13 bags per acre between 2015 and 2018.

Table 17: Maize yields from demo plots 2015-2018

County	2015 Unlimed	2016 Limed	2017 Limed	2018 Limed
Kakamega	3	5	10	15
	7	10	8	7
	8	20	13	15
	12	16	15	15
	5	12	10	
	7	17		
	3	7		
Trans Nzoia	15	43	41	32
	19	37	28	27
	10	15	22	25
	15	20	25	20
	15	18	22	27
	12	24	35	40
	13	22	31	28
	16	19	24	
Uasin Gishu	14	20	25	28
	10	15	23	28
	23	37	32	35
	10	32	35	25
	14	20	25	30
	17	23	30	35
	23	30	32	18
	15	25	30	20
	18	40	32	34
	20	30	43	41
	26	36	20	35

Source: HLCL.

Looking at the whole data set, the assumption of homogeneity of variance was not met; therefore, instead of one-way ANOVA, we undertook Welch's test. Welch's adjusted F ratio (23.47) was significant at Welch's $F(3, 50.43) = 23.47$, $p < .001$ (or, $p < .05$). The conclusion was that at least two of the four-years groups differ significantly on their average maize yields.

Table 18: Results of Welch's test on maize yield data

Comparison	Mean difference (90kg bags)	Significance level	
UNLIMED			
Unlimed 2015 vs. Limed 2016	-9.885	p (.000) < a (.05)	Significant
Unlimed 2015 vs. Limed 2017	-12.442	p (.000) < a (.05)	Significant
Unlimed 2015 vs. Limed 2018	-13.437	p (.000) < a (.05)	Significant
LIMED			
Limed 2016 vs. Limed 2017	-2.557	p (.713) >a (.05)	Not significant
Limed 2016 vs. Limed 2018	-3.552	p (.459) > a (.05)	Not significant
Limed 2017 vs. Limed 2018	-0.995	p (.972) > a (.05)	Not significant

Kruskal Wallis tests were undertaken for the data of individual counties.

Kakamega: There was a statistically significant difference in yields before liming and after liming at H (3) = 16.600, p<0.05. Post hoc analysis showed there was no significant difference in the pairwise comparison. This could be attributable to the small sample sizes (2015(7); 2016(7); 2017(5); 2018(4)) and data variability.

Trans Nzoia: A Kruskal Wallis Test showed there was a statistically significant difference in yields in the four years recorded of before and after liming at H (3) = 17.488, p<0.05. Post hoc test conducted to test pairwise comparisons indicated that: the yield for 2015 (not limed) was significantly different to those of 2017 (2 years after liming) (p=0.002) and 2018 (3 year after liming) (p=0.002). However, 2015 (not limed) and 2016 (year of lime application), 2016 and 2017, 2016 and 2018 and 2017 and 2018 were not significantly different at P=0.92, p =1.000, p=1.000 and p=1.000 respectively.

Uasin Gishu: A Kruskal Wallis Test showed there was a statistically significant difference in yields in the four years recorded of before and after liming at H (3) = 16.602, p<0.05. Post hoc test conducted to test pairwise comparisons found: that the yield for 2015 (not limed) was significantly different to those of 2016 (year of lime application) (p= 0.017), 2017 (2 years after liming) (p=0.004) and 2018 (3 year after liming) (p=0.003). But the yield of 2016 and 2017 (p=1), 2016 and 2018 (p=1) and 2017 and 2018 (p=1) were not significantly different.

.A careful view of the summary of data in Table 19 below supports the above conclusions.

Table 19: Maize yields 90 kg bags per acre from limed plots

	BEFORE (Unlimed)	AFTER (Limed)		
County	**2015**	**2016**	**2017**	**2018**
Kakamega	8.57	16.57	14.93	17.33
No of farmers	7	7	5	4
Trans Nzoia	14.38	24.75	28.50	24.88
No of farmers	8	8	8	7
Uasin Gishu	17.27	28.00	29.73	29.91
No of farmers	11	11	11	11
All three Counties	**13.46**	**22.81**	**25.46**	**26.36**
No of farmers	26	26	24	22

Source: HLCL

Conclusion: The tests on the demo data on maize yields showed clearly that limed fields yielded significantly higher than unlimed fields.

The demo plot yields were supported by the figures reported by farmers in household interviews. The lowest increase was experienced in the first season with lime use but thereafter, the yield increase was generally significant. county reports show the ranges of yield increases reported by sample farmers.

Baseline maize yields for 2015 and 2016 for some of the farmers who later applied lime were between four and 20 bags per acre; with a mean of 10 bags per acre for nine farmers. Yields in subsequent two to three seasons (limed plots) were in the range from 10 to 35 bags per acre with a mean of 21 bags per acre per year. The increase of yield that comes largely from liming is therefore 21-10 = 11 bags/acre.

According to HLCL, a farmer in Kitale was able to raise his maize yield from 15 to 43 bags per acre in the first crop; in Eldoret a farmer raised the yield from 12 to 24 bags per acre in the first season and later to 35 bags per acre.

In Kakamega some farmers were able to treble their sugar cane yields by applying lime; crops without lime experienced stunted growth. Farmers around Mumias Sugar Company (MSC) were getting about 38 tons of cane per acre while HLCL on their Koru sugarcane field were getting 75 tons per acre.

In Kakamega demos, in the first season, maize yield increased from zero to eight bags per acre (lime only); from zero to 16 bags per acre (lime + DAP); and from zero to 22 bags per acre (when nutrients applied as per soil test). These results showed that farmers were not feeding their soils with the required nutrients.

"In 2015, I harvested 10-15 bags of maize from my one acre piece of land. I then heard about lime from Equity Foundation and started applying lime in 2016 and I got 20 bags. In 2017 I got 25 bags. This year, I have harvested 30 bags from the one acre where I applied lime." *A farmer from Moiben region, Uasin Gishu*

"I bought a piece of land in 2016 and realized that the yields were very low. That is when I heard about lime and through the assistance of Equity Foundation, my soil was tested and I applied lime on one acre. My yields for maize increased from 15 to 28 bags, in 2017, I planted potatoes and horticultural crops and I was impressed by the yields from the section I had applied lime. The yields were almost double." *A farmer from Plateau region, Uasin Gishu*

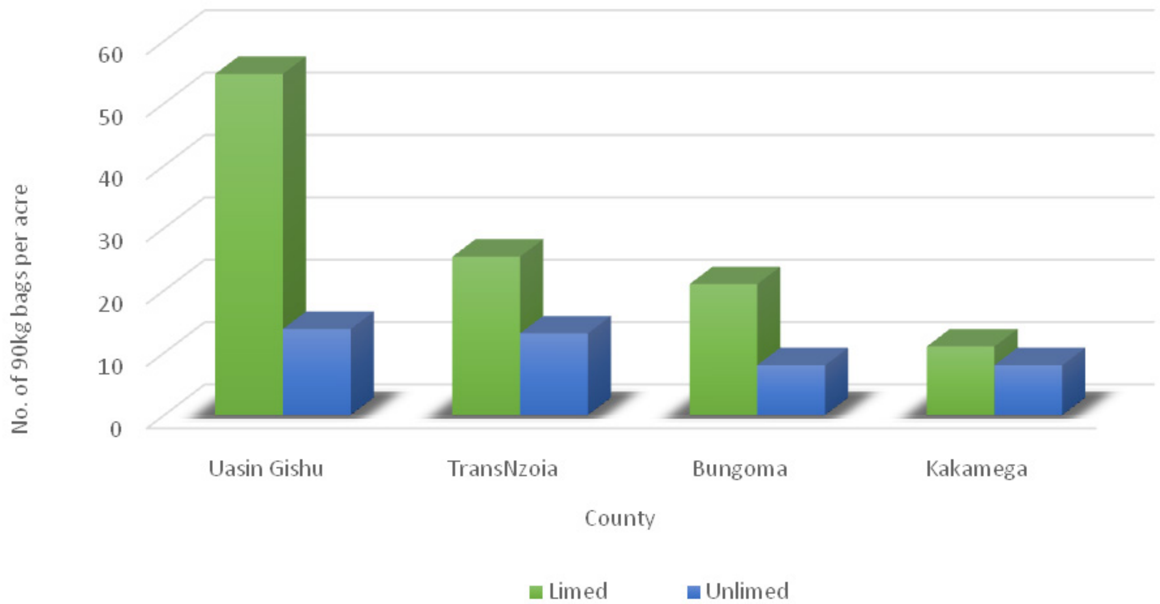
"I had never heard about lime before and when HLCL approached us, we formed a group of farmers. They led us through a process of soil testing. I was given lime to apply on one acre. In 2016, my maize yield from that acre increased from 18 to 26 bags per acre and in 2017, it increased to 30 bags per acre. This was not the case for the rest of my farm where the yields either increased minimally or just remained the same." *Another farmer from Uasin Gishu*

"Although I have heard about lime, I do not have an idea of how it works or even where to get it. I am willing to give it a try if it could help me improve my yields because I have observed significant decrease in the yields from my farms." – *A farmer from Plateau region, Uasin Gishu*

Maize yield data obtained from respondents for the five year period 2013 to 2017 was used to compare the performance of limed plots versus non-limed plots. Limed plots out yielded non-limed plots in all four counties but interestingly, the yield from limed plots in Kakamega were lower than that from non-limed plots in Uasin Gishu and Trans Nzoia.

The difference between the yield from limed plots and from non-limed plots was greatest in Uasin Gishu and Bungoma. The difference was smallest in Kakamega where limed plots were only marginally better than the non-limed plots. The highest yield (for limed plots) was about 50 bags per acre in Uasin Gishu while the lowest was about 10 bags/acre in Kakamega.

Figure 25: Maize yield on limed plots versus non-limed plots 2013-2017



Analysis of variance showed that there was a significant difference between mean maize yields from limed compared to unlimed soils; one-way ANOVA ($F(1, 71) = 6.428$, $p = 0.013$ with maize planted on limed soils having increased yields.

6.3 Impact on farm incomes – benefit/cost analysis

Very few farmers indicated that they had achieved higher incomes from the application of lime. Even where the yields had increased the challenge of marketing maize had made it difficult to get the benefit in terms of income. Many commercial farmers rely on the National Cereals and Produce Board (NCPB) and this Organisation has had challenges in paying farmers for their deliveries of maize. Some farmers indicated they are still holding the 2017 crop in their stores, waiting for better market prices. Nevertheless, for the smallholder farmers who produce maize primarily for home consumption and sale of small surpluses, the value of the increased production was considered attractive since their households had better supplies of food.

Using the sample data shown in the county reports, the study demonstrates through a simple analysis of benefits and costs, that it is possible for farmers to increase their incomes through liming their maize crops.

As already noted above, the increase of yield that came largely from liming was 11 bags of maize per acre. This validates the figures reported during household interviews. The value of the maize harvested can be estimated using an average price of KES 2,500 per bag which gives a value of KES 27,500 per acre per year.

The question is, are the additional costs from liming significantly lower than this value? Typical costs (obtained from focus group discussions) include the cost of soil testing (KES 1500 per sample divided by the three year duration before another test); cost of lime assuming an application rate of one ton per acre (20 bags @ KES 600 divided by three years); cost of transport of lime (an average of KES 150 per bag divided by three years); and cost of hired labour for applying the lime (an average of 10 person-days @ KES 300 per person-day) divided by three years.

These costs add up to KES 6,500 per acre per year. The net benefit is thus KES 27,500-6,500=21,000 per acre per year (or KES 1,900 per bag of maize). Of course the actual situation for each farmer will depend on the degree of acidity of his soil (the lower it is, the more lime should be applied and the higher its cost and that of transport and labour); and the actual price he/she is able to command for the maize.

6.4 Impact on gender

There are biological differences (sex) and social differences (gender) between women and men. Social differences are learned, they change over time, and are rooted in culture. Gender is thus a socio-economic variable and seeks tounderstand gender-based and/or sex-based differences between women and men as they affect roles, responsibilities constraints and opportunities of the people involved, both men and women. Every society or community has defined its own gender roles, which guide which activities, tasks and responsibilities are considered masculine and feminine.

Men and women differ in their reproductive roles, i.e, in the tasks involved in reproduction, care of the household, child bearing and rearing and domestic work. These activities are largely the role of women. Men and women also differ in their productive roles, i.e. the tasks that provide for the economic livelihood of a household or community. While this is a role for both sexes, some activities are done mainly by either men or women. For example, cash crop production is mainly a role for men while women dominate in food production. There are other roles such as community work where men typically take up leadership roles while women manage community resources and social services like caring for the sick and elderly.

An analysis of the roles of women and men typically looks at division of labour between men and women and the differences between men and women in the resources they have to work with; access and control over those resources and the benefits they derive from them; as well as the constraints they face.

The study sought to find out whether in terms of soil testing and lime use interventions, there were any challenges/impacts that were linked to gender. The respondents were farmers through household interviews and participants in focus group discussions. In general it was observed that it was men who made decisions about the adoption of soil testing and lime use but for women-headed households, women also made such decisions. Given that 85% of the households had male household heads, more men than women were involved in the decision making. Decisions are based on information and in general women have less access to technical information than men, further reinforcing their marginalization in this role. The application of lime was described as being labour and time intensive (and particularly with spot treatment) and since women provide a disproportionate share of the farm labour, they would be affected more than men. This also means they would bear the brunt of the health impacts of the dusty powder if they applied it without gloves and masks, which is common due to lack of adequate information about the danger as well as the lack of money to buy protective gear.

Although the youth are generally better equipped academically to understand the issues of soil testing and liming, they do not participate in decision making mainly because they are not given room by the old men. The discrimination against women and youth has little to do with their gender *perse* but it has more to do with socio-cultural attitudes. Adoption of innovations such as new technologies is generally higher among younger and better educated farmers. In terms of adoption of liming, there were examples of men adopters as well as women adopters. The issue of lime application being labour-intensive could be seen as adding to the already heavy demand for women's labour. Hence the need to find a mechanism (such as granulation or a manual lime applicator).

As discussed in Chapter 4, farmers below 35 years of age were on the minority. In theory, younger and better educated farmers should be attracted by liming technology but the fact that this is not happening shows there is a socio-cultural hindrance at play.Sociologists and anthropologists could shed some light on how to overcome such challenges (Sarker, 2017).

Respondents mentioned the sensitive issue related to giving youth access to land so that they could practice agriculture. Some old men were of the view that youth are irresponsible and all they want is money and they are ready to sell the land to get money but they are not interested in farming. One man said, *"I am not convinced I should give* *my sons land. I bought the land I have and so my sons should follow my example and buy their own land."* Another one said, *"The land is the feedlot for the old man. If an old man gives it to sons, what will the old man do?"* From these sort of comments it is evident that communities and individuals see the issue of succession planning in agriculture through the prism of tradition rather than the demands of a changing world.

The old are not as fast in taking up new technologies like the educated youth yet the youth do not have access to land, creating a troublesome impasse. Some respondents were of the view that many farmers using lime were not adequately trained on gender aspects that touch on lime and this may have contributed to the hostile view on succession planning.

Some respondents in Uasin Gishu noted, however, that Equity Group Foundation had included in its training an aspect of succession planning. A representative of Equity Group Foundation mentioned that the Foundation has decided to offer, in a new project they are rolling out in six counties, training of youth and assisting them access credit without the need to use land as collateral in an attempt to find a possible entry point to break the impasse.

6.5 Climate resilience

Farmers in the target counties perceive climate change in a variety of ways including: drying of wells and rivers, changes in rainfall patterns, reduction of water volumes, deforestation, soil degradation, landslides, incidences of new pests and diseases, hailstones, etc. Some farmers have adopted climate change adaptation strategies such as planting trees, changing the type of crops or livestock, practice of crop rotation, adoption of irrigation, taking up agricultural insurance, etc.(ASDSP, 2014).It is also noteworthy that after many rain failures, farmers are reluctant to plant maize before the onset of rains.

Farmers were generally aware about changes in weather patterns especially in terms of the increasing frequency of prolonged dry weather and floods but not many had deeper understanding of climate change and how they could prepare themselves to cope with drastic changes in weather. Some farmers who had adopted the use of lime had also been trained on "climate smart agriculture" and were practicing various aspects of it such as crop rotation, integrated soil management, biological pest management (such as "Push-pull" technology developed by ICIPE), diversification of crop production (from maize only to fruit horticulture, traditional vegetables, bananas, beans, sugarcane, etc.).

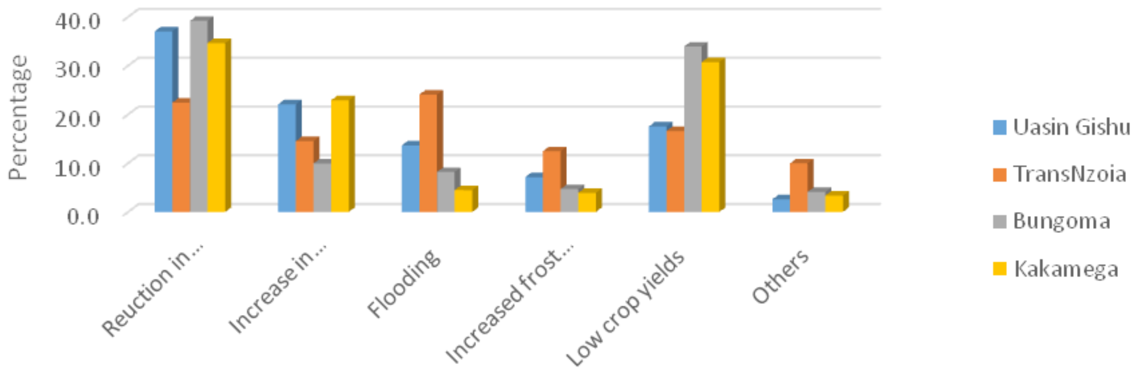
Some of these had adopted lime in these other crops as well. Others had planted cover crops such as *mucuna* beans as a means of enhancing nitrogen fixation in the soil while others had also planted agroforestry trees. Some trained by Equity Group Foundation, seemed aware about the importance of liming for improving the ability of soil to hold together and therefore reduce erodibility; and the improvement of soil structure leading to better water holding capacity of soil and hence its productivity.

Some farmers reported that they were practicing various aspects of conservation agriculture (CA) or minimum tillage. But it would appear that the number of farmers who have adopted climate resilience adaptations are in the minority. One farmer reported that after use of lime the soil structure changed and became compact such soil erosion from heavy rains or wind was minimum.

According to feedback from household interviews, 94% of the households in Bungoma, 63% of the households in Kakamega, 88% of the households in Trans Nzoia and 78% of the households in Uasin Gishu, indicated that climate change has affected them. The respondents were asked for specific impacts they have noticed on the farm associated with climate change.

The responses varied but clustered around five major categories across the four counties: reduced rainfall, increased drought frequency. Flooding, low crop yield and frost.Reduced rainfall and low crop yields and increased drought frequencies were reported in all the counties. Flooding which is due to increased intensity of rainfall episodes rather than an overall increase in rains was cited mainly in Trans Nzoia, Uasin Gishu and to some extent Bungoma.

Figure 26: Climate change impacts reported by households



Households were asked about **rainfall patterns in the last five years**. About two-thirds (68%) of the respondents reported the rainfall received to be average with 21% stating it was above normal and 11% indicating it was below normal. Those reporting it was below normal were from Kakamega and Trans Nzoia while in Uasin Gishu the rainfall level was categorized as normal.

As weather variability and incidence of extreme weather events with impacts on agriculture intensify and increase in frequency, there is a need to impart capacity on the population to consume meteorological data. Reasons for preference of traditional knowledge and the perceived unreliability, inaccessibility and unavailability of meteorological data have to be identified and remedied while taking into account the community's capacity to synthesize this type of information.

Climate coping strategies: Households were asked about their climate change coping strategies. A fifth of them (21%) stated they do nothing to cope with the changes; 20% of the households stated soil conservation as their strategy; 10% mentioned planting drought resistant crops/varieties; 9% stated irrigation; and8% said their strategy was to use more fertiliser; and another 8% stated pesticides. It was only 3% of respondents who stated that using certified seeds was their preferred strategy. As a matter of fact most maize growers in those regions plant certified seeds.

Those who reported doing nothing were mainly from Bungoma county representing 50 per cent of the respondents.

In Uasin Gishu, the use of drought resistant crops/varieties and soil conservation were the major coping strategies while in Trans Nzoia, soil conservation, irrigation and use of more fertiliser were cited as preferred coping strategies.

More households reported of irrigation and pesticides as strategies in Kakamega compared to the other counties.

Table 20: Climate change coping strategies (% of households)

Coping strategies	Bungoma	Kakamega	Trans Nzoia	Uasin Gishu	All counties
Nothing	50	10	5	19	21
Drought resistant crops/varieties	2	10	2	24	10
Soil conservation	7	15	36	22	20
Changing crops grown	1	4	2	3	3
Changing planting patterns	4	3	8	3	5
Irrigation	7	13	10	7	9
Early planting	3	9	4	9	6
Use of herbicides			5	1	2
Use of pesticides	6	18	7	0	8
More fertiliser	7	8	10	5	8
Use of meteorological data	5	3	6	3	4
Use of anti-frost	2		3	3	2
Use of certified seeds	6	4	1		3
Plant variety of crops		4		2	2
Total	**100**	**101**	**99**	**101**	**101**

It was surprising to find that crop diversification was not picked by many households as a coping strategy. Of all the respondents only nine had introduced new types of crops to cope with climate change.

6.6 Public extension services

One issue that kept cropping up in focus group discussions was the limited availability of government extension services. Many farmers and stakeholders had the view that the reason why farmers were not accessing soil testing services and lime suppliers was largely due to lack of information from agricultural officers. When agricultural officers responded to the serious allegations, they pointed to a number of factors that limit their effectiveness.

They reported that the government had not employed extension officers since the late 1990s while many officers had retired between that time and the present. As a result the numbers of serving officers was dwindling gradually. They also pointed out that budgetary allocations to agriculture were grossly inadequate and serving officers did not receive the support they required to improve their service delivery to farmers.

It was also observed that the policy of the government was the provision of demand-driven extension services and therefore farmers had an obligation to organize themselves into viable groups and approach extension officers for assistance.

Extension service provision to individual farmers was difficult to sustain under the current climate of low staff numbers. Farmers were also advised to take advantage of the multiplicity of stakeholders in the agricultural industry as well as multiple information channels. It was also made clear that some county Governments had embarked on subsidised of fertilisers, soil testing services and lime to farmers so as to give farmers more choice.

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In the following sections, discussions turns to two other cross-cutting issues: factors influencing farmer buyer behaviour and lime resources in Kenya. To conclude the chapter, the need for a paradigm change in soil testing services and government policy on liming are addressed.

6.7 Lime resources in Kenya

Some FGD participants were keen to find out if Kenya had adequate lime resources to deal with the threat of soil acidity. This issue was also tied to the question of monopoly in agricultural lime production. Limestone is a very widely available mineral resource in the country but it has variable quality. The different limestones in the various regions Kenya include crystalline limestone, marbles, calcitic lime, dolomites, Coquina, travertine, etc. However, while numerous limestone occurrences have been recorded and mapped in the country, detailed work has yet to be carried out to establish the extent of the majority of limestone occurrences.

Geochemical analyses carried out in various areas show good quality limestone suitable for cement manufacture and others of low quality that have high silica and magnesia content, while others have other materials that can be used for other purposes instead. For example, Kajiado county has a long history of limestone production in the Turoka valley and in Sultan Hamud area (F. J. Matheson (1966)[3]. Malindi's coquina has poor quality limestone and can be used for construction stones.[4]

In Kitui, limestone resources appear concentrated in Kitui South in Mutomo and Ikutha sub-counties, This 'Limestone Belt' covers the following locations: (a) Mathima Location, Mutha Division, Mutomo District; (b) Kanziku Location, Kanziku Division, Ikutha District; and (c) Simisi Location, Kanziku Division, Ikutha District. The same resource has recently been discovered in other parts of the county, including Thaana Nzau, Tharaka and even inside the Mui coal basin. Cement manufacturers are angling to expand their business portfolios on the basis of exploiting these reserves, some of which are said to hold enough limestone to last cement companies more than 50 years (Financial Standard Tuesday, June 2nd 2015).

For farmers in the western region, the most relevant deposits are those around Koru. Already, a new cement manufacturer (Rai Cement) has invested in a cement factory at Koru and is reportedly buying limestone from local farmers; but it is conceivable that if farmers' lime cannot meet the factory's demand, the factory may turn to HLCL for supplies. The surveyed limestone reserves on HLCL company land amount to 65 million tonnes but there are also some unsurveyed deposits. In addition there is limestone in the vicinity in excess of 20 million tonnes (http://www.homalime.com/).

In conclusion, availability of lime resources is not currently a serious constraint to the use of agricultural lime in the country and neither is it likely to become so in the near future. However, cement manufacturing provides a challenge to a lime supplier. If a supplier gets one large and reliable customer, the temptation to downplay scattered demand is hard to resist and so may be a temptation to raise prices. county governments and their farmers should be on their lookout to ensure competitive supplies of commodities such as lime.

6.8 Need for a paradigm change in soil testing

There is a need for a paradigm change in soil testing and supply of lime to poor farmers. Currently the rate of adoption of these goods and services by smallholder farmers is low. Farmers complained about high prices for lime and soil testing services. Whether this reaction is based on fact or perception is immaterial as the net result is low adoption.

There is need to find a way to encourage farmers to increase their adoption rate. Some historical steps in the 1960s and 1980s provide a valuable lesson. In the 1960s, the government deliberately introduced subsidies for artificial insemination (AI) services so as to make the service affordable to small-scale dairy farmers [Duncanson, G.R. (nd)]. The result was the robust dairy sector we have today. Likewise in the 1980s the government subsidised school milk and this created a huge demand for milk, further strengthening the dairy sector.

Those subsidies have since been withdrawn. Another lesson can be Rwanda's approach to the provision of spectacles to its poor citizens. These examples illustrate the need to create demand among specified target populations first through subsidies before full commercialization. It is important to note that commercial services were offered to those who could afford them. Judicious use of supply-led intervention can often foster the development of demand-led markets for goods and services among targeted segments of the population and this is fully in line with the sustainable commercial model.

The essential pillars would be (i) free supply of soil testing services and lime to the poorest 20% of smallholder farmers; (ii) subsidised prices for the rest of the poor smallholder farmers; and (iii) commercial prices for the non-poor. To reduce opportunities for leakage, targeting of beneficiaries is critical. An appropriate methodology would have to be developed. Pilot trials can be made but ultimately a policy guideline by the government may be required to sustain such an initiative.

Even though there are several competent Organisations with well-equipped laboratories for undertaking detailed testing of soil samples such as Crop Nut Ltd, Soil Cares, county Governments, KALRO, KEPHIS and Eldoret University, the truth is that the total capacity to test soils is limited. While limited soil testing services partly explains why the uptake of lime has been low in the region, it is perhaps the cost element that is the real deterrent for many farmers. If demand for soil testing services was high, the results of soil tests would take long before being provided to the farmers.

The cost of doing detailed soil tests is viewed as high as expressed by farmers. There is therefore a case for changing the focus of soil testing. The most critical parameter to establish, at least initially, is the acidity of the soil as measured by its pH. That aspect can be established by a simpler testing process such as soil scanner, which also taKES much shorter to release results and is affordable to most farmers.

While there are various types of equipment in the market some as simple as a pH meter, a person who wishes to provide sustainable soil testing services should be prepared to invest in hardy and reliable equipment that may cost in the region of KES 300,000. There are soil scanners that can provide results within less than an hour. Such a scanner relies on sending soil scans to a database in the cloud, where the analysis and recommendations are done. Results are received by the soil tester on his email that he/she can be share with the farmer. If a business case can be made through a business plan, an investor can easily attract funding from commercial banks. Such investors could be agrovets, commercial extension officers, out growers, cooperatives or anyone who has direct connection with farmers in the field to give advice and input. Assuming that an investor conducts 750 tests per year at a price of KES 500 per test, that would translate to a revenue of KES 375,000 per year per machine. This service could be coupled with a lime distribution activity to boost revenues.

Box 6: Lesson from Rwanda

Hong Kong businessman and philanthropist James Chen founded a charity in Rwanda, Vision for a Nation. With partners, the charity trained more than 3,000 nurses in health centres to undertake eyesight tests and prescribe glasses. This three day training overcame the critical shortage of specialists by relaxing the rules that required vision tests be performed by qualified optometrists and treatment be provided by qualified ophthalmologists. The glasses were available at an affordable price of the equivalent of KES 150 but they were given free of cost to the poorest 20% of the population. More than 150,000 glasses have been distributed and more than 100,000 patients were referred to hospitals for further checkup and treatment *(Sources: Media stories, e.g. BBC, CNN, Guardian, VOA).*

6.9 Policy on inputs

Low agricultural productivity which is reflected in low yields per unit of land results in high per unit production costs. One reason for low yields is that farmers apply little or no yield improving inputs such as fertilisers because they cannot afford them. One long-term policy in agriculture has been to increase output using improved farming technologies such as modern inputs so as to increase both farm productivity and farmers' incomes.

The National Accelerated Agricultural Input Access Program (NAAIAP), touted as a "market smart" modern input subsidy scheme (2007-2010) was one effort towards making fertilisers affordable to poor smallholder farmers through a government subsidy. NAAIAP was designed as a safety net programme to reach 2.5 million farmers and to cost KES 36 billion over the initial three years (Odhiambo and Fengying, 2015).

Smallholder farmers were provided with a one-year subsidy voucher covering fertilisers and certified maize seed and extension services to raise their farm productivity and graduate them to commercial agriculture. Farmers used the vouchers to access the fertiliser and seed from agro-dealers. One of the key activities under NAAIAP was countrywide soil testing to inform fertiliser recommendations for different soils and regions. For this purpose NAAIAP contracted the then Kenya Agricultural Research Institute (KARI) (now KALRO) in 2012/2013 financial year to analyze soils from 4,470 farmers in 147 sub-counties.

The country requires about 650,000 tonnes of fertiliser per year. Most of this fertiliser is imported. KMT played a key role engaging with the Ministry of Agriculture, the International Fertiliser Development Corporation, AGRA and KALRO in planning for the establishment of a Kenya Fertiliser Roundtable (Ke-Fert) whose main mandate is to steer development of the Kenyan fertiliser market towards better performance of farmers in increasing yields and incomes.

A first meeting of Ke-Fert was held in Nairobi, 16-18 October 2013. During that meeting, a key point of Discussions turned out to be the issue of soil acidity and liming. During the FGD meetings, participants raised the issue of the need for a policy framework for lime and fertiliser to guide such issues as subsidies, labelling of lime products and application methods.

A study by Awuor (2012) concluded that the input subsidies provided by the government to farmers had led to increased agricultural productivity. Such a policy would guide some extension officers who hold the view that farmers must have a certificate of soil testing before they are sold lime; while agrovets disagree given that lime is not a dangerous substance.

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[3] **F. J. Matheson (1966): Geology of the Kajiado area. https://library.wur.nl/isric/fulltext/isricu_i2753_001.pdf).**

[4] **University of Nairobi, Department of Geology: AN APPRAISAL OF LIMESTONE OCCURRENCE AND QUALITY IN KENYA. http://geology.uonbi.ac.ke/content/appraisal-limestone-occurrence-and-quality-kenya.**

CHAPTER SEVEN

Change in Business Performance for Homa Lime Co. Ltd and its Distribution Networks

7.1 Promotion of lime before KMT-HLCL partnership

Smallholder farmers in the western region have had opportunity to learn about lime and soil testing for about a decade, from 2009, the start of Phase one of the AGRA-supported joint KALRO-Moi University lime project, to the current time. That project identified on-farm trials/demonstration sites in various locations in Kakamega North, Emuhaya and Siaya. In addition to demonstrations, the project gave free lime (which it purchased from Homa Lime Co. Ltd.) to interested farmers to try on their own farms. Thus the first lot of smallholder farmers who used lime in the region did so under that project.

As that project approached its winding up, it encouraged farmers to link up with selected agrovets for the supply of lime with the expectation that the link would be sustained. As far as soil testing services were concerned, the main service providers were KALRO and Moi University. When Phase one ended in 2012, the need was felt for another phase to expand the access to lime by more farmers. phase two was implemented over the period 2012-2015.

Then in 2015, KMT partnered with HLCL to promote soil testing and lime use in the three counties of Kakamega, Uasin Gishu and Trans Nzoia. Vihiga and Bungoma Counties benefited from spillover effects. As farmers explained in FGDs and in household questionnaires, many of them learned about lime from county Government extension personnel, One Acre Fund and the Equity Group Foundation. Most farmers received free lime and some benefited from subsidised soil tests. Based on the activities of that decade, one would expect a significant adoption of soil tests and lime use by farmers.

7.2 Change in Homa Lime Co. Ltd. business performance – a success story

The HLCL business performance success story was evaluated on increase in market share, sales and product uptake levels, marketing strategies, increase in distribution networks and increase in overall revenue. Prioritised interventions that need to be scaled up are also discussed.

Homa Lime Co. Ltd (HLCL) was started in 1928 and was then based in Homa Bay where it had a lime deposit but when that deposit was exhausted the company moved to Koru in Kisumu county in 1938. The firm has 3000 acres of land and has diversified into large-scale livestock (dairy and beef) and sugarcane production.

The farm has 1000 head of cattle and 800 acres of cane. The surveyed limestone reserves on company land at Koru amount to 65 million tonnes but there are also some deposits that have yet to be surveyed. The lime deposit at Koru is probably the largest single deposit in the country. According to Yager (2012), the company produces about 30,000 tonnes of lime per year.[5] HLCL's main limestone products are shown in Table 21.

The limestone is a carbonatite, volcanic in origin, unlike most limestones which are sedimentary rocks. As a result, the stone varies in colour from dark grey to light ochre due the presence of other compounds apart from calcium carbonate, such as oxides of manganese, phosphorus and iron. This also results in the hydrated product being light grey in colour. Except for very particular applications, these impurities do not reduce the effectiveness of the product. Limestone is quarried and then crushed and graded for various uses.

Table 21: Range of limestone products

	Product	Description
1	*Principal product - Hyrdate of Lime*	Calcium hydroxide (Slaked lime) is HLCL's principal product. It is used in the sugar, leather, water treatment, building and road construction industries among others. This product can also be used as a wash, light grey in colour but works just as well as whitewash. Production capacity is 90 tonnes per day, packed in 25 kg sacks. This product complies with International Standards such as KS02-97/1982, KS03-221/1983, BSS 890/1972 and ASTM C25.
2	*Boresha Calcium Fertiliser*	This product contains calcium which is an essential macro nutrient for plants. It is also used for soil conditioning, both to reduce acidity and to make heavy clay soils more workable.
3	*Boresha Super Calcium Fertiliser*	**T**his is a mixture of calcium hydroxide (soluble in water), calcium oxide (less soluble) and calcium carbonate (least soluble). It therefore becomes available to the plant and reduces soil acidity much quicker than conventional crushed limestone.
4	*Calcium Stock feed*	This comes as a powder (<2mm) and is suitable for mixing in animal rations. HLCL limestone has up to 2% phosphates, which can be a valuable addition to animal rations. They also produce a coarser product ideal as Poultry Grit.
5	*Building Stone*	Machine cut and Hand Dressed stones are available in 9" x 4", 9" x 6" and 9" x 9"sizes. These give an extremely attractive finish to a wall when not plastered due to the varying texture and colours of the stone.
6	*Stone Tiles*	Stone tile are available in 6" Length 4" Width 1" Height and 6" Length 4" Width 2" Height. These give an attractive finish for paving.
7	*Chippings/ Ballast*	Various sizes from 1/4" up to 1" are available. Because our limestone is volcanic in origin and has a crystalline structure it is harder than conventional limestones and thus the chippings can be used effectively in concrete for floor slabs. (Product is not recommend for use in multi-storey construction).
8	*Limestone*	Graded for size
9	*Lime Grit*	This is another by-product from hydrate production. This can be used to stabilize boggy ground and also maKES an excellent road surfacing material. It can be used in foundations for buildings as a filler, providing it is well watered before covering. It is also excellent for livestock yards which tend to be dug up by animal hooves in wet weather as it sets hard. In addition it has a disinfecting effect and so reduces parasites and pathogens
10	*Quarry/Kiln Murram*	This is a good product for applying to areas where flooding and water-logging occurs. It has the effect of drying out the soils and rendering the area more stable. It can also be used in foundations for buildings as a filler and as a road surfacing material.

The lime operation includes quarrying and processing; the latter involves crushing limestone rock and separating the various components based on the particle sizes. The crusher is operated by mains power bought from KPLC. One of the components with high levels of calcium carbonate is heated to remove the carbonate to leave calcium oxide (CaO). The CaO is then hydrated to form CaOH2. In the heating process, wood fuel is used as well as baggase, a by-product of cane processing into jaggery.

The firm produces different types of lime for different purposes such as construction, livestock feedstock and agricultural lime. Lime grits are sold to feed manufacturers for incorporating in poultry feed to raise its level of calcium. The grits are also used as binding material in the maintenance of earth roads. Alliance for a Green Revolution in Africa (AGRA) partnered with KALRO in a two-phase project between 2009 and 2015 to promote the use of lime among smallholder farmers in parts of Nyanza and Western Kenya. The project sourced its lime supplies from HLCL.

Following that partnership in 2015, HLCL formed another partnership with KMT. Prior to the AGRA/KALRO project, HLCL sold agricultural lime mainly to large-scale farms such as sugar plantations and large-scale cereal growers; smallholder farmers were not on their radar. It is useful to appreciate that the 2015 partnership between HLCL and KMT was aimed at fostering a commercial model for farmers to access lime on a sustainable basis through distributors and retailers.

This process was built on the foundation laid by the AGRA/KALRO partnership of 2009-2015 in which lime purchased by the project from HLCL was distributed free of charge to farmers as a means of introducing them to the technology so that they could counter the rising acidity of their soils. But the project acted as a wholesaler, buying the lime from HLCL and distributing it to farmers directly and thereby bypassing established input retailers.

Through the KMT partnership, HLCL recruited 17 lime distributors and stockists in the four target counties. As a result of this model, HLCL reported that since joining the partnership with KMT, the sales of their agricultural lime have more than doubled.

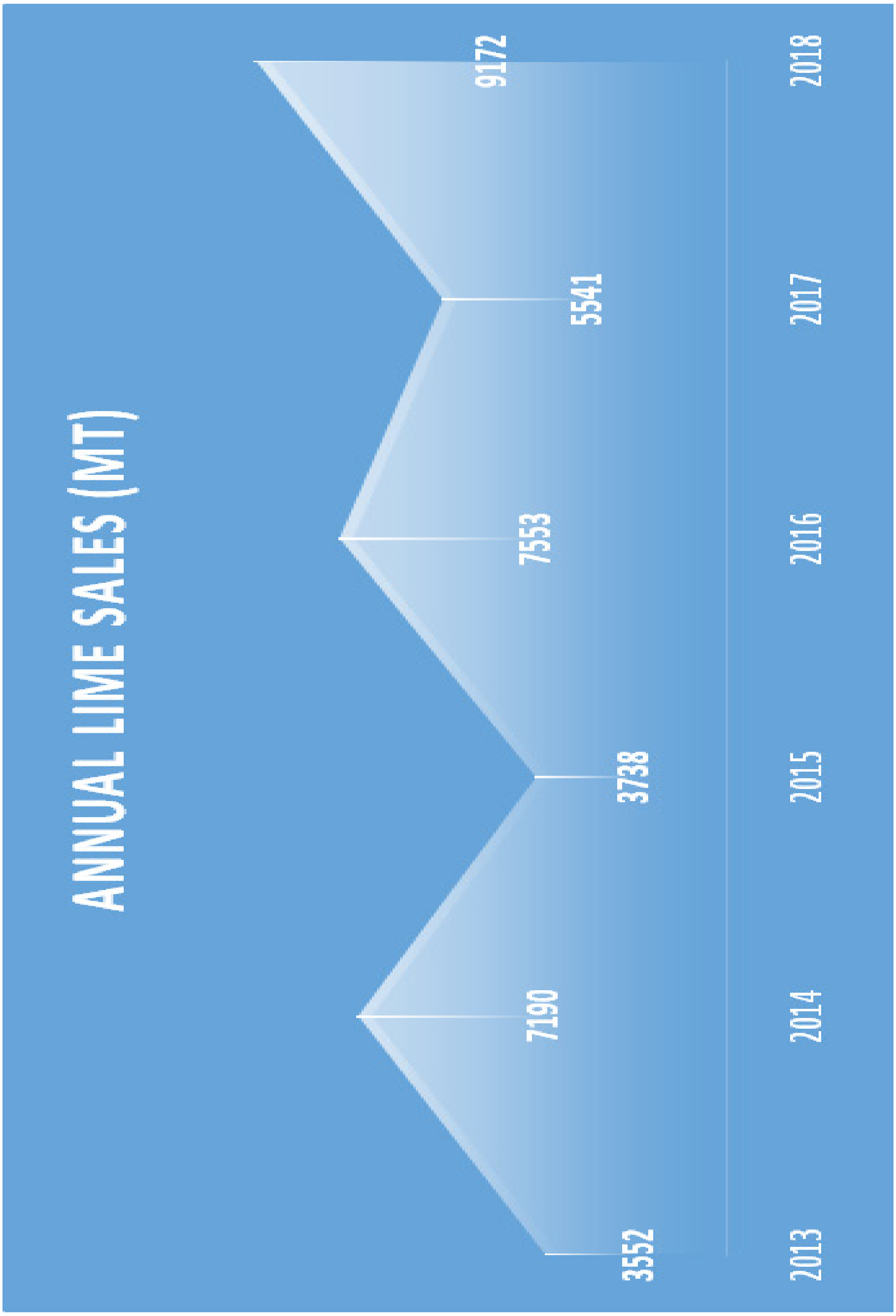
They were unwilling to give specific volumes and monetary details. One source indicated HLCL's annual production of agricultural lime in 2010 to be 30,000 tonnes (Yager, T. (2012). It is difficult to tell if production has increased substantially above this level. Feedback from HLCL and farmers suggest that the only major buyer of lime destined to smallholder farmers was One Acre Fund. Distributors and stockists were more reticent, unsure about the market for lime. In our view, the participation of the county Governments in direct procurement of lime had a negative impact on the distribution chain. As a supplier of lime, HLCL benefits from purchases of lime by any buyer. Irrespective of who provided the lime to the smallholder farmers, the opening up of the use of lime by smallholder farmers was important for HLCL.

According to HLCL records, some of the farmers who adopted the use of lime in the four counties of Bungoma, Kakamega, Uasin Gishu and Trans Nzoia are shown in Annex 10.3. The list of 15 is drawn from the list of 79 farmers who had hosted demo farms. The sales of lime by HLCL increased from about 3600 tonnes in 2013 to just under9,200 tonnes in 2018.

The increase was not smooth but fluctuated from year to year as depicted in Figure 23 below; the critical aspect is that the overall trend was increasing. HLCL and counties did not provide a breakdown of the lime salesto each county. It is difficult, therefore, to tell how much of the lime ended among smallholder farmers in each of the four study counties. Some of the lime might have been purchased by larger farmers. In the absence of evidence to the contrary, one can, however, assume that most, if not all the sales, were taken up by smallholder farmers.

Given that the HLCL/KMT project objective was to establish a commercial distribution channel for sustainability, the growth in sales was definitely encouraging. Significant amounts of those sales were made by county Governments; they were provided to farmers free of cost. Unfortunately figures of the actual amounts they purchased were not available. The subsidy acted as an incentive for farmers to apply lime but not necessarily to adopt its purchase. Another challenge that arose was that since the said amounts of lime were not channeled through stockists to farmers, stockists perceived the action as a disincentive to stock lime.

Figure 27: Super calcium and calcium fertiliser sales 2013-2018 (MT)



Source: Based on data from HLCL

In terms of the territories in which HLCL has distributors, the company has strengthened its footprint in Vihiga, Kakamega, Bungoma, Uasin Gishu and Trans Nzoia and is now in the process of building networks in Kisii, Bomet, Kericho and other places. HLCL reported that some coffee farmers in Central Kenya have expressed interest in the lime.

According to a study by Achieng, H. et. al. (2018), customers are satisfied with the products and services they get from HLCL. The study reviewed customer feedback (e.g. complaints and compliments) to the company in its public relations department. The study indicated that most orders received by the company are through referrals from previous customers.

Based on the results of the partnership, HLCL is now considering partnering with its interested distributors/stockists in finding a solution to the issue of spreading lime on farms.

Some distributors reported that they have received communication from HLCL asking them for their views on investing in mechanical lime spreaders. Should the idea appeal to distributors it could well see some of them buying spreaders and providing lime spreading services to farmers at a fee and thereby resolving one of the constraints mentioned by farmers as a disincentive to their adoption of lime use.

The partnership with KMT helped HLCL in (i) linking with distributors and stockists and identifying 17 of them to work with; (ii) organizing 79 demo farms in the region; (iii) holding five field days in 2016 with an attendance of 569 farmers; (iv) branding its agricultural lime.

With respect to the branding, the naming of the two products as "calcium fertiliser" has added to the confusion among farmers who now think that lime is a fertiliser, which it is not. HLCL reports that the partnership has also led to growth in agricultural lime sales; however, not all of this has been channeled through its distribution networks. KMT support to HLCL also included sensitizing farmers on importance of lime through demo farms and radio messaging.

Therefore a key objective of the assessment was to find out how Homa Lime has performed in this aspect and to establish the methods they have used. HLCL has relied on field officers to maintain contact with farmers on the ground.

At the time of the study there were only three such officers in all the counties where HLCL sells agricultural lime and according to the management, the firm was planning to increase the number slightly. Although some farmers indicated they had learned about soil acidity and liming through the radio, feedback from farmers did not give this source of information a high priority rank.

HLCL has been engaging in promoting soil testing, but it has not been a core service; they have relied on soil testing firms to sell this service.

Box 4: Homa Lime Co. Ltd.'s headache

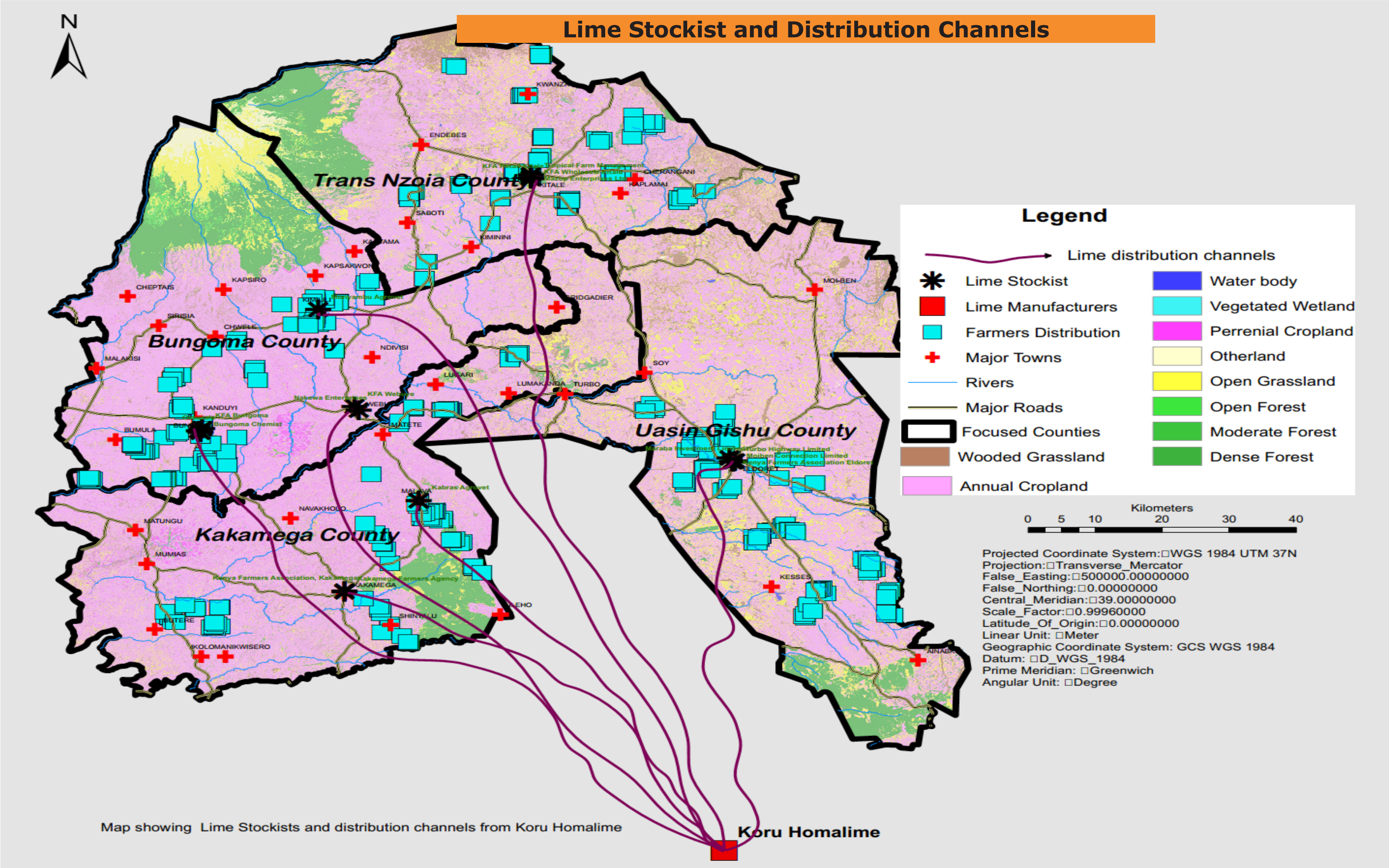
"The major problem we have encountered is that even after undertaking a pilot project, where we have facilitated farmers to get lime for free, many farmers have not scaled up the project despite reporting significant results from the section of their farm where they applied lime." *Homa Lime Co. Ltd. representative*.

7.3 Change in business performance of distributors and stockists

7.3.1 Lime distributors and stockists

The map below shows the spatial distribution of HLCL's lime distributors and stockists in the four target counties. The names of these agencies are shown in the volume on annexes. HLCL invited input distributors and stockists to a meeting and recruited those who expressed interest and who were able to meet some basic conditions. The map shows a reasonably good distribution of these input suppliers across the counties. One unequivocal message from this spatial distribution is the realization that if farmers cannot access lime it is not because input suppliers are not physically in place. The reason has to do with other constraints. Although the map suggests there are seven distributors/ stockists, there were 17 identified by HLCL; the challenge in showing all of them arises from some being in the same town.

Figure 28: Lime distributors and stockists



Views on awareness about lime and soil testing: During key informant interviews, lime distributors and stockists in the four counties were asked to give their own assessment of the level of awareness about lime and soil tests among county government extension staff, CSO staff in agriculture, Researchers, Input distributors, input stockists (agrovets) and smallholder farmers. The majority of respondents perceived smallholder farmers as having low awareness levels; while perceiving county government extension staff, CSO staff in agriculture, Researchers, Input distributors, input stockists as having medium to high levels of awareness. There were ten lime distributors/stockists who were interviewed in all four counties. Details of the assessment for individual counties are shown in the county reports.

7.3.2 Performance of distributors and stockists

The performance of distributors and stockists was mixed. With the exception of a few, the majority seemed to have had their business compromised by county governments that directly ordered lime for the farmers from the manufacturers, specifically, Homa Lime Co. Ltd., MavunoFertilisers (from ARM Cement) and Baraka Fertilisers- locally blended NPK fertilisers (from Toyota Tsusho Fertiliser Africa Limited). HLCL does in fact package agricultural lime for OAF directly and thus OAF does not depend on the distribution network in the region. Apart from such competition, distributors also have to cope with challenges posed by county Governments that bypass them in the supply of lime. None of the distributors or stockists has invested in soil testing services. This may imply they are being cautious but it could also be an indicator they do not yet see the potential in the lime market.

Out of the four counties, it was only in Bungoma and Kakamega where some data on sales of lime were provided by lime distributors and stockists. In the case of Bungoma, one distributor indicated that they had sold 10 tonnes of lime in 2016, 10 tonnes of lime in 2017 and 30 tonnes of lime in 2018.

In the case of Kakamega, estimates of sales for two stockists for the period 2009 to 2018 show that one stockist sold between 1.0 and 3.6 tonnes per year while the other sold between 1.2 and 3.0 tonnes per year (County reports). For the Bungoma distributor who increased his sale of lime from 10 to 30 tonnes per year, assuming he sold the lime at KES 500 per 50 kg bag the sales were worth some KES 300,000. For the two stockists in Kakamega who each managed an average of about two tonnes per year, their individual sales brought in a revenue of KES 20,000 per year,

Box 5: Gaining a competitive edge….

Baraka Kibao Bonanza (January 21 to April 22 2018), was a promotional show by Toyota Tsusho to create awareness of its Baraka brand of fertiliser formulations and boost sales.

[5] **Thomas R Yager (2012): The Mineral Industry of Kenya. US Geological Survey 2010 Minerals Yearbook – Kenya.https://minerals.usgs.gov/minerals/pubs/country/2010/myb3-2010-ke.pdf.**

CHAPTER EIGHT

Conclusions and Recommendations

8.1 Conclusions

1. Empirical studies by KALRO and university scientists have indicated that soil acidity and low fertility are widespread in soils in the western region and that to raise the productivity of these soils there is need to address the twin challenges. Since the levels of acidity and infertility differ from soil to soil, it is important to undertake soil analysis before attempting to correct the situation.
2. For more than a decade, lime use projects have been implemented in the western region and as a result many farmers have become aware about lime and soil testing services. Some adopters of soil testing and lime use have achieved commendable results in their maize yields. However, the number of farmers that had undertaken soil testing or/and adopted the use of lime was lower than the number that had been made aware about these technologies and had not adopted both technologies or had only had their soils tested but had not gone further to adopt the use of lime. Lack of adoption hinges on many factors such as poverty for some farmers, inadequate understanding of the benefit-cost relations in liming, confused messaging, etc. These challenges cannot be addressed by one stakeholder in isolation.
3. The main reason why farmers had not adopted soil testing was the perception of high cost without a clear understanding of the benefits thereof. In the case of adoption of lime use, the main reasons included perception of high cost (in terms of money, labour and inadequate impact on crop yield); inadequate information concerning types and application methods of lime; and distance to source of lime (related to cost of transportation of the bulky and dusty product).
4. Only a minority of farmers paid commercial rates for having their soils tested; the majority of farmers obtained services subsidised by the county Government or the Equity Group Foundation. Only a minority of farmers has purchased lime.
5. There does not seem to be any study that has addressed the economics of lime application explicitly comparing the costs and benefits of the technology. The demo farms ought to have included such a component. Estimates put the incremental value of maize from lime application at about KES 1,900 per bag.
6. There exists lack of harmony in the messages given to farmers by different stakeholders about lime. This situation is exacerbated by lack of a policy on lime and fertilisers.
7. Lime packaging does not contain adequate information about lime such as application instructions. The exception is brief safety instructions in the packaging by HLCL.
8. The study sought to test two hypotheses. The first hypothesis was that a private-sector distribution model for lime could significantly improve access to lime by smallholder farmers. In other words, it was assumed that as a result of KMT facilitation, HLCL would expand the number, skills and reach of its distributors and stockists and hence significantly increase farmers' access to lime. The verdict: HLCL did its part by appointing distributors and stockists of lime in the region and is expanding into other regions in the country. The complication came from county governments that bypassed the private sector in their efforts at assisting farmers to access lime. The

second hypothesis was that application of lime to acidic soils would improve productivity; thus when farmers apply lime to their fields, they should increase their crop yields. Data from the limited number of farmers applying lime showed that liming raised maize yields by an average of about 11 bags per acre. Additional evidence was provided by HLCL data from demo plots showing statistically significant differences in maize yields between limed and unlimed plots.

8.2 Recommendations

1. Farmers need to be given consistent information about the importance of soil testing prior to application of lime and fertilisers. Currently some actors do not ask farmers to undertake soil testing. Government should facilitate farmers and especially the most vulnerable to access affordable and timely soil testing facilities.
2. The gap between farmers and service providers can be bridged by youth (they have better education) that take the opportunity to invest in a combined service offer of soil testing (using soil scanners; acting as agents for soil testing labs for more detailed tests) and bringing lime from agrovets/suppliers to the farmers at affordable prices. Such youth can be supported by Organisations such as Equity Group Foundation (through their new programme) to develop bankable business plans and undertake necessary capacity development in business management[6]. KMT, soil testing service providers and other donor Organisations can provide seed money to pilot the idea in one county. Sustainability criteria should guide the selection of the model to be piloted.
3. KMT should take the lead in facilitating dialogue among stakeholders (HLCL, fertiliser companies, Ministry of Agriculture, KALRO, input distributors, county governments, etc) to promote advocacy for finalization of policy on agricultural lime and fertilisers that includes minimum technical information that should be provided to farmers on fertilisers and lime.
4. There is need for the GoK extension officers, NGO, research Organisations, development partners and government to collaborate to ensure that the information given to farmers is correct and area specific. Intervention is needed to give farmers information that is sufficient, area relevant, specific, from reliable and professional sources and ensure uniformity and consistency in the information they get. There is also need for farmers to have a centralized source of reliable information. Homa Lime Co. Ltd. and other sellers of agricultural lime should liaise with KALRO and Ministry of Agriculture extension staff to develop detailed information leaflets for inclusion in packages of lime.
5. Studies on the economics of lime application explicitly comparing the costs and benefits of the technology are required; such data should then be used in extension messages to assist farmers assess for themselves the value liming adds to their farming.
6. Crushed limestone is in powder form. If inhaled in excessive quantities over a prolonged period or extended period, respirable dust can constitute a long term health hazard. Dust inhaled or exposed to the eyes can cause severe burning of the eyes and mucous membranes. Therefore, inhalation of dust from aggregates should be avoided through wearing of personal protective equipment (PPE) such as suitable dust masks, goggles, gloves for hand protection and overalls for skin protection.
7. County Governments especially in those counties with high levels of soil acidity should support the exploration of agricultural limestone deposits.
8. There is a need for a paradigm change in soil testing and supply of lime to poor farmers. Currently the rate of adoption of these goods and services by smallholder farmers is low. The essential pillars would be (i) free supply of soil testing services and lime to the poorest 20% of smallholder farmers; (ii) subsidised prices for the rest of the poor smallholder farmers; and (iii) commercial prices for the non-poor. To reduce opportunities for leakage, targeting of beneficiaries is critical. An appropriate methodology would have to be developed. Pilot trials can be made but ultimately a policy guideline by the government may be required to sustain such an initiative.

[6] **EGF has plans to roll out a progamme with such features in six counties (personal communication with John Kemboi on 2nd November, 2018.)**

ANNEXES

Conclusions and Recommendations

An early impact assessment on enhancing access and use of lime among smallholder farmers in western region, Kenya.

Contents

1. Terms of reference

REQUEST FOR PROPOSAL

An early impact assessment on enhancing access and use of lime among smallholder farmers in western region, Kenya.

2. Background

2.1. About Kenya Markets Trust.

Kenya Markets Trust (KMT) is a Kenyan Organisation that works in partnership with the private sector, county and national government to unleash large scale, sustainable market growth by changing the underlying incentives, capacities and rules that shape how markets work. KMT currently works in Agriculture (Livestock and Agricultural Inputs) and Water sectors.

We focus on markets as they are the main mechanism through which wealth is created and growth occurs and our long-term goal is to deliver large scale, systemic change in selected markets that benefits all players including small businesses, larger firms, investors, producers and consumers.

To achieve this, we identify markets with high growth potential but which are saddled with systemic constraints. Working with key market actors, policy makers and other stakeholders, we address these constraints to improve competitiveness, efficiency and inclusiveness. As a result, we hope to grow the range of market opportunities, support competition in these sectors, eventually creating a market system that is profitable to investors, improves incomes for suppliers and is beneficial to consumers.

2.2. Study background and KMT-Homa Lime Engagement.

Acidic soils (pH lower than 6) are becoming an important issue in Kenya, especially in maize growing areas traditionally regarded as the "bread basket" of Kenya. Soil acidity with associated aluminium toxicity and nutrient deficiency affects crop growth and limits agricultural productivity.

The National Soil Survey (2014 Report) showed that about 50 per cent of the total samples taken from over 18 Counties were acidic. The most affected regions are in Lake Region, North Rift, Mt Kenya, Aberdare and coast. Acidic soils cover about 18 million hectares (44 Million acres) which make up about 13 per cent of Kenya's arable land.

Some of the key constraints that have been identified on agricultural lime use by smallholder farmers include; limited awareness on the levels of soil acidity; lack of access to lime; as well as limited access to soil fertility.

KMT engaged Homalime in a pilot a model that can sustainably supply agricultural lime to smallholder farmers in western region, particularly in Uasin Gishu, Trans Nzoia, Kakamega and Bungoma Counties. This model includes working with the lime manufacturers, agro-dealers (distributors and stockists) and other key stakeholders. The model is coupled with promoting soil testing among smallholder farmers, which is a key component in understanding the soil health status as a precursor for liming, quantities of lime to be used depending on the acidity status, enhance awareness on soil acidity and lime use as a correction measure, improve access of lime through establishment of agro-dealer distributor network.

In this engagement, Homa lime is targeting to improve its distribution chain to effectively reach out to over 50, 000 farmers in western Kenya region with information on soil acidity and agricultural lime use. In turn, this would create a positive shift in adoption of soil testing services and lime use, translating into increased demand for yield enhancing technologies and improved productivity among local smallholder farmers.

2.3. Objectives of the Assessment.

This study is intended to achieve **five** main objectives as outlined below. These objectives will be first interrogated per County, while retaining an option for a cross-County comparison.

- To establish the current knowledge levels, knowledge gaps and information awareness on lime use and soil testing services among smallholder farmers in western region.
- To establish the uptake levels of lime use and soil testing services among smallholder farmers in western region.

- To establish the changes in business performance/market share/sales and revenue for Homa lime and its distribution network through sale of lime and soil testing services.
- To demonstrate the impact of lime use and soil testing services on farmers productivity, yields and income in western region.
- To demonstrate the intervention's impact on gender (women and youth) and climate.

2.4. Scope of the Assessment.

This study will be conducted in Uasin Gishu, Trans Nzoia, Kakamega and Bungoma Counties and will incorporate an interaction with a cross-section of stakeholders including public officials.

2.5. Expected deliverables/Outputs.

1. Inception Report, which includes a clearly defined research design and assessment plan, work plan, proposed methodology, sampling approach, data collection instruments and analysis plan.
2. Summary of Preliminary Findings per County.
3. Comprehensive Research Report structured along the research objectives.
4. At least two Case Studies demonstrating the farmers' success story and Homalime business performance story.
5. Cleaned raw survey data submitted in either MS Excel or SPSS.

2.6. Skills and Experience Required.

Kenya Markets trust is seeking to recruit a consulting firm with strong technical competence in undertaking research and impact assessments for market development programs, value chain development, business modeling and understanding of market systems. Other eligible requirements are as follows;

1. Demonstrable conceptual understanding of market-led agricultural production, market systems analysis and market research.
2. Demonstrable understanding of the agricultural inputs sector value chain in Kenya.
3. Experience working with multiple stakeholders.

2.7. Managing Delivery.

The research firm/consultant will report on day to day the Monitoring, Results and Evaluation Specialist in charge of evaluation work in the inputs sector, and the Policy and Research Specialist for quality assurance.

2.8. Timelines.

This work should commence on July 16, 2018 and be completed by August 17, 2018. The consultant will be required to develop a detailed work plan including the timelines. The table below presents an indicative time schedule.

Activity	Time
Inception Discussions and prepare data collection tools	1 week
Testing tools and enumerator training, Field Work	2 weeks
Data Cleaning and Analysis	1 weeks
Draft Report, Presentation & Final Report	1 week

2.9. Mandatory Application Documents.

In response to this RFP, the following documents MUST be submitted as part of the proposal:

1. Cover letter: A short (maximum one page) letter addressing their capability to this assignment.

1. Technical Proposal: A (maximum 20 pages) technical proposal highlighting: brief explanation about previous experience in conducting similar work; understanding of the TOR, description of the stipulated methodology, research design, sampling methodology, type of data collection tools, draft evaluation framework. *(To be evaluated at 70%)*

· Financial Proposal: The financial proposal should provide cost estimates for services rendered including daily consultancy fees. *(To be evaluated at 30%)*

1. Curriculum Vitae: Detailed CV should be annexed to the technical proposal as separate documents and should indicate three professional references.

1. Certificate of Incorporation/Partnership deed/business certificate.

2. Valid Tax compliance certificate. (KRA/PIN/)

3. Two examples of evaluation reports recently completed. If possible, at least one of the reports should be relevant, or similar, to the subject of this assessment.

2.10. Enquiries & Expression of interest.

1. Questions regarding this request may be addressed to KMT procurement on procurement@kenyamarkets.org and must be received no later than 2nd July 2018. Responses to questions will be distributed to all interested parties no later than 4th July 2018. All enquiries must strictly be on email.

2. The Expression of Interest and enclosed documents must be received no later than **July 6th 2018, at 4.00 p.m**. Kindly ensure that the technical and the Financial proposals are enclosed separately.

3. The Expression of Interest MUST be delivered in hard copies to a tender box provided in our offices (See the address below). Kindly ensure that they are received at the reception and time of receipt is recorded on the envelop.

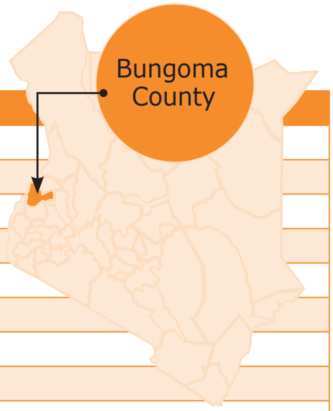
4. The Expression of interest must be marked **'EOI/KMT/LIME IMPACT'**

5. Failure to comply with the guidelines given herein will result to outright disqualification.

THE CEO
Kenya Markets Trusts
14 Riverside, Cavendish Block, 2rd Floor
Suite B, Riverside Drive
P.O. Box 44817, 00100, Nairobi, KENYA,

3. Names of sub-counties and wards in target counties

The following four tables provide details of the names of sub-counties and wards in each County. It is from these lists that sample wards will be identified (during the training of research assistants and enumerators).

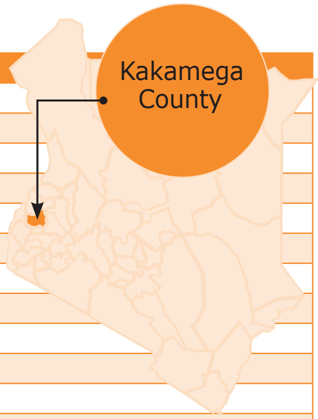


Bungoma county (9 sub-counties, 45 wards)

Name of Sub-County	Name of Ward
Elgon (6 wards)	Cheptais
	Chesikaki
	Chepyuk
	Kapkateny
	Kaptama
	Elgon
Sirisia (3 wards)	Namwela
	Malakisi/South Kulisuru
	Lwandanyi
Kabuchai (5 wards)	Kabuchai/Chwele
	West Nalondo
	Bwake/Luuya
	Mukuyuni
	South Bukusu
Kanduyi (9 wards)	Bukembe West
	Bukembe East
	Township
	Khalaba
	Musikoma
	East Sang'alo
	Marakutu
	Tuuti
	West Sang'alo
Bumula (6 wards)	Bumula
	Khasoko
	Kabula
	Kimaeti
	South Bukusu
	Siboti
Webuye East (3 wards)	Mihuu
	Ndivisi
	Maraka
Webuye West (3 wards)	Sitikho
	Matulo
	Bokoli
Kimilili (4 wards)	Kibingei
	Kimilili
	Maeni
	Kamukuywa
Tongaren (6 wards)	Mbakalo
	Naitiri/Kabuyefwe
	Milima
	Ndalu/Tabani
	Tongaren
	Soysambu/Mitua

Source: Bungoma county Government website.

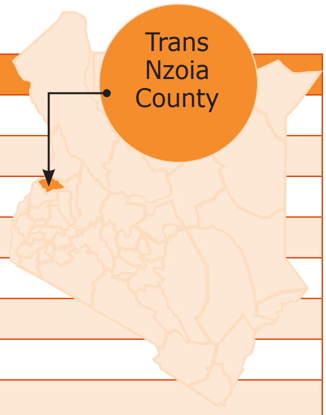
Kakamega county (12 sub-counties, 61 wards)



Name of Sub-County	Name of Ward
Lugari (6 wards)	Mautuma
	Lugari
	Lumakanda
	Chekalini
	Chevaywa
	Lawandeti
Likuyani (5 wards)	Likuyani
	Sango
	Kongoni
	Nzoia
	Sinoko
Malava (7 wards)	West Kabras
	Chemuche East
	Kabras
	Butali/Chegulo
	Manda-Shivanga
	Shirugu-Mugai
	South Kabras
Lurambi (6 wards)	Butsotso East
	Butsotso South
	Butsotso Central
	Sheywe
	Mahiakalo
	Shirere
Mumias East (3 wards)	Lusheya/Lubinu
	Malaha/Isongo
	Makunga/East Wanga
Navakholo (6 wards)	Ingotse-Mathia
	Shinoyi-Shikomari
	Esumeyia
	Bunyala West
	Bunyala East
	Bunyala Central
Mumias West (4 wards)	Mumias Central
	Mumias North
	Etenje
	Musanda
Matungu (5 wards)	Koyonzo
	Kholera
	Khalaba
	Mayoni
	Namamali
Butere (5 wards)	Marama West
	Marama Central
	Marenyo-Shianda
	Marama North
	Marama South
Khwisero (4 wards)	Kisa North
	Kisa East
	Kisa West
	Kisa Central
Ikolomani (4 wards)	Idakho South
	Idakho North
	Idakho East
	Idakho Central
Shinyalu (6 wards)	Isukha North
	Isukha Central
	Isuka South
	Sukha East
	Isukha West
	Murhanda

Source: Kakamega county Government website.

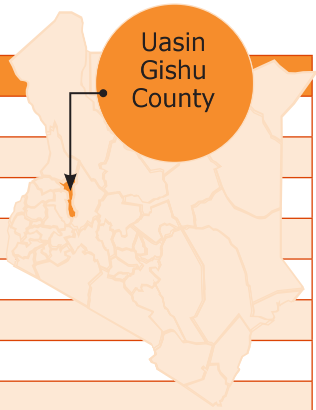
Trans Nzoia county (5 sub-counties, 25 wards)



Name of Sub-County	Name of Ward
Kwanza (4 wards)	Kapomboi
	Kwanza
	Keiyo
	Bidii
Cherangany (7 wards)	Sinyerere
	Makutano
	Kaplamai
	Motosiet
	Cherangany/Suwerwa
	Chepsiro/Kiptoror
	Sitatunga
Kiminini (6 wards)	Kiminini
	Waitaluk
	Sirende
	Hospital
	Sikhendu
	Nabiswa
Saboti (5 wards)	Kinyoro
	Matisi
	Tuwani
	Saboti
	Machewa
Endebess (3 wards)	Chepchoina
	Endebess
	Matumbei

Source: Trans Nzoia county Government website.

Uasin Gishu county (6 sub-counties, 30 wards)



Name of Sub-County	Name of Ward
Soy (7 wards)	Moi's Bridge
	Kapkures
	Ziwa
	Segero/Barsombe
	Kipsomba
	Soy
	Kuinet/Kapsuswa
Turbo (6 wards)	Ngenyilel
	Tapsagoi
	Kamagut
	Kiplombe
	Kapsaos
	Huruma
Moiben (5 wards)	Tembelio
	Sergoit
	Karuna/Meibeki
	Moiben
	Kimumu
Kapseret (5 wards)	Simat/Kapseret
	Kipkenyo
	Ngeria
	Megun
	Langas
KES ses (4 wards)	Racecourse
	Cheptiret/Kipchamo
	Tulwet/Chuiyat
	Tarakwa
Ainabkoi (3 wards)	Kapsoya
	Kaptagat
	Ainabkoi/Olare

Source: Uasin Gishu county Government website.

4. Some of the farmers who adopted the use of lime to correct soil acidity

FARMER/FARM	COUNTY/AREA	CONTACT
Elizabeth Sang'	Uasin Gishu/Kipchamo	0723710112
Angaluki Muaka	Kakamega/Malava	0727480853
Fred Barasa	Kakamega/Malava	0720690170
John Mukopi	Trans Nzoia/Sikhendu	0721558633
Michael Kipkorir	Uasin Gishu/Soy	0719230679
Konyit Farm	Uasin Gishu/Ngeria	0721927015
Simon Tanui	Trans Nzoia/Chematich	0722244927
Alice Injendi	Bungoma/Kimilili	0719405684
Nelson Mwangi	Bungoma/Kimilili	0711626891
Mr. Sawe	Uasin Gishu/Moiben	0721877358
Moses Kiptanui	TransNzoia/Cherengany	0722745688
Josephine Koiser	Uasin Gishu/Moiben	0723981182
Tankina Dairies	Uasin Gishu	0721220477
George Kili	Uasin Gishu/Soy	0722732757
Jerry Lilako	Kakamega/Isulu	0722864924

Source: HLCL.

5. List of lime distributors and stockists

Distributor	County	Town	Contact
Mazop Enterprises	Trans Nzoia	Kitale	0721400413
KFA (Wholesale)	Trans Nzoia	Kitale	0722605378
KFA Retail	Trans Nzoia	Kitale	0724878241
Tropical Farm Management	Trans Nzoia	Kitale	0713320616
Moiben Connections	Uasin Gishu	Eldoret	0722396769
Maraba Investment	Uasin Gishu	Eldoret	0722875149
KFA – Eldoret	Uasin Gishu	Eldoret	0722663695
Turbo Highway	Uasin Gishu	Eldoret	0722699777
Kakamega Farmers Agency	Kakamega	Kakamega	0722813719
Kabras Agro-Vet	Kakamega	Malava	0722348158
KFA – Kakamega	Kakamega	Kakamega	0722432692
Bungoma Chemist	Bungoma	Bungoma	0722958037
Omusale Ltd	Bungoma	Bungoma	0721865511
Munyambu Agro-Vet	Bungoma	Kimilili	0723795637
KFA – Bungoma	Bungoma	Bungoma	0724732174
KFA-Webuye	Bungoma	Webuye	0729915213
Nakewa Enterprises	Bungoma	Webuye	0722860664

Source: HLCL.

6. Distributors and stockists of lime who were interviewed

County	Name of distributor/ stockist	Location	Person interviewed/ position	Date interviewed
Trans Nzoia	Mazop Enterprises (Distributor)	Kitale, Kenyatta Street	Wafula (Agronomist)	29 Oct 2018
	KFA Wholesale (Distributor)	Maziwa Road	Humphrey, Malik and Kimani	29 Oct 2018
	KFA Retail (Stockist)	Kitale, Kenyatta Street	William (Branch Manager)	29 Oct 2018
Bungoma	Bungoma Chemist (Distributor)	Moi Avenue	Vincy Amiani	29 Oct 2018
	Omusale (Stockist)	Moi Avenue	Lenah Makokha	29 Oct 2018
Uasin Gishu	Maraba Investment Ltd (Stockist)	Ronald Ngala Street, Eldoret	Sarah Korir (0713443502)	29 Oct 2018
	Moiben Connections Ltd (Stockist)	Nandi Street, Eldoret	Anderson (0702835406)	29 Oct 2018
	KFA (Distributor)	Eldoret KFA-Unga Road	Joseph Tiampati (0722253981)	2 Nov 2018
Kakamega	Kenya Farmers Association	Kakamega Town	Secretary	29 Oct 2018
	Kakamega Farmers Agency (Stockist)	Kakamega Town	Celestine (Daughter to owner)	29 Oct 2018

7. Soil testing and liming: summary of county features

Annex 10.6 provides a summary of the main features in four counties for soil testing and lime use based on feedback from participants in focus group discussions and household interviews.

Soil testing and lime use: summary features in four counties

Issue	Kakamega	Bungoma	Uasin Gishu	Trans Nzoia
Who created awareness about soil acidity, soil tests and use of lime to correct acidity?	KALRO/AGRA Innovations for Poverty Action (IPA)	All FGD participants had heard about lime primarily through the efforts of One Acre Fund, Baraka fertilizer team and the county Government extension personnel.	All FGD participants had heard about lime primarily through the efforts of One Acre Fund, Equity Group Foundation, and Homa Lime Co. Ltd.	County Government extension personnel (model farms, shows, Shamba Shape Up, TV, Radio); Equity Group Foundation (EGF)
Who trained farmers about lime?	One Acre Fund County Government extension personnel	One Acre Fund County Government extension personnel Baraka fertilizer team	Equity Foundation Group/ Technoserve through Soil Cares Homa Lime Co. Ltd. (Agronomist) The county Government has planned for training in soil testing and liming but they are carrying out soil testing. They also have hand held gadgets to test soil but they are not enough for all the staff.	County Government extension personnel Equity Group Foundation (trained about soil health)
Adoption of the use of lime				
Retail price of lime at Agrovet (KES per 50kg bag)		500		
Farmers' view of affordable lime (KES per 50kg bag)		200		
Farmer knowledge about where they can get lime	Some farmers claimed not to know. Others mentioned agrovets.			KFA stores Some farmers introduced to HLCL
Is lime "fertilizer"	Some CSOs accused of promoting spot application of lime as if lime is a fertilizer.	Some farmers misled by sellers claiming lime is fertilizer	Farmers seemed to be aware that lime is not a fertilizer.	

Issue	Kakamega	Bungoma	Uasin Gishu	Trans Nzoia
Fertilizer and lime subsidy	In 2015/16 season Kakamega county Government acquired Mavuno fertilizer and supplied it to farmers at subsidised rates. The idea was to deal with low soil fertility and acidity. Farmers reported disappointing results.	Bungoma does not subsidize lime but subsidizes soil testing, charging KES 800 per sample.		In 2014, TN CG did 3300 soil tests; invited fertilizer companies to blend soil and crop specific fertilizers. This led to the formulation of Mavuno and Mazao blended fertilizers. TN CG Subsidizes fertilizer, not lime or soil tests; Demo farmers received free lime from EGF
Soil tests service providers	KALRO-Kakamega Homa Lime Co. Ltd. through Crop Nut Ltd Soil cares County of Bungoma Welt hunger hilfe (German Agro Action) through SGC Kenya	The department of agriculture has a mobile soil testing machine / lab that it uses to assist farmers from the larger western region at KES . 800/= for residents and KES 1200/= for non-residents.	Crop Nut Ltd Moi University Eldoret University Soil Cares through EGF	Bungoma county Government mobile lab; Soil Cares through EGF KEPHIS KALRO
Cost of soil test per sample	KALRO: KES 1000	KES . 800/= for residents and KES 1200/= for non-residents.		KEPHIS: KES 2500 per sample (Argue that their wet analysis method gives superior results); farmer to pay for transport Soil Cares KES 1000(through EGF)
Subsidised soil tests	No.	Yes.		Equity Group Foundation linked farmers to service provider and subsidised cost of soil testing by KES 500 per soil sample – farmers paid KES 1000 per sample. Service provider normally charges KES 1500 per sample.

Issue	Kakamega	Bungoma	Uasin Gishu	Trans Nzoia
Adequacy of soil testing facilities		Limited soil testing services partly explain why the uptake of lime has been low in the county.		
Initial soil pH and pH after three years	F1: 4.8	F1*: 4.7 to 5; F2*: 4.3 to 5.5.		F1: 4.6 F2: 4.8
Challenges faced by distributors and stockists (agrovets) in lime supply		Some agrovets do not stock lime becauseBungoma county government gives it away free. Hence there is poor demand. Someone was buying the free lime and repackaging it into smaller quantities and selling to the farmers. Farmers had their lime subsidised by the government Some farmers lack awareness about soil acidity and lime use.		
Maize yield before and after liming (bags/acre)	Farmer 1: 2016: four 2017: 10 2018: 12	Farmer 1: 2016: 7 2017: 16 2018: 22 Farmer 2: 2016: 12 2017: 18 2018: 20 Farmer 3: 2016: 13 2017:19 Farmer 4: 2016: 20 2017: 35 Farmer 5: 2016: <8 2017: 16 2018: 22	Farmer 1: 2015: 10-15 2016:20 2017:25	Farmer 1: 2016: 10 2017: 18 2018: 30 Farmer 2: 2015: 10 2016: 17 2017: 24 2018: 28

Issue	Kakamega	Bungoma	Uasin Gishu	Trans Nzoia
Policy	Some parties are promoting micro-dosing of lime as an option to the bulky nature of lime. We know this is wrong and partly explains the low demand for the same.	There is need for a county soil policy to give clear guidance to all stakeholders in the county. Reportedly, Soil policy for Bungoma is available.		Lacking policy on quality of fertilizer (by KEPHIS)
Challenges		Due to limited knowledge on lime use, some farmers mix lime and fertilizer during planting. Manual application of lime when windy presents risks of respiratory challenges to the users.	Farmers still insist on using DAP even when advised to use non-acidifying fertilizers. Lime application by hand is tedious; need for lime applicators. county government budget allocated to agriculture is too small. We encourage farmers to form groups and use them to lobby for much more attention in the sector" county Department of Agriculture Officer. Some stockists are lying to gullible farmers that their fertilizer has lime. Farmers need to know correct information.	Few farmers take part in public participation meetings. Price of maize is low and small farmers cannot raise enough to pay for soil tests and lime. The department of agriculture through the extension officers insists that farmers must have a certificate of soil testing before they are sold lime. But lime sellers do not agree.
		Lime use challenges/constraints Calling lime fertilizer is confusing; Brand the lime. Lack of To have user's manual in the lime packaging. You have to test soil before using lime Labour and time intensive Cause respiratory issues but if you follow instruction and recommended attire (gloves and masks) there are no adverse effects Farmers' ignorance Farmers love for free things (soil testing, free lime) Lack of buy in from leadership and even some of them discouraging them from soil testing and lime use Varying and different information to farmers		

8. List of participants in Focus Group Discussions

	LOCATION OF FGD: BUNGOMA KIMILILI SUB-COUNTY			DATE FGD HELD: 1ST NOVEMBER 2018	
	NAME	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY/ WARD**	**AGE**
1	George Simiyu	MOALFIC - Maeni Ward	722444932	Kimilili - Maeni Ward	52
2	David Masinde	Farmer	712040554	Kibingei	58
3	Silas Kusimba	Farmer	718463060	Kimilili - Kibingei Ward	51
4	Beatrice Kundu	Farmer	714077173	Kimilili	58
5	Philipine Nyongesa	Farmer	711859682	Kimilili	48
6	Justine Nyongesa	Farmer	718699201	Kimilili	26
7	Everline N. Chemwami	Farmer	714034752	Kimilili	41
8	Geoffrey S. Nalwa	Farmer	714816592	Kimilili	40
9	Claudia Misiko	Farmer	791718108	Kimilili	27
10	Janet N Wamalwa	Farmer	746244355	Kimilili	26
11	Kamau Kelvin	KMT	727341720		
12	Gideon Muyokho	Farmer	717919997	Kimilili	22
13	Cyprian Wafula	Ministry of Agriculture Bungoma County	723709793	Bungoma County	39
14	Dorice Walela	Ministry of Agriculture Bungoma County	727317615	Kimilili	58
15	Florence Wakhungu	Ministry of Agriculture Bungoma County	725026492	Kimilili - Kibingei Ward	55
16	Hellen WeKES a	Farmer	713767073	Kimilili - Kibingei Ward	39
17	Phanice Wangara	Agrics Co. Ltd	702180635	Kimilili - Kibingei Ward	40
18	Lilian Barasa	Ministry of Agriculture Bungoma County	729436020	Kimilili - Kibingei Ward	28
19	Violet Kihago	Farmer	726158504	Kimilili - Kibingei Ward	29

	LOCATION OF FGD: BUNGOMA county (TOWNSHIP/ BUNGOMA SOUTH)			DATE FGD HELD: 31 OCTOBER 2018	
	NAME	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY/ WARD**	**AGE**
1	Moses Wanjala Furaha	Farmer	728805837	Webuye East	68
2	David K. Masind	Farmer	720827610	Webuye East	45
3	Laban Simiyu	Farmer	799766409	Webuye East Mihu Ward	37
4	Timothy S. Marabi	Farmer	710825282	Bungoma South	63
5	Jane Nasaka	Distributor	721865511	Bungoma	53
6	Nyongesa Nathans	Farmer	721931934	Bungoma	47
7	Elizabeth Amutsi	Distributor	717492604	Kanduyi	29
8	Doris Malaba	Farmer	716116189	Bungoma South	30
9	Mary Toya	MOALFIC (MOA)	722550956	Bungoma Kanduyi	55
10	Anicetus Wafula	Farmer	711293207	Bungoma County	74
11	Cyprian Wafula	MOALFIC (MOA)	723709793	Bungoma County	39
12	Michael Kamau	KMT	720936536	KMT	
13	Kamau Kelvin	KMT	727341730	KMT	
14	Kelvin Ouma	Homa Lime	717197088	Koru	
15	Felix Wamukota	MOALFIC (MOA)	725941248	Kanduyi	58
16	David Khaeyiza	MALFIC	722579344	Kanduyi	58
17	Caroline Wameme	Farmer	700911826	Kanduyi	32
18	Tom Situma	MOALFIC (MOA)	724816552	Kanduyi	55
19	Cyprian Wafula	KALRO	7065763331	Musikoma	25
20	Robert Rapando	Silikon Consulting Group	724101181	Bungoma	38

LOCATION OF FGD: KAKAMEGA - LURAMBI SUB-COUNTY				DATE FGD HELD: 30 OCTOBER 2018	
	NAME OF THE PARTICIPANT	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY/WARD**	**AGE**
1	Shem M. Luonga	Malaha Agro Business	724338623	Mavakholo	
2	Gilly Okwayo	Shibuli (Farmer)	712331950	Kakamega – Lurambi	
3	Millicent Keya	Shibuli (Farmer)	702853802	Kakamega – Lurambi	
4	Hellen Andala	Shibuli (Farmer)	714689351	Kakamega – Lurambi	
5	Caroline A. Kundu	KALRO - Kakamega	708693185	Kakamega – Central	
6	Sunford Yeswa	Shibuli (Farmer)	702673765	Kakamega – Lurambi	
7	Roselyne Aliaro	Shibuli (Farmer)	721668546	Kakamega – Lurambi	
8	Robert Rapendo	Silikon Consulting Group	724101181	Nairobi	
9	Pamela Waudo	M.O.A.L.F	710178132	Lurambi	
10	Dennis Nyakundi	Farm Concern International	719322326	Kisumu	
11	Celestine Okumu	Kakamega Farmers Agency	717373389	Kakamega	
12	Remgius Ochebo	KALRO - Kakamega	712638201	Kakamega	
13	Florence Wesonga	M.O. A.L.F - Malava	720578304	Malava	
14	Chrispinus Musungu	Innovations for Poverty Action - Busia	720812436	Busia	
14	Anne Owino	MOA - Lurambi	725891750	Lurambi	
15	Habakkuk Khaamala	County Agrodealer Association	720833431	Lurambi	

	LOCATION OF FGD: KAKAMEGA county - BUTERE/ IBOKOLO/MARAMA CENTRAL WARD			DATE FGD HELD: 31 OCTOBER 2018	
	NAME	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY/WARD**	**AGE**
1	Patrick Okinda Chitechi	Marama Central Grains Co-op Ltd	723941190	Marama Central Ward	53
2	John Silvia Kundu	Farmer	727891943	Butere/Marama Central	61
3	Esther Anyonje Okute	Farmer	715260722	Butere/Marama Central	52
4	Malaki Anyangu	Farmer	710467841	Butere/Marama Central	50
5	Margaret Nyorotso Kulundu	Farmer	701671251	Butere/Marama Central	-
6	Herbert Luso	Farmer	720716074	Butere/Marama Central	44
7	Amina Suleiman	Stockist	725965129	Butere/Marama Central	36
8	Abdallah Shiundu	Farmer	711104836	Butere/Marama Central	37
9	Zablon Indakua	Farmer	790885111	Butere/Marama Central	47
10	Andrew Opwolo	MOA (Crops Officer)	712037071	Butere Subcounty	51
11	Juma Makokha	Farmer	723135539	Butere/Marama Central	57
12	Roseline Mjebeni	Farmer	704591421	Butere Central	42
13	Christine Nekolo	Farmer	718372561	Butere Central	40
14	Gilbert Osore	Farmer	724141511	Butere Central	42
15	Josephat Inzobezi	Farmer	726782515	Marama West	-

	LOCATION OF FGD: TRANS NZOIA county - KITALE			DATE FGD HELD: 1st NOVEMBER 2018	
	NAME	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY**	**AGE**
1	Chrispine Owino	KEPHIS	720479991	SABOTI	35
2	Joseph Chanzu	KEPHIS	722466031	SABOTI	42
3	Jabil Lodeki	KEPHIS	721283578	SABOTI	45
4	Timothy Wafula	Equity Foundations	764339019	Rift Valley	35
5	John Mukoloi	Farmer	721558633	Kiminini	67
6	Edward Yokela	Farmer	713198686	Kiminini	58
7	Humphrey Kisanya	K.F.A Main	725015012	Kitale	54
8	Philip Maiyo	K.F.A Kitale	720200503	Kitale	32
9	Robert Watila	Farmer - Meru	722650820	Hospital Ward Kitale	30
10	Celcilia Wafula	Farmer	710289163	Namanjalala	58
11	Roda Munubi	Farmer	706792592	Namanjalala	78
12	Mary Sahani	Farmer	726017359	Namanjalala	42
13	Michael Ochieng	Farmer	720721157	Saboti/Matisi	41
14	Kenneth Kagai	County Director of Agriculture	722433699	Trans Nzoi County	50
15	Paul Busienei	Extension & Research Agriculture	727308311	Trans Nzoi County	58

	LOCATION OF FGD: UASIN GISHU county - ELDORET			DATE FGD HELD: 2ND NOVEMBER 2018	
	NAME	**INSTITUTION REPRESENTED**	**TELEPHONE NUMBER**	**SUB-COUNTY/ WARD**	**AGE**
1	Richard k. Tuwei	Farmer	728364512	KES ses	34
2	Cosmas Keter	Farmer	722505241	KES ses	42
3	Nicholas Chesumbai	Farmer - Sirikwa Dairies	723333133	Turbo	44
4	Joseph Chelilim	Farmer	713478234	Soy	44
5	Petro Rotich	Director Sirikwa Dairies	721329927	Turbo	46
6	Sally Kosgei	Farmer	716937960	Turbo	40
7	Agnes Sang	Farmer	720748486	Kaptakat	59
8	John Kemboi	Equity Group Foundation	763939809	Kapseret – Simat	38
9	Susan Kemboi	Farmer	712047392	Kaptagat	40
10	Christine Mutheu	KMT	710617911	Nairobi	27
11	Ismael Asowa	County Department of Agriculture	722684811	Eldoret	50
12	Kelvin Kamau	KMT	727341730	Nairobi	
13	Robina Abuya	KMT		Nairobi	
14	Nickson Koech	Moiben Connection	740840618	Kimumu	24
15	Paul Mutiso	Moiben Connection	704116993	Kimumu	25
16	Rose Menchich	Plateau Location	721560653	Kaptagatwar	59
17	Maryline Serem	Plateau Location	713065374	Kaptagatwar	27
18	Abraham Bett	Farmer	710221881	Turbo/Kamagut	60
19	Larson Chebii	Crop Nutrition Lab	725413248	North Rift Region	28
20	Michael Kamau	KMT	720936536		
21	Kevin Ouma	Homa Lime Co Ltd	717197088		
22	Caroline Kute	KALRO - Kitale	722356142	North Rift Region	60
23	Philemon Nyolei	Farmer - Talatany Cooperative	722441081	Turbo	41

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INCLUDE A LIST OF APPENDICES

- DATA COLLECTION INSTRUMENTS
- CONSENT FORMS (IF ANY)
- LIST OF CLUSTERS (IF NOT CAPTURED IN THE 'FINDINGS' SECTION)

INCLUDE A LIST OF CONTRIBUTORS TO THIS RESEARCH WORK

MAP SHOWING CLUSTERS (IF AVAILABLE)

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