

EGERTON



UNIVERSITY

**TEGEMEO INSTITUTE OF AGRICULTURAL
POLICY AND DEVELOPMENT**

Tegemeo RCT Conference 2017: Proceedings

**Enhancing Smallholder Productivity in Kenya: Evidence from a Randomized
Controlled Trial of New Seed Varieties**

HELD AT SAROVA PANAFRIC HOTEL, NAIROBI ON 8TH FEBRUARY 2017

February 2017

TABLE OF CONTENTS

Foreword.....	iv
Acknowledgements.....	v
List of Acronyms and Abbreviations.....	vi
Opening and Introduction.....	1
Welcoming Remarks by Dr Mary Mathenge - <i>Director, Tegemeo Institute</i>	1
Introductory Remarks by Prof. Alfred Kibor - Acting Deputy Vice Chancellor, Research and Extension, Egerton University.....	1
Conference Overview and the Objectives by Dr Mary Mathenge - <i>Director, Tegemeo Institute</i>	4
Session One: Maize Production Environments and Practices in Kenya.....	6
Diversity of Production Environments and Practices.....	6
Productivity Profile under Different Technology Bundles.....	7
Plenary Discussion.....	7
Session Two: Technology Adoption Among Smallholder Farmers in Kenya: Key Highlights from RCT of Maize Hybrids.....	10
Filling a niche? Findings from an impact evaluation of maize hybrids in mid-altitude zones.....	10
Views from the field by Mr Joseph Opiyo Sakwa.....	11
Plenary Discussion.....	11
Session Three: Panel Discussion: Agricultural Innovations and Poverty Reduction.....	13
Panel Discussion.....	14
Plenary Discussion.....	17
Session Four: Constraints to Maize Productivity for Smallholder Farmers: Further Lessons.....	19
How do small-scale farmers learn about new agricultural innovations?.....	19
Soil quality information and fertiliser use: Does knowledge influence choice?.....	20
The returns to fertilisers: The impact of soil fertility and input quality.....	21
Plenary Discussion.....	21
Session Five: Round Table Discussion: Improving Precision and Efficiency of Data in the Agricultural Sector.....	25
Efficiency of Computer Assisted Personal Interviewing (CAPI) by Dr Mercy Kamau, <i>Tegemeo Institute</i>	25
Precision through Field Measurement by Dr Tim Njagi, <i>Tegemeo Institute</i>	26

Network Measurement and Analysis by Asst. Prof. Emilia Tjernstrom, <i>University of Wisconsin, USA</i>	26
Phone and Field Survey: A Comparison by Mr Samuel Bird, <i>University of California, USA</i>	26
Wrap-up and Conference Summary	27
Closing Remarks	29
Annex 1: Conference Programme	31
Annex 2: List of Participants	35

Foreword

The core mandate of Tegemeo Institute is to conduct policy research and disseminate findings in an objective manner. In so doing, the Institute responds to contemporary agriculture-related policy issues as well as providing information to policy makers that can help in the formulation of appropriate policy strategies in the agricultural and rural development sectors of Kenya. Through its work, the Institute has developed into one of the leading centres for agricultural policy research and analysis and has become a reservoir of knowledge and information on rural livelihoods. The Institute undertakes empirical research and analysis on topical agricultural policy issues and promotes policy dialogue and advocacy via the dissemination of various research findings to a large number of stakeholders including government, the private sector, development agencies, and civil society, among others.

In line with the mandate, the Tegemeo Institute and the University of California (Davis) undertook a three - year Randomized Controlled Trial study to track and assess adoption of seed technologies for maize production in mid-altitude zones, while documenting the productivity gains at the household level. The main objective of the study was to identify critical bottlenecks to the adoption of improved seed in the mid-altitude and transitional lands to gain insights on pathways through which potential of these zones can be unlocked through agricultural innovations.

The study was conducted with the support of the ACUMEN fund, USAID (BASIS Innovation Lab) and Bill and Melinda Gates Foundation (BMGF) through Agricultural Technology Adoption Initiative (ATAI). It (research) was carried out on the implications of various challenges affecting the agriculture sector – including low technology adoption in the mid-altitude zones

The Institute organised a one-day conference in Nairobi to disseminate preliminary research findings on the theme '*Enhancing Smallholder Productivity in Kenya: Evidence from a Randomized Controlled Trial of New Seed Varieties*'. The results shared during the conference aimed at providing alternatives policy interventions to improve adoption of yield-enhancing technologies for smallholder farmers based on the RCT research. It also provided a platform for the exchange of ideas between experts on the issues discussed. The conference drew participants from the public sector, specifically from the Ministry of Agriculture, Livestock and Fisheries; semi-autonomous government agencies in the agricultural sector; County governments; private sector organisations; civil society organisations; development agencies; universities and research institutes; farmer representatives among others. Presentations were mainly from the RCT study.

Acknowledgements

We are grateful to the ACUMEN Fund, USAID (BASIS), and BMGF (ATAI) for the financial support in undertaking the research work for the conference. We express our gratitude to the State Department of Agriculture Livestock and Fisheries and other ministry officials for their participation and support. We highly appreciate the management of Egerton University for their continued support.

We thank all participants from other government ministries, County governments, private sectors and civil society institutions for their participation and contribution during the conference. We extend our sincere gratitude to farmers, public officials and other stakeholders who provided us with information that was analysed and presented in this conference. Efforts by all those who made the conference a success are also acknowledged. In particular, we recognise the work of the organising committees, the researchers from Tegemeo/UC Davis and invited speakers for their high quality and informative presentations, and colleagues at Tegemeo for their support.

List of Acronyms and Abbreviations

AERC	African Economic Research Consortium
AEZs	Agro-Ecological Zones
AFSTA	African Seed Trade Association
AfDB	African Development Bank
AGMARK	Agricultural Market Development Trust
AGRA	Alliance for a Green Revolution in Africa
ARM	Athi-River Mining
ASAL	Arid and Semi-Arid Lands
ATAI	Agricultural Technology Adoption Initiative
BMGF	Bill and Melinda Gates Foundation
CAPI	Computer Assisted Personal Interviewing
CDA	County Director of Agriculture
CEC	Cation Exchange Capacity
CeC	County Executive Committee
CEO	Chief Executive Officer
CGA	Cereal Growers Association
CIMMYT	International Maize and Wheat Improvement Center
COMESA	Common Market for Eastern and Southern Africa
DCS	Director Crops Systems
DNA	Deoxyribonucleic Acid
DTMA	Drought Tolerant Maize for Africa
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
ICED	International Centre for Evaluation and Development
IHE	Institute for Water Education
IITA	International Institute of Tropical Agriculture
KALRO	Kenya Agriculture and Livestock Research Organization
KAVES	Kenya Agriculture Value Chain Enterprises
KENAFF	Kenya National Farmers' Federation
KEPHIS	Kenya Plant Health Inspectorate Service
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KSC	Kenya Seed Company
MoALF	Ministry of Agriculture, Livestock and Fisheries
NCPB	National Cereal and Produce Board
NPK	Nitrogen Phosphorous Potassium
ODK	Open Data Kit
pH	Potential of Hydrogen
PPM	Parts Per Million

RCT	Randomized Controlled Trial
STAK	Seed Trade Association of Kenya
UC Davis	University of California, Davis
UNESCO	United Nations Educational Scientific and Cultural Organization
UON	University of Nairobi
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollar
WSC	Western Seed Company

Opening and Introduction

The meeting started with the moderator, Dr Dennis Otieno welcoming all the participants and thanking them for finding time to attend the event. A word of prayer from Ms Violet Nyando followed the welcome by the moderator, and after that, the moderator led the participants through a brief session of self-introduction. He then invited Dr Mary Mathenge, the Director of Tegemeo Institute to give her welcoming remarks.

Welcoming Remarks by Dr Mary Mathenge - Director, Tegemeo Institute

The Director welcomed all participants and thanked them for finding time to be in the conference. She said she was optimistic that with stakeholders' engagement, the forum would be prolific towards eliciting discussion on ways for enhancing agricultural productivity. She further acknowledged the Principal Secretary (PS) from the Ministry of Agriculture, Livestock and Fisheries (MoALF) and the Vice Chancellor, Egerton University who was among guests but unable to attend the conference. She went ahead to invite their corresponding representatives namely; Ms Mary Karanja, Head traditional high-value crops programme and Prof. Alfred Kibor, Acting Deputy Vice Chancellor, Research and Extension. To begin with, Prof. Alfred Kibor was called upon to make his introductory remarks. After that, Ms Karanja gave an opening speech on behalf of the PS - MoALF.

Introductory Remarks by Prof. Alfred Kibor - Acting Deputy Vice Chancellor, Research and Extension, Egerton University

Prof. Kibor began by delivering greetings from the Vice Chancellor, Egerton University, Prof. Rose Munya who was unable to attend the forum because of a women conference that was taking place at the University where she was the main host. He went ahead to emphasise that agriculture remains the backbone of the Kenyan economy and key to food security and poverty reduction. He, however, noted that the sector is facing many challenges which include: low productivity, declining agricultural land, weak input and output markets, under-investment in the industry, climate change among others. He added that productivity is highly linked to food security status. Hence, enhancing productivity is recognised as vital.

He also noted that the theme of the conference "*Enhancing Smallholder Productivity on Kenya: Evidence from a Randomized Controlled Trial of New Seed Varieties*" was relevant and timely as Kenya and other countries struggle with food security and poverty. He commended Tegemeo Institute and Feed the Future Assets and Market Access from University of California, Davis (UC Davis) for the good work and was happy that the participants would have an opportunity to listen to the research findings. He encouraged the participants from the agricultural sector and especially those that are associated with small-scale farmers to pay particular attention to the presentations.

Prof. Kibor said that Egerton University is one of the oldest institutions of higher learning in Kenya and a leader in Agriculture training and he is very proud of the impact the alumni of Egerton University are making in the sector. Also, he said that Egerton has been on the forefront of developing innovations/technologies and projects in the agricultural sector in partnership with various institutions. These include: (i) public sector - Ministry of Agriculture, Livestock and Fisheries (MoALF), (ii) Donor/development partners e.g. World Bank, Mercy Corps, USAID, Ford Foundation (iii) Regional curriculum initiatives e.g. Joint Programmes with UNESCO-IHE, AERC.

Egerton University has also been involved in extension and outreach e.g. seeds of gold magazine, which is a mass extension drive on livestock and crop production. The University has also tailored support for local communities in production and multiplication of quality seed varieties. Furthermore, Egerton University has been rehabilitating water catchment areas and is involved in water conservation efforts. On the other hand, the University has established new programmes to contribute towards transformations in the agricultural sector. On policy research, he noted that Tegemeo Institute of Egerton University is an agricultural policy think tank in Kenya and the conference will attest to that.

In his conclusion, he thanked the sponsors, the researchers and welcomed the representative of the Principal Secretary State Department of Agriculture, MoALF to give her remarks.

Introductory Remarks by Ms Mary Karanja - Head, Traditional High-Value Crops programme, MoALF

Ms Karanja was representing the director crop resources directorate in the State department of agriculture, MoALF who was to represent the Principal Secretary, Agriculture.

She then proceeded to read the speech by the Principal Secretary for the State Department of Agriculture.

Principal Secretary State Department of Agriculture - Dr Richard Leresian Lesiyampe - Speech as read by Ms Mary Karanja - The coordinator of the traditional high-value crops programme formerly orphan crops

“Adoption of improved seed varieties is recognised as a key *driver* in improving productivity and addressing food security. Let me take this opportunity to thank the organisers and welcome the private sector players, civil society, practitioners in the seed industry, stakeholders and researchers of agricultural development among others to this important event.

Worldwide, informal seed systems provide between 80 and 90 percent of seed stocks. Kenyan farmers depend on both the formal and informal seed systems, with the latter accounting for over 80 percent of total seed used in the country and even a much higher percentage in arid and semi-

arid lands (ASALs). Increasing agricultural productivity of small and medium scale farmers requires a well-functioning seed system.

The national seed requirement for maize alone is about 35,000 metric tonnes per annum which as a country we can achieve through local production and imports. There are more than 250 maize hybrid varieties in Kenya. However, the expected gain from adoption of these varieties has not been realised due to low inputs use and poor agronomic practices.

Maize is the key staple food for the Kenyan population providing about 65 percent of staple calorie intake. The majority of both rural and urban population consider maize and maize meal as essential items in their household food basket. Kenya produces enough maize to feed the population based on estimated per capita consumption, but when other uses like seed, feed and manufacturing are considered, the supply falls slightly short of demand. This shortfall is usually provided through imports from both the East African Community and COMESA. The majority of the smallholder farmers who produce about 64 percent of maize in Kenya are resource poor. In times of severe deficit, the country waives import duty to allow maize. As a way of improving farmer's access to seed companies package it in units of 2kg that are demanded and afforded by the farmers.

The government will continue to review and enforce regulation on seed packaging and strengthen measures to promote the use of certified seed. Where possible, all seed companies should adapt the use of transparent packaging or use packaging material in which a portion or entire contents are visible to the customer

Further research is recommended to develop acceptable and less grain borer weevil susceptible maize crop varieties; test efficacy and efficiency of some commonly used storage pesticides; test and identify the best cereal: legumes intercrop spatial arrangement for up-scaling to maximise on land use.

The government will continue to review and develop policies together with the stakeholders so that the seed industry and other subsectors of agriculture can grow. We must all endeavour to transform smallholder agriculture into a viable business for the farmers through commercialization and linkages with players in the sector.

In conclusion, it is my conviction that through continued improvement through research and the dissemination of these findings to stakeholders, the seed industry in Kenya, East African Community region and Africa at large will enhance farmers' access to good quality seed and improve productivity.

I take this opportunity to appreciate the effort of Tegemeo Institute in agricultural research and development and wish you all the best”.

In her remarks, Ms Karanja thanked Tegemeo Institute for their good work in agricultural research and policy formulation. She urged the institute to do more studies in the ASALs and congratulated the WSC for providing the Striga resistant variety to the western region and farmers for their determination in feeding the country.

After Ms Karanja's remarks, the director Tegemeo Institute thanked her for the informative words to the audience and the advice to do more research in the ASALs. She also thanked Prof. Kibor for enlightening the participants about Egerton University's achievements in the areas of training and conservation of the environment.

She then acknowledged the presence of Prof. Michael Carter, the study's principal investigator and the director of BASIS Research Program, UC Davis and Mr Antony Kioko, the CEO, Cereal Grower Association (CGA). She then proceeded to give the conference overview and objectives.

Conference Overview and the Objectives by Dr Mary Mathenge - *Director, Tegemeo Institute*

In her introduction, Dr Mathenge said that there was low use of hybrid maize seed in the mid-altitude and wondered whether it was due to unmet demand, supply side constraints or low returns. She added that in an exploratory survey in 2012, the Institute visited the western region and specifically Western Seed Company (WSC) and Kenya Seed Company (KSC) and received some helpful information. The exploratory tour revealed that certain seed varieties were fine-tuned for the mid-altitude and transitional zones by the WSC and that lead to focusing the RCT on the Western Seed varieties.

The objectives of this study were to: track adoption behaviour of smallholder farmers, identify constraints to adoption (use of complementarity inputs, credit constraints and soil quality), productivity gains due to adoption, performance in different mid-altitude zones and effects on household welfare. The study sites included: Homabay, Kakamega Siaya, Migori and Nakuru counties in the western region and Kiambu, Kirinyaga, Meru, Embu and Murang'a in the central region. The sample size for the study was 1200 and 600 households in western and central region respectively. The RCT project began in 2012 and ran through to 2016. Data was collected through personal interviews at the baseline in 2013, midline in 2015 and endline in 2016 and phone surveys in between the three waves. The key treatment /components in the study were: seed information, soil test (soil quality information), fertiliser (blended) and seed access/distribution.

The project partners consisted of:

- (i) the research team (Tegemeo Institute, University of California, Davis);
- (ii) service and input providers (Western Seed Company, MEA limited and CropNuts limited); and

- (iii) donors (ACUMEN fund, USAID (BASIS Innovation Lab) and Bill and Melinda Gates Foundation (BMGF) through Agricultural Technology Adoption Initiative (ATAI)).

The conference objectives were to (i) present preliminary results research findings to stakeholders to elicit debate and feedback from the participants and, (ii) to provide a forum for open discussions. Additionally, the conference aimed at laying some background for a wider discussion on policy options/interventions to improve adoption of technology maize productivity for food security and household welfare.

She concluded by appreciating the support from various organisation and institutions. These included: research partners, UC Davis, Acumen Fund, Western Seed Company, USAID (BASIS), BMGF (ATAI), farmers who provided information/data, Government of Kenya - MoALF, County Governments, Kenya Seed Company, Other Universities/ Research organizations, private sector - MEA Limited, CropNuts, etc. and civil society especially farmer organizations and other actors.

Session One: Maize Production Environments and Practices in Kenya

This session was chaired by Mr Antony Kioko, the Chief Executive Officer (CEO), CGA. He began by clarifying that he was also a board member of Seed Trade Association of Kenya (STAK). He informed the audience that CGA is a national membership organisation that unites both large and small-scale cereal farmers and has about 80 associate members who include input suppliers among other institutions. Mr Kioko noted that the theme of the conference was of profound interest to him individually and to CGA because at CGA they represent a segment of actors who would ordinarily be at the 'bottom of the hill' i.e. faced with enormous challenges with no easy solutions. In this respect, he was of the opinion that the solution to challenges facing cereal farmers' productivity must involve all actors. Looking at the whole value chain, he added, there is need to address production, productivity and marketing issues. As such, improving cereal productivity would avoid burdening consumers with demands for higher cereal floor prices. He said that he looked forward to an engaging conversation and encouraged participants to contribute to the discussion. He then invited Dr Mathenge to give her presentation.

Diversity of Production Environments and Practices

Presentation by Dr Mary Mathenge, Tegemeo Institute

This presentation gave a background on the practices and trends of maize production in Kenya with more emphasis on seed and fertiliser technology adoption across different environments. It also explained the rationale of the project.

Research shows that about 80 percent of farmers in Kenya are smallholders producing about 75 percent of agricultural production under a myriad of challenges. These include; poor and degraded soils, increasing land constraints in the context of the uneconomical land subdivision, the high cost of inputs, poor access to agricultural information, low returns to input use, low access to financial services and low agricultural productivity (about 1.6 MT/Ha).

In the context of agricultural structural transformation, productivity is linked to food security and poverty reduction. It also stimulates the development of the non-farm sector through the creation of linkages. However, the agriculture sector in Kenya and much of SSA is faced with low/stagnating productivity despite the existence of an enormous potential.

The major impediment is the low use of productivity enhancing inputs due to unavailability of liquid capital to purchase these inputs together with the risk-averse nature of small-scale farmers against low or non-existent credit and insurance markets for crops and livestock. Most affected are food crops with maize being the most important food crop which remains an excellent entry point for food security and income generation at the household level. Maize occupies 40 percent of crop area in Kenya and provides 65 percent staple calories to the country. Although Kenya has a relatively high adoption rate for improved seed maize, the gains in productivity growth are yet to be realised. Statistics from Tegemeo panel data between 2000 and 2010 show that despite a

general increase in adoption of improved maize seed there are disparities across regions. High potential maize zones and the Highlands showed high rates of improved seed and fertiliser technology adoption unlike the western lowlands and transitional zones that reported low adoption rates of both hybrid seed and fertiliser. When maize seed use and fertiliser use are bundled, the consistency in use again shows different patterns with no consistent users in western lowlands while about 40 percent of farmers consistently used both improved seed and fertiliser across the four survey waves.

Given the preceding, the RCT study was designed to establish the reasons behind the gap in seed and fertiliser use and productivity gains. The project ran from 2012 to 2016. Data collection was in three waves, a baseline in 2013, midline conducted in 2015 and an end-line in 2016. There were phone surveys in between the household surveys.

Productivity Profile under Different Technology Bundles

Presentation by Dr Timothy Njagi, *Tegemeo Institute*

Dr Njagi's presentation was based on an analysis in progress looking at how farmers take up farming technology but introducing the concept technology bundles. The bundles are a classification of the households on their production technology orientation i.e. those using local seed only, local seed with fertiliser, improved seed with fertiliser or use of improved seed only. The presenter observed that most studies look at technology adoption in isolation while in practice farmers adopt technology in bundles consisting of multiple components. It is also important to consider other household welfare indicators in analysing the impact of adoption.

The main findings from the study were that use of improved seed and fertiliser can increase productivity and households' food security. The highest gains were observed in the households that used both improved seed and fertiliser. This finding highlights the importance of complementarity in technology adoption although the intensity of fertiliser use is still low. Also, constraints in knowledge, finance and gender exist in the adoption thereby underlining the importance addressing financial difficulties among the farmers while providing tailor-made extension services to enhance the learning process necessary for technology adoption.

Plenary Discussion

The chair thanked the presenters for illuminating the role of technology adoption in food security and welfare aspects. He proceeded to invite participants for reactions on the two presentations.

One participant was concerned that the 31-year-old KS 614 maize variety from Kenya seed was in the list of farmers preferred varieties considering that varieties were developed for specific climates and environments which change over time. He noted that the presentation also showed many varieties had been released so far, but farmers still prefer old or local varieties. He, therefore, wondered whether there was a problem with the new varieties. He also requested for a comment on variety turn over in our seed systems.

Another participant wanted to know whether there was a reason why farmers prefer specific varieties considering the many varieties that have been released in the past. The participant said that poverty exists in the high potential zones because climate variability affects farmers in these zones as well. She, however, noted that adoption of seed technology was low in the lower midland areas and wanted to know if there was a specific reason for this particular trend.

Dr Mathenge responded by first appreciating the presence of other experts in the gathering who could fill in on the areas where they had expertise. She then illustrated farmers' insistence on specific varieties by citing an instance in Kisii County in one of the Institute's outreach events where farmers requested that the right traits in the newer varieties be added to the KS 614 instead of removing it from the market. She, however, observed that the uptake of other varieties was encouraging as seen in the RCT study which was focusing on other well-performing seed varieties like WS 505.

Another participant wondered whether the quality of the varieties was questionable given that there are over 250 hybrid varieties released but productivity is declining. He also asked whether the declining maize yield was due to substitution on maize by other crops like millet and sorghum.

Another participant expressed concern over the fact that despite many varieties already released, breeders/scientists were still releasing more varieties. She wondered why maize is still performing poorly, considering that it is planted alongside other crops which tend to perform better.

A participant informed the conference that they had recently commissioned a study on agro-dealer access to certified seeds in eight counties. Among the findings, about 51 percent of the 438 agro-dealers said they could not meet farmers' demand for certified seeds and fertiliser. He thus wondered why adoption was still low despite high demand for the bundled technology and whether it meant that farmers are being denied the inputs.

Dr Njagi observed that newer varieties are microclimate specific compared to earlier varieties that were more general in coverage which could lead to poor performance if the new varieties are not planted in the specific agro-ecological zones. On the findings where agro-dealers cannot meet farmers planting inputs demand, he suggested it would be good to look into the results of the initiative by KEPHIS and other stakeholders to track seed bought by farmers because this would show whether farmers are receiving the right seeds in the right agro-ecological regions.

Another participant argued that presence of low yields despite when there are over 250 varieties released to the market by the breeder in Kenya is a manifestation of disconnection in the seed supply chain as the commodity (new generation seed) moves from the breeders to the farmers through the agro-dealers.

Dr Mathenge concurred with the concern expressed on low yields despite many varieties being released. She noted that the yield gap was beyond any measurement bias because the 1.6 tonnes

reported in the study was way below the potential of 6 metric tonnes. She encouraged the other experts especially breeders to comment on the issues raised concerning the seeds.

Another participant wondered whether there could be measurement challenges regarding levels of hybrid seed adoption. He noted that research has shown that farmers overestimate acreage which underestimates yield. As an example, in one study, farmer recall showed 44 percent adoption rate while a DNA analysis based on the same population showed that over 80 percent land was planted with improved seed. Given the narrative that hybrid seed adoption seems high yet productivity is low, he inquired whether the researchers used alternative methods of measurement. He said that according to other sources, the quantity of improved seed is increasing and a lot of new generation seed is being taken up. To illustrate possible explanations he gave an example of when people buy seed for their relatives in the rural areas. If seed information is asked later from these farmers, they (farmers) may not remember the variety they planted since it was just supplied to them and there is a possibility that it is new to them. As a result, they (farmers) may end up reporting what the neighbours planted. Finally, he wondered how the seed breeders like WSC and KS are making money or where they are selling their seeds if the low adoption rates are correct.

Dr Mathenge confirmed that accuracy is an issue with farmer reported data. Ideally, yield should be based on crop cuts while adoption rates should be based on DNA analysis. She expressed hope that the next study in this area should be built on these methods of measurement. Additionally, seed quality should be traced from breeder to farmer because it is possible that farmers are getting adulterated seed even before planting such that the reported yields are not of the breeder released varieties.

The chair requested Mr Soi of Kenya Seed to respond to the quality check program and how effective it has been in controlling counterfeit seeds. Mr Soi began by thanking the presenters. He further noted that productivity decline could be due to several factors like low fertiliser use as shown in the presentations. He said that most farmers have challenges accessing certified seeds and end up planting the local varieties or unknowingly counterfeit seed. On seed quality, he said there had been an increase in counterfeit seed especially KS614. This was because farmers believed that the variety is very resilient. Other varieties were doing well, but adoption is also a function of farmer/consumer preference. The KS614 variety was developed 35 years ago and was promoted through value proposition to farmers on specific salient features. It has been improved severally from 614A to the current 614D.

On countering counterfeit seed, Mr Soi said Kenya Seed has come up with a system working with other stakeholders including the MoALF and KEPHIS where farmers get a code with the seed package. They send the code via SMS to confirm if the seed is genuine. For 2017 Kenya seed reported that farmers were receiving the genuine seed.

Session Two: Technology Adoption Among Smallholder Farmers in Kenya: Key Highlights from RCT of Maize Hybrids

The session was chaired by Dr Paswel Marenya, a socio-economist at CIMMYT. He began by emphasising the importance of developing a vibrant seed system for Africa towards improved crop productivity. He further expressed his excitement to be part of the participants at the conference and the chair of this session. He noted that issues in this session and the overall conference coincide well with the activities at the CIMMYT.

He continued to say that taking technology to farmers is very critical given the hard work the scientists are doing towards this. Therefore, the lessons learnt from the mid-altitude zones will inform the overriding philosophies of getting new generation seeds that are drought tolerant and climate resilient and subsequent commercialization the seed technologies. He pointed out that at CIMMYT, the scientists are working very hard to develop relevant seed technologies. Among the cutting-edge efforts towards vibrant seed systems, they are contributing that well aligned with the RCT conference includes the drought tolerant, drought tolerant maize seed systems for African seed scaling and stress tolerant maize for Africa.

In this session, one paper was presented on the impact evaluation of maize hybrids in mid-altitude zones by Prof. Michael Carter from UC Davis University. Mr Joseph Opiyo Sakwa - a farmer representative from Homa Bay County, was also called upon to give his remarks on the experiences of the western seed varieties and participating in the RCT experiment. The chair welcomed Prof. Michael Carter to share the findings from the RCT study.

Filling a niche? Findings from an impact evaluation of maize hybrids in mid-altitude zones

Presentation by Prof. Michael Carter, Director BASIS Research Program/University of California

This presentation gave an overview of the impact of niche seed variety (in this case mid-altitude zones) on various agricultural outcomes and if a small/private local seed company can succeed in such a market segment. Kenya's Western Seed Company (WSC) built its business on maize varieties selected to perform well in mid-altitude regions. This model of developing seed fine-tuned to niche agro-ecological environments may help to increase smallholder agricultural productivity. In a randomised controlled trial, they evaluated the impacts of WSC's commercial expansion in both mid- and higher-altitude regions of Kenya.

The main conclusions show that in mid-altitude regions, the option to purchase WSC maize seed unambiguously increased productivity, but most significantly among better-resourced farmers who had historically used hybrid seed. The farmers who had opportunities to purchase hybrid seed developed for their agro-ecological niche increased their per-acre productivity by 41 percent compared to the control group.

Also, the treated farmers who had historically used hybrid seed increased maize productivity by 85 percent, compared to 30 percent among treated farmers who did not regularly use hybrid seed. Furthermore, farmers who historically used hybrids appear to be better resourced than those who did not, suggesting that financial constraints limit the impacts of even an appropriate seed technology in a poor population.

This study provides strong evidence that a local seed company can increase smallholder productivity by developing varieties fine-tuned to niche agro-ecological environments that are often overlooked by larger seed companies.

Views from the field by Mr Joseph Opiyo Sakwa

Prof. Carter invited a farmer from Homa Bay County to give his account of what transpired from the RCT project and the emerging lessons from a farmer's perspective. Mr Opiyo began by thanking the professor on behalf of all partners in the RCT project which involved various activities from 2013 and 2016. Mr Opiyo commended the project for the invaluable lessons gained by farmers through different interventions such as the introduction of new seed varieties, blended fertiliser dissemination, soil testing activities and demonstration plots.

According to the farmer, these interventions have yielded positive results in the area in various ways. First, the learning environment has enabled households to adopt high yielding maize varieties thereby increasing the crop yield. Second, the information gained through different channels including the demo plots has facilitated in improving crop management which in essence has been instrumental for the local farmers to catch on the modern farming technologies. Lastly, the setup of the study helped to catalyse the learning speed among the farmer.

The farmer was excited that the project managed to introduce farming technologies that were previously not readily used by the local farmers.

Plenary Discussion

The chair thanked the presenters especially the farmers' representative for his perspective on the ability of new information delivery to farmers to catalyse their learning ability on modern agricultural technologies. Dr Marenya then invited all participants to seek clarifications, give comments or suggestions and ask questions if any in a bid to contribute to the discussion on technology adoption.

A participant from CIMMYT gave a comment regarding technology adoption. In his opinion, he argued that there should not be much worry on the rapid uptake of technology among the wealthier farmers compared to other farmers since wealthy individuals are likely to be more adventurous relative to their resource-constrained peers. Thus, effort should be geared towards addressing the liquidity constraints. He further noted that the incremental growth in yields from this study was very impressive, but he wondered about the scale of farm operations should the farmers go for to realise the economic benefits of adopting the seed varieties for mid-altitude. Also, he inquired the way forward on the use of these findings.

Another participant also from CIMMYT re-joined in questioning the profitability of adopting the fine-tuned hybrid seeds. In his account, while on average, a 30 percent change in yields is a splendid gain to farmers, it was however not economically profitable given other such costs of production such as labour input. In his view, there was a need to reconcile cost of production with the expected returns to investment in the seed.

Another participant noted that while targeting niche market is a great thing, there is a gap between the development of seed technologies and dissemination of the same to the farmers. In his view, he felt that much of the emphasis has been on yield traits while forgetting other non-yield traits such as pest and disease resistance, early maturity, storage among other characteristics that farmers consider. He gave an example of experience with maize farmers in the lower eastern regions of Kenya whereby despite there being high yielding varieties for this region, farmers have persistently used the low yielding local seed varieties. He thinks that lack of sufficient involvement of farmers in developing of the hybrid seed technologies (non-inclusion of attributes of farmer preferences) coupled with poor marketing and awareness on the benefits of the modern seed varieties by seed companies and agro-dealers could have contributed towards farmer resistance.

In response to reactions from the plenary, Prof. Carter clarified that the statistics used in the analysis were medians and not means as conceived by that participant. This was for a statistical reason (to represent a typical farmer). He further agreed that measurements used in the study were based on a tiny plot size which could have increased the margin of error. Nevertheless, he noted that they explored the impact of seed technology adoption on outcome indicators whereby farm incomes were positively significant, but the total incomes were positive but insignificant.

On the contribution of the study to the overall theme of technology adoption, he (Prof. Carter) said that the project focused on illuminating the need to consider both genetic and financial tools when seeking options for scaling-up productivity. For instance, when genetics attributes have been optimised to improve characteristics, can we use financial instruments to deepen returns to investment. He argued that the study has demonstrated that relaxing the liquidity constraints can induce farmers to adopt high yielding varieties. Given the importance of smallholder farmers regarding their numbers and contribution to overall maize output, it is, therefore, imperative to emphasise the importance of interventions that would increase their maize productivity.

Session Three: Panel Discussion: Agricultural Innovations and Poverty Reduction

The moderator, Dr Lilian Kirimi (stepping in for Dr Otieno) invited Mr Mulinge Mukumbu the Deputy Chief of Party, USAID Kenya Agriculture Value Chain Enterprises (KAVES) to chair and moderate the panel discussion. KAVES work is mainly on value chain development. **Mr Mulinge Mukumbu** has about 30 years' experience of doing developmental projects.

The broad subject of the discussion was “*Agricultural Innovations and Poverty Reduction*” under which the specific topics of interest had been communicated to the panellists. The chair invited and introduced the panellists who included:

1. **Dr David Ameyaw** – *President, International Centre for Evaluation and Development*
2. **Mr Saleem Esmail** – *Founder C.E.O, Western Seed Company*
3. **Ms Julia Franklin** – *Global Sourcing Director, One-acre fund*
4. **Mr Patrick Oketa** – *ACUMEN Fund*
5. **Hon. Herbert Mwaniki** – *CEC, Agriculture, Livestock & Fisheries, Murang'a County*
6. **Ms Mary Karanja** – *Head, Traditional High-Value Crops Program, MoALF*

Dr David Ameyaw – *President, International Centre for Evaluation and Development*

Dr Ameyaw is Adjunct Professor at the University of Ghana, and board member basis assets and market access innovation board. He has worked at AGRA as an MLE director, and before this, he worked as acting senior director for monitoring, evaluation and economics unit of millennium challenge corporation, USA. He has over 20 years' experience in direct project design and management research capacity and a strong analytical background.

Mr Saleem Esmail – *Founder C.E.O, Western Seed Company.*

He is a plant breeder by self-training who founded the company about 20 years ago. The Western Seed Company built its business on maize varieties selected to perform well in mid-altitude regions. This model of developing seed fine-tuned to niche agro-ecological environments may help to increase smallholder agricultural productivity.

Ms Julia Franklin – *Global Sourcing Director, One-acre fund*

She is based in Nairobi and is responsible for the full supply chain of fertiliser seed and other products. Her main focus is on sourcing high-quality seed and fertiliser to ensure quality material for planting are delivered to farmers at their doorstep. Before this, she was the lead in planning and executing seasonal logistics for one-acre fund rural warehouse in Western Kenya.

Mr Patrick Oketa – *ACUMEN Fund*

He is the ACUMEN director in charge of ACUMEN investment activities in East Africa. ACUMEN are fund managers. He has over 17 years' experience in the finance sector and previously managed the Africa seed investment fund set up by AGRA.

Hon. Herbert Mwaniki – *Representative County Government*

He is a county executive committee member or minister of agriculture for Murang'a County. He is also the chair of the Inter-governmental (county) thematic working group of projects and inputs.

Ms Mary Karanja – *Head, Traditional High-Value Crops Program, MoALF*

She is the Head, Traditional High-Value Crops Program, state Department of Agriculture, MoALF

Panel Discussion

The chair noted that farmers are willing to adopt technology as long as they can perceive the value of the technology. He further said that farmers are more likely to adopt a technology that is close to the value realisation for instance storage technologies close to harvest time. After the introduction, the Chair requested the panellists to make quick remarks on the topic of discussion before getting into an interactive session. After that, to start off the discussion, the chair began with three observatory remarks on technology adoption concerning the areas he worked in, that:

1. *People in the countryside are either residents or farmers.*
2. *The residents are subsistence farmers.*
3. *Real farmers respond to incentives. Thus, if shown money, they will adopt the technology.*

That said, he went ahead to say that seed is used in compliment with other technologies. Therefore, although the concern in adopting new seed is the need to increase food and income, the seed on its own won't sell; in pure economic theory, seed demand is derived demand - demand is derived from other things that are pushing the farmer to adopt.

From personal experience in KAVES program where he works with around 560,000 farmers, Mr Mukumbu stated that 72 percent of the farmers have at least adopted one technology. He indicated that they work across the whole value chain. The observation from working with these farmers is that real farmers adopt new technology. The potential for adoption of any technology is related to the effective time of application of that technology in regards to planting. He also observed that farmers seem to relate technology to output (harvest). For example in adopting threshing technology affordable to them to thresh what they have then for them to adopt seed. Storage bags to store what they have produced than seeds. The reason is that he said they are rational thinkers and the closer to the harvest time, the lower the risk of losing the whole crop. The easier the potential to increase produce is foreseen, the easier it is to make investments in the technology. As long as farmers can see the impact regarding income or saving it is easier for them to adopt; these are the real farmers.

He also observed that price is critical and the question was whether the technology was affordable. The technology must be explained in a manner that is understandable to them. The trick is making them understand the relationship between technology and the final income.

Mr Saleem said that the journey with the seed business started 25 years ago with no access to germplasm which at that time was a domain of Kenya seed. They now have access to

germplasm, and this has made the company to grow into a big seed company now. He said that in the past, the seed business was only left to the national government or the international bodies. Twenty years down the line much has changed, and they have worked with other organisations like IITA and AGRA to take technology to the farmer.

He indicated that seed companies produce seeds with attributes that are likeable to the farmer. By making the seed available for taking by the farmers for the first time, it is 25 percent of the work in the adoption. 75 percent of the job in adoption is the start to help farmers build trust to influence adoption. The company has released 25 varieties, but only three varieties have been commercialised. They meet the taste and confidence by the farmers. He concluded by stating that the point in the marketing of technology is getting the small scale farmer build trust about the seed.

Ms Julia Franklin said that one-acre fund serves about 400,000 smallholder farmers across south and east Africa. She stated that the programs concentrated on the marketing of quality agricultural inputs provided on credit coupled with distribution training and postharvest part. She indicated that the key component to the bundle of input is seed with the aim of increased productivity. She stated that for the technology to have the impact, it has to be accessible (this why distribution part by the one-acre fund), affordable (financing through credit), easy to use (training on fertiliser use and agroecological management).

She said that in sensitising the farmer to adopt new technology, it is important to train the farmers in a choice of enterprises regarding agro-ecological zone and proper management of the crop/ enterprise to achieve the full benefits that come with improved seed. In advising and training farmers, the farmers need to understand the nature of their soil and how to use the fertilisers and therefore rates and suggest of brands is important. She said that they try to understand the farmers and the farms by doing a test such as soil analysis help in assisting the farmer to make decisions. They then train and advise the farmer on management and use of fertiliser

She noted that there is a gap when the researchers release technology. They have a vast number of extension officers to train farmers (900 field officers in Kenya alone) on the use of new technology to ensure that technology is employed in the right way.

She added that financing and quality guarantee to the farmers was an important part. They get the input from reliable sources and ensure that the seed of good quality. She indicated that tests were done before distribution to ensure that farmers get high-quality seed. She said that testing of seed before distributing to the farmers was important because it ensured that small-scale farmers are not affected by poor quality.

Hon. Herbert Mwaniki from Muranga County and a representative of county government indicated that the work of county government among others is to bridge the gap between information from research and farmers through extension services. He stated that adoption is about information flow to the farmers. He further noted that farmers plant the local seed because

they trust the seed will give some output and do not trust the change. Therefore, to improve seed adoption, there was a need to build from the information that the farmers have. He also said that information required to be getting to the farmers promptly. He pointed that they have a network of field officers and they need to have the most recent and right information to the farmers.

He also observed that Kenyan farmers believe that crop is maize and if maize failure is experienced then there is crop failure. He indicated the need for diversification because other crops may withstand conditions that maize cannot. Such perspective on maize crop demonstrates its relevance in the addressing food security in the country.

Despite the contribution of the smallholder farmers in crop production, most of the time, they are exploited unfairly. Mr Oketa noted that in the past, major players in the agricultural sector such as output buyers/marketers, financial institutions and agro-dealers take advantage of the low level of knowledge among the small scale farmers. He pointed out that ACUMEN had adopted the veracity of taking equity back to humanity by helping the smallholder farmer understand pertinent issues in agribusinesses such as accounting, banking and crop protection to enable them to adapt to trade/market environment.

Mr Oketa further emphasised that since production factors like land and labour that these farmers own are limited, there is a need to ensure that all they (factors) are used efficiently. In this respect, he pointed out that ACUMEN advances availability of necessary products and services that would promote returns to investment among the smallholder producers. Furthermore, he noted that ACUMEN is in support of technologies that make work easier for the farmers to do less and get the maximum benefits from the farm.

Ms Mary Karanja said that while researchers are doing the best to avail suitable new generation seed, there is a need to bridge the crop management gap. She pointed out that the ways in which farmers manage the farming enterprise determine the output they get from adopted technology. Late planting, for instance, causes major crop losses. If management is done right the benefits from improved technology will be sure.

From a devolved dispensation perspective, she said that county governments need to offer excellent extension service to promote adoption of new farming technologies. This can be achieved through the formulation of policies that favour adoption of new seed technology. However, she noted that policies by the national governments on new technology are necessary to support implementation efforts of the county governments.

Besides extension on good agricultural practices, she also pointed out that capacity building among farmers is essential to ensure that new research findings are communicated. Furthermore, capacity building should be continuous and sustained.

Dr David Ameyaw said there is a need to figure out how to demonstrate that technology adoption is having an impact and the methodologies we can use to support the evidence that is being generated to show that impact is happening. In doing so, there was a need to ask whether our

system of farming or the technology adopted is reducing poverty and whether there evidence that poverty is being reduced.

He stated that increase in agricultural productivity leads to a higher reduction in poverty where the majority of people are in agriculture. He added that Agriculture reduces poverty than any other sector. He stated the main factors of production in farming are seed, fertiliser, healthy fertile soils and capital, and he said that with these factors the farmer could increase productivity. The other concern he said was necessary for consideration, was how much the farmer is paid for adopting the new technology. He argued that a good price then would become a major factor and that there should be a similar price factor when the farmer invests more in capital. He also pointed out that marketing and good price for the produce are important. He concluded by saying that the farmers are interested in returns to capital.

He stated that farmers need to change to commercialised farming. He added that moving labour to off-farm activities is important in increasing demand for maize produce and seed. He said there is a need to change the concept of farming. In Kenya, the land is becoming smaller (average of 0.75 acres); it is hard to commercialise with this small size of land. He added that more people were turning to commercialised farming and the rich farmers were doing commercialised farming more. He also pointed out that corresponding demand and high price will influence adoption. He concluded that Innovation must be coupled with demand and high price for the produce.

Plenary Discussion

Other participants were given a chance to ask questions and additions to the discussion. One participant argued that farmers are rational when making decisions and what they need is information about the new technologies. They take up technology that best fit their situation

It was confirmed that technology adoption is complimentary and it was, therefore, necessary to consider other factors that may influence technology adoption.

A participant asked what scale of operation would optimise productivity and was informed that proper management would optimise productivity for any scale of operation.

Another participant asked whether the extent of soil mining was equal to nutrient replenishment. The response was that there are efforts by the county government and other stakeholders to ensure that the soils are replenished, some county government are advising farmer on the use of organic manures to correct soils. Murang'a county government for example provided manure from pastoral areas to replenish soils

Another participant observed that it takes a long time for the seed to be developed and adopted by the farmers. In this respect, another participant added that Africa has a longer seed varietal turnover of up to 10 years relative to turnover in developed nations like the U.S and Asian countries which are less than 8years.

Using Kenya as an example to explain the long turnover in Africa, another participant noted that policy on registration of new seed with the relevant bodies takes about seven years before the seed is released to farmers. Hence, it was also suggested that policies on access to seed from the regional market like COMESA needed to be reviewed.

Constraints faced by this group of farmers and can be useful to help move the crop productivity closer to 6 MT/acre as this would contribute to improving their welfare.

Session Four: Constraints to Maize Productivity for Smallholder Farmers: Further Lessons

This session was chaired by the Director, Crops Systems, Kenya Agricultural Research and Livestock Organization (KARLO), Dr Lusike Wasilwa. She invited the presenters of the three papers presented in this session.

How do small-scale farmers learn about new agricultural innovations?

Presentation by - Assistant Professor Emilia Tjernstrom, *University of Wisconsin*

In this study, the presenter highlighted how small-scale farmers learn from their peers about new technology innovation in the effort to enhance agricultural productivity. In Kenya and other countries, there are concerted efforts by researchers and policymakers to increase the use of higher-yielding inputs, such as improved seed and fertiliser, among poor and smallholder farmers. Promoting general recommendations through training or **government** recommendations can overlook significant variations in soil quality and the availability of quality seed and fertiliser.

The pH from the sampled ranged from 4 to 8.5, organic matter content ranged from about 2 to 8 percent, and potassium content ranged from less than 100 ppm to about 1,800 ppm. Even between fields within the same villages, these measures differed significantly. Similarly, Cation Exchange Capacity (CEC), which is a measure of a soil's ability to hold onto essential nutrients and to supply them to a crop or a measure of soil's fertility showed considerable variation both within and between villages.

A high variation in soil and available inputs even within villages means that farmers are unlikely to learn from their neighbours what will work best for their plots. In this case, the experience one farmer has with fertiliser and seed will not function well as an example for other farmers who may have a different type and quality of the soil. However, when farmers learn from each other's experiences, they might avoid costly and risky experimentation on their plots with new fertiliser or seed.

In a social network-based study, they examined the information passed from farmer to farmer. In some villages, soils varied a lot, and in others, soils were more similar. Results show that in villages where soils were comparable, farmers were willing and able to learn from their neighbours. However, in villages where soils varied widely, individual farmers experiencing success with a new seed did not translate into a higher likelihood that their friends and neighbours would try that new seed.

The results on soil variation show an opportunity to target improved seed and other interventions based on the change in soils within a village or larger geographic area. Overall, farmers will

benefit from recommendations that are more accurately tailored to their soil quality and by ensuring that the appropriate fertiliser and seed is available in their local stores.

In areas with more variation between localities, demonstration plots and news about higher yields could help spread information through social networks. In areas with greater variation within localities, trial seed packets or subsidies may be needed to promote individual experimentation and learning, though at a potentially higher cost. Also, farmers in areas with high soil variation within localities need tailored recommendations on amendments and fertiliser, or the information will likely not be helpful.

Results demonstrate heterogeneity, as researchers describe it, a complex challenge in helping poor or smallholder farmers to adopt agricultural innovations that achieve the yields possible today.

Soil quality information and fertiliser use: Does knowledge influence choice?

Presentation by Dr Priscilla Waninaina, *Tegemeo Institute*

The study emphasised that soil degradation was a major concern in sub-Saharan Africa resulting in bare and undernourished soils. Dependence on bare soil is a key reason why sub-Saharan Africa lags behind other developing regions in meeting its agricultural productivity goals. The low productivity is also exacerbated by the imbalanced use of fertilisers by the farmers without knowing soil fertility status and nutrient requirement of crops thus causing adverse effects on soil and crops both regarding nutrient toxicity and deficiency.

Diagnostic techniques such as soil tests are methods of detecting and analysing soil at an appropriate field level make it possible for farmers to obtain precise information about the nutrient needs specific to their fields. Also, most fertilisers in the markets in sub-Saharan Africa are made as to supply only the macronutrients mainly nitrogen, phosphorus and potassium. However, recent studies have highlighted that in reality, the soils may also be deficient in other macronutrients as well as micronutrients such as Sulphur, Boron, and Zinc. Such deficiencies may render crops unresponsive to the application of these fertilisers.

Owing to this, we conducted soil tests for farmers in Kenya and issued farmers with results from the soil tests indicating which nutrients were deficient in their soils. We sought to find out whether information on the quality of the soils influences the type of fertiliser the farmers use and yields.

The main conclusions of the study are that: compliance to the recommended fertiliser minerals is low among the farmers and constraints to compliance include affordability, accessibility, and knowledge (some farmers could not understand the test results). This implies that availing the information to farmers is not enough: there is need to empower them financially and also present

the information to farmers in a way they would understand. Also, some of the recommended mineral components are currently not available in the markets hence the need to blend conventional NPK fertilisers with additional nutrients including micronutrients.

The returns to fertilisers: The impact of soil fertility and input quality

Presentation by Assistant Prof. Emilia Tjernstrom, *University of Wisconsin*

The presentation sought to examine the role of soil health in the performance of seed technology alongside fertiliser use. The presenter started by emphasising that soil is not the only source of variation that affects whether farmers will use inputs like fertiliser or improved seed. Variation in the quality of those inputs also has an impact. We compared crop yields between farmers who used fertiliser bought from local stores and fertiliser that the research team delivered directly from a high-end supplier.

We found significant variation in yields between the store-bought and the delivered fertiliser. For farmers who used fertiliser they bought directly from local sources, yields showed little response to the fertiliser. However, at average levels of fertiliser, the yields among farmers who used fertiliser sourced directly from the producer received yields that were 50-100 percent higher.

Besides fertiliser, they further compared germination rates of one seed producer's hybrid variety that the research team purchased from a sample of local suppliers within a single growing season. For these locally-purchased seeds, packaging varied in appearance and condition, as did the price and the colour of the seeds. Importantly, germination rates varied widely. The average germination rate was 76 percent but in some samples, as few as zero seeds germinated. Kenya's seed regulations stipulate that 90 percent of basic seed should have no damaged or poor-sprouting seeds. For certified seed, the requirement is 95 percent.

We do not know yet whether the seeds in our sample were of poor quality because they were stored poorly or for extended periods of time, both of which can limit their viability. We are currently conducting DNA tests of these samples against seed purchased directly from the producer to see if they were indeed counterfeit.

Results on variation in fertiliser and seed quality and poor storage suggest the need to educate suppliers on appropriate seed handling. Counterfeiting requires policing and verification. Sample packs of fertiliser and seed from reputable sources would provide farmers willing to experiment a chance for higher yields and longer-term success.

Plenary Discussion

After the presentation of the three papers, the session chair opened the floor for the participants to give comments or ask questions.

A participant was interested to know why there was the difference in fertiliser use among farmers in Central and Western regions. Also, he was curious to know why the use of fertiliser also varied by the gender of the household head such that male headed households performed better than the female-headed households. In response, Dr Wainaina argued that the observed differences in fertiliser were driven by differences in wealth across regions and empowerment within genders. She pointed out that farmers in Central are relatively more experienced than their western counterparts. From a gender perspective, male-headed households are relatively more endowed hence more likely to take up the use of fertiliser than female headed households. However, she was careful to say that the observed differences in fertiliser use trends are not related to agro-ecological zoning given that all households were drawn from similar zones.

Another participant was also interested to know why fertiliser use among the sampled households across the three periods of the survey was highest in 2015 in the Western region. In response, Dr Wainaina clarified that possible increase in the use of fertiliser in the year 2015 in the western region could have been as a result of the fertiliser distribution to farmers (given as an injection to ease liquidity constraint). In total, 600 households in the western region were given a 50kg bag of blended fertiliser.

One of the participants had noted during Prof. Emilia's presentation that the level of organic matter has implications on the returns to nitrogen application. Therefore, she sought to know how this finding would affect conservation agriculture on recommendation and application of Nitrogen mineral. In response, Prof. Emilia gave a clarification that the results from her study do not say that yield are lower at higher organic matter but rather applying an extra kilo of nitrogen has a lower return at the higher organic matter. That said, she noted that returns to inorganic fertiliser have to do with what is limiting factor in the soil whereby at a higher level of organic matter, nitrogen is less limiting.

Another participant was curious to know if farmers can differentiate soil characteristics with respect to soil's CEC. Prof. Emilia responded by saying that CEC relates very strongly with observable soil characteristics. She added that during the study, three questions that relate to perceived soil features such as *soil fertility* (is your soil fertility below or above average in the village), *texture* (sandy, loamy, etc.), and *slope* relative to other farms in the village were asked to elicit the types of soils in the villages. With these 3 questions, about 65percent of observed variability in CEC in the soil could be explained. In addition, she noted that it was clear that farmers know quite a lot their soil quality and can be used as a basis to learn from their neighbours. She emphasised that though the correlation between CEC levels and soil fertility may seem basic, their study revealed that when farmers were asked *who had similar soils to theirs*, villages with more variable CEC levels had fewer farmers with similar soil to neighbours'.

Another participant from Acre Africa was interested to know how personalised, tailored/customised fertiliser recommendations could be made sustainable by keeping costs low. In response, Prof. Emilia noted that soil testing is a fundamental component of making fertiliser

recommendation. In her view, the high cost of soil testing in Kenya which ranges between 20-30 USD per lab test is the major limiting. Her suggestion towards sustainable fertiliser recommendation were things like innovation into low-cost soil testing kits and perhaps scaling down a number of tests to focus on the main soil characteristics. She informed the audience that there was an upcoming project from Columbia University that is focusing on making affordable soil recommendations.

The session chair also contributed to the conversation by asking if the observed differences in fertiliser use between households in central and western Kenya whereby the former outperformed the latter could have been driven by past efforts to promote input use horticulture. The session presenter argued that previous experience with fertiliser could have also contributed to the observed differences.

Another participant argued that given the complexity of giving recommendations to farmers in the face of varying soil conditions, it would be ideal if they could be provided with information for them to make a decision. Prof. Emilia concurred with this observation in the sense that given the recommendations specified to a particular farmer may not translate well with their neighbours' needs, providing information would allow them to experiment with all possible scenarios at absolutely zero cost. She informed the audience that she is running another project in western Kenya where she is experimenting with farmers their learning ability when information on yields versus input use levels is readily available.

A participant who is a staff at Kakamega County pointed out that they were partnering with Athi River Mining (ARM) the manufacturer of Mavuno fertiliser brand to have a factory in the county. She added that besides its liming properties, Mavuno planting is fertiliser (NPK 10:26:10) has micronutrients like zinc, boron, manganese and Sulphur. Given that the county is subsidising both seed and fertiliser, she inquired if the investment is worthwhile now that the study has shown existence high variability in soil characteristics within the villages.

In her reply, Prof. Emilia noted that providing a fertiliser with micro-nutrient is a good step. However, another participant from Acre Africa pointed out that there are immediate challenges with locally produced fertilisers as well as blending the recommendation. In her remarks, overdependence on import market for fertiliser raw materials will have an impact on the price thus affordability of the same. Again given the existence of micro-variations in soil quality, many recommendations will be made for thousands of plots. However, the challenge would be to make all these blends which cannot be achieved economically using small scale blenders because of the high cost of blending small batches.

After deliberations, the session chair thanked all the participants for their active participation. She was grateful for her invitation and for Tegemeo organising such a high-level forum to demystify barriers to technology adoption and issues to do with technology bundling. However, she joked that next time, Tegemeo should extend such a forum to 2-3 days to allow enough time for discussions.

Session Five: Round Table Discussion: Improving Precision and Efficiency of Data in the Agricultural Sector

Prof. Michael Carter, Director, *BASIS Research Program/UC Davis*

The MC invited the session chair, Prof. Michael Carter, Director, BASIS Research Program/UC Davis who in turn invited the panellists. The chair gave an overview of the session. He said that in the process of the research they tried out several things and learned a few lessons. He then requested each researcher to say what they brought into this study.

The panellists by subject were as below;

Efficiency of Computer Assisted Personal Interviewing (CAPI) by Dr Mercy Kamau, *Tegemeo Institute*

Dr Kamau thanked the chair and proceeded to share Tegemeo's experience in CAPI. She observed that Tegemeo uses a lot of data collected from various sources including farmers and agro-dealers. The institute depends on empirical evidence in its policy research work. Tegemeo feels they had achieved a lot in tool design, data collection, quality protocols in entry and analysis. By 2013 the institute began transitioning into CAPI starting with about three staff members. This was motivated by the need to improve data efficiency and quality. Around the same time, University of Davis California was implementing the RCT study using CAPI. Since then, the institute has progressed in CAPI using several programs/software such as surveyCTO and ODK. The institute has had an advantage in picking up technology, learning, applying and improving through use.

Advantages of CAPI include:

1. Data relayed in real time
2. Increased data quality from data collection to analysis
3. Been able to train many enumerators and majority of these enumerators first learn these skills from Tegemeo

She encouraged other colleagues to add to the experience. She informed the workshop that there had been a lot back and forth in trying to incorporate the CAPI with other partners because it requires building capacity in the skills and syncing operations. She said some challenges exist in terms of connectivity, power outages but overall the experience has been good with farmers and enumerators.

The chair gave an example of new developments in research where there are questions about what it means to be poor. Through CAPI games are installed in tablets and given to respondents to interact with them. In the process, scores are generated that can be used to study levels of food insecurity. Looking forward to seeing if these kinds of inventions do bring about change in behaviour or they become limiting factors.

Dr Kamau said that CAPI is environment-friendly because it has reduced cutting down on trees for paper.

Precision through Field Measurement by Dr Tim Njagi, Tegemeo Institute

Dr Njagi showed how CAPI was used to measure the area of the farms to compare with recall values and help answer the notion that farmers overestimate land size. This he said can be attributed to the standard way of using acreage to report land size even where the area has reduced from the assumed. He also showed a graph by Asst. Professor Emilia that showed bias in reporting for land sizes.

He mentioned several efforts by the ministry and national statistical bureaus to improve measurement by using CAPI technology. Emilia added that area is not a big problem in statistics if it's random. In the current situation, however, has a bias towards smaller farmers meaning the error in yield is more for small fields than larger fields.

The chair wanted clarification on whether this means the yields were underestimated now that the exact area is lower than the values reported by farmers.

Network Measurement and Analysis by Asst. Prof. Emilia Tjernstrom, University of Wisconsin, USA

She presented two pictures to show how network surveys can be done. In this example, she used photos on the tablet that could be selected and then followed up with questions on only the selected. This brings improvement in network surveys in assessing whether farmers behaviour is similar because they are friends or are friends because they are similar.

Phone and Field Survey: A Comparison by Mr Samuel Bird, University of California, USA

He presented on using phone survey together with tablet survey. He observed that phone surveys could not replace face to face interviews because they do not provide ways of authenticating the respondent. They provide a real-time assessment at early stages of the survey like during planting, and it's possible to predict farmer problems long in advance. He gave an example of how phone survey helped to know that farmers were not able to access seed. They then made provisions to avail seed using phones again to establish which farmers were willing to order and pay for the second supply.

A participant observed that Dr Njagi's presentation seemed to assume using GPS is more accurate than recall. He wanted to know if that was correct and what the margin of error was in GPS measurement.

Dr Njagi replied that Tegemeo talked to several experts in GIS to learn the recommended ways of measuring area using GIS. These included the *Survey of Kenya* and *Geo maps*. One major deterrent among the suggested tools was the huge cost of higher accuracy equipment. The institute thus resorted to using GPS given its affordability and compatibility with the CAPI platform. Nonetheless, the method used had its shortcomings. First, it required enumerators to be

patient for GPS reading to improve to the set accuracy level. Another challenge was in area measurement where the farm is arched since the enumerators were walking in straight lines. This would affect the smaller acreages more. Also if the enumerator was not keen in marking the start and end, there could be some overlaps.

A participant responded that there are other technologies like GPS loggings where one clocks the gadget and walks around the parcel then the GPS logs the route and calculates the area.

Another participant asked about “ground-truthing” as a method of field measurement, but Dr Ameyaw explained that it was the same as GPS logging.

Dr Kamau observed that the cost implications in measuring each and every parcel of land the farmer accessed were quite high given that some parcels are far apart.

Dr Ameyaw said the use of technology to improve measurement was impressive. He said these are some of the innovations and implementations that they are working on. He said land measurement was crucial and that African Development Bank (AfDB) are rolling out land digitisation. Digitisation in developed countries enables tracing input use on specific plots for a long time.

On the phone innovation, he said they had experimented with the use of mobile phone to know the accuracy of recall. Calling farmers close to planting season enables decision makers to respond to farmers needs fast. He said innovations have multiple dimensions which researchers should explore.

The moderator then called upon Dr Milton Ayieko to give the closing remarks.

Wrap-up and Conference Summary

Session One:

The session focused on maize production trends and practices looking at the environment, bundling of technology and complementarity of the bundled technologies.

Key Highlights

Adoption of maize hybrids in the middle altitude areas is generally low despite the availability of varieties suited for that environment. Consistent adopters of maize hybrid are low. western lowlands had no consistent users in bundled technology. Maize productivity with improved seed is still low partly due to low use of complementary inputs like fertiliser.

Production increases where technology adoption is bundled as compared to the adoption of unique technologies. Constraints to adoption still exist e.g. lack of education which appears to hamper adoption. This requires rethinking how technology is packaged and delivered to farmers to enhance adoption.

Session Two:

This session involved discussion on technology adoption among smallholder farmers from the RCT study on seed technology.

Key Highlights

Adoption rates are higher where farmers are engaged in farm trials. Farmers are motivated by the need to increase food and incomes so that adoption is influenced by the timing of the technology. If the incentives like potential harvests exist, farmers will adopt the relevant technology because the benefits are foreseeable.

Gaps do exist between technology developers and users which call for more engagement between the farmers and breeders so that the traits relevant to the farmers are included in the new varieties which will increase adoption. Extension services are critical in bridging this gap, but there is need to improve the information systems especially now that agriculture is devolved.

The key to adoption is the quality of seed because farmers build trust in the seed which increases adoption.

Session Three:

The discussion was on technology innovation and poverty reduction.

Key Highlights

Though there are many seed varieties released in Kenya, only a few have been adopted. Of the 250 varieties released, only about 80 are adopted and commercialised. The trust by farmers/users increases adoption of these varieties.

Variability of maize prices tends to increase the risk aversion among farmers hence a corresponding demand and high prices of maize produce should accompany adoption. Additionally, adoption should be linked to poverty reduction.

Moving labour to off-farm activities is likely to increase demand for produce and adoption of hybrid maize if the off-farm income is re-invested in the agricultural activities.

Session Four:

The session looked at social networks and how soil quality information affects the technology adoption.

Key Highlights

Social networks are critical to technology adoption. Farmers tend to learn from their neighbours and networks are crucial in technology uptake.

Incentives to learn of new technology are critical in technology adoption. Use of fertiliser was low partly because farmers' perception of soil quality affects the use of fertiliser such that if farmers perceive their soils as very poor, they do not use fertiliser.

Session Five:

This section focused on improving the precision of agricultural data.

Key Highlights

Use of computer aided interview (CAPI) technology has made data collection easier and allowed real-time data manipulation. It is also possible to add more functions like the use of farmer images to study networks unlike in the paper interviews. There is also improved precision and efficiency.

Using farmers' self-reported information is less accurate as compared to more precise CAPI compatible innovations like area measurement using GPS which can improve on measurements like productivity. Networks are not easy to capture, but with CAPI technology it is easy to help farmers to recall and point out faces in their networks which can then be integrated into the bigger data for more detailed analysis. Mobile phone surveys are more accurate than the face to face interviews.

Closing Remarks

Dr Mary Mathenge Director, *Tegemeo Institute for Prof. Alfred Kibor, Ag. Deputy Vice Chancellor, Research and Extension, Egerton University*

The moderator invited the Director Tegemeo Institute to give some closing remarks on behalf of Prof. Kibor. She appreciated the moderator for steering the event and the participants for attending to the end. She thanked the staff for the hard work in preparation for the conference and commented that such a fruitful workshop was a rewarding feeling for all. She noted that Prof. Kibor who was to give the closing remarks had left for Nakuru.

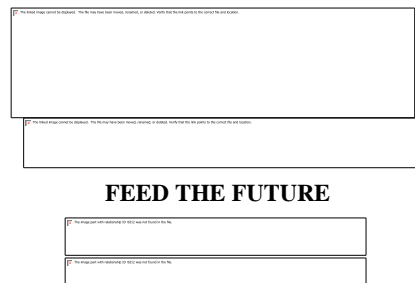
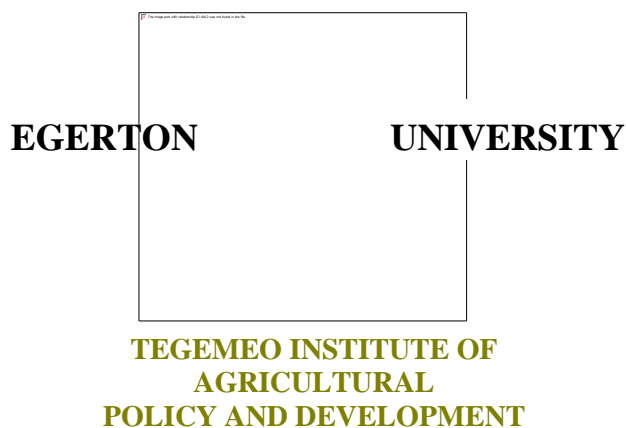
She specifically thanked the presenters for quality presentations, chairs for managing the time well, panellists, IT staff, and the secretariat for handling all the logistics well.

On the way forward, she apologised for Dr Wasilwa's complain about delayed sharing of Tegemeo's conference proceedings and presentations for a past event. The director explained that the way the proceedings were compiled then was not very efficient. She noted that already for this workshop the presentations were to be shared in pen-drives for each participant. She promised that the proceedings would be shared later with via the Institute's website and email.

She then invited Prof. Carter to make a few remarks. Meanwhile, she specifically thanked Prof Carter, Asst. Prof. Emilia & Sam from UC Davis and all Tegemeo staff who made the event a success. She said it was an honour to work with Prof. Carter having read his many academic papers prior to meeting him in person.

Professor Carter promised to share presentations on their web page www.basis.ucdavis.edu early the following week including interviews and other relevant materials. The director mentioned that the arrangement to bring Tegemeo and UC Davis was recommended by ACUMEN and it has worked well as evidenced by the workshop proceedings. She wished the participants safe travel to their destinations and closed the conference.

Annexe 1: Conference Programme



Conference Programme

Enhancing Smallholder Productivity in Kenya: Evidence from a Randomized Controlled Trial (RCT) of New Seed Varieties

Sarova Panafric Hotel, Nairobi, Kenya

February, 8th 2017

TIME	ACTIVITY
8.00-8.30 am	<i>Arrival and Registration</i>
8.30-9.30 am	<i>Welcome and Introduction</i>
	<p>Welcoming Remarks: <i>Dr Mary W. K. Mathenge, Director, Tegemeo Institute</i></p> <p>Introductory remarks</p> <ul style="list-style-type: none"> • Vice Chancellor, <i>Egerton University</i> • Principal Secretary, <i>Ministry of Agriculture, Livestock and Fisheries</i> <p>Conference Overview and Objectives</p>

9.30-10.30 am	Session 1: Maize Production Environments and Practices in Kenya <i>Chair: Antony Kioko – C.E.O., Cereal Growers Association (CGA)</i>
	<ul style="list-style-type: none"> • Diversity of production environments and practices – <i>Dr Mary Mathenge, Tegemeo Institute</i> • Productivity profile under different technology bundles – <i>Dr Timothy Njagi, Tegemeo Institute</i> <p>Plenary</p>
10.30-11 am	Tea/Coffee Break/ Group photo
11.00-12.00	Session 2: Technology Adoption among Smallholder Farmers in Kenya: Key Highlights from RCT of Maize Hybrids <i>Chair: Dr Paswel Marenya, Socioeconomist, CIMMYT</i>
	<ul style="list-style-type: none"> • Filling a Niche? Findings from an Impact Evaluation of maize hybrids in mid-altitude zones – <i>Prof. Michael Carter</i> – Director, BASIS Research Program/ UC Davis, USA • Views from the field – <i>Mr Joseph Otieno Saka, Maize Farmer, Homa Bay County</i> <p>Plenary</p>
12.00-1.20 pm	Session 3: Panel Discussion: Agricultural Innovations and Poverty Reduction <i>Chair: Mr Mulinge Mukumbu - Deputy Chief of Party, USAID KAVES</i>
	<p>Panelist</p> <ul style="list-style-type: none"> • <i>Dr David Ameyaw</i> – President, International Centre for Evaluation and Development • <i>Mr Saleem Esmail</i> – C.E.O, Western Seed Company • <i>Ms Julia Franklin</i> – Global Sourcing Director • <i>Ms Mary Karanja</i> – Head, Traditional High-Value Crops Programme, MOAL&F • <i>Dr Joyce Malinga</i> – Director, Food Crops Research Institute, KALRO • <i>Mr Patrick Oketa</i> – ACUMEN Fund

	<ul style="list-style-type: none"> • Representative - <i>County Government</i> <p>Plenary</p>
1.20-2.30pm	Lunch Break
2.30-3.30 pm	<p>Session 4: Constraints to Maize Productivity for Smallholder Farmers: Further Lessons from Study Findings</p> <p><i>Chair: Dr Lusike Wasilwa-Director, Crops Systems, KARLO</i></p>
	<ul style="list-style-type: none"> • How do small-scale farmers learn about new agricultural innovations? Asst. Prof. Emilia Tjernstrom, University of Wisconsin, USA • Soil quality information and fertiliser use: Does knowledge influence choice? Dr Priscilla Wainaina, Tegemeo Institute • The returns to fertilisers: The impact of soil fertility and input quality. Asst. Prof. Emilia Tjernstrom, University of Wisconsin, USA <p>Plenary</p>
3.30-4.20 pm	<p>Session 5: Round Table Discussion: Improving Precision and Efficiency of Data in the Agricultural Sector</p> <p><i>Chair: Prof. Michael Carter, Director, BASIS Research Program/ UC Davis, USA</i></p>
	<ul style="list-style-type: none"> • Efficiency of Computer Assisted Personal Interviewing (CAPI) – Dr Mercy Kamau, Tegemeo Institute • Precision through field measurement – Dr Tim Njagi, Tegemeo Institute • Phone and field survey: A comparison – Mr. Samuel Bird, University of California, USA • Network measurement and analysis – Asst. Prof. Emilia Tjernstrom, University of Wisconsin, USA

4.20-4.35 pm	Wrap up/Conclusions – Dr <i>Miltone Ayieko</i>, Tegemeo Institute
4.35-4.50 pm	Closing Remarks - Prof Alfred Kibor, Ag. Deputy Vice Chancellor, Research and Extension, Egerton University
4.50 pm	Tea/coffee and Departure

Annexe 2: List of Participants

	NAME	DESIGNATION	AFFILIATION
1	Alex Russel	Communications	UC Davis
2	Anne Chele	National Policy Officer	FAO
3	Anthony Kariri	IT Assistant	Tegemeo Institute
4	Antony Kioko	CEO	Cereal Growers Association
5	Ashley Speyer	Innovation Associate	Acumen
6	Azariah B. Soi	CEO	Kenya Seed Co. Ltd
7	Benson Mureithi	County Director of Agriculture	Kirinyaga County
8	Claudia Casarotto	Deputy County Director	Innovations for Poverty Action
9	David S. Ameyaw	CEO	ICED
10	Dionisia M'Eruiaki	County Director of Agriculture	Meru County
11	Dr Caleb Wangia	Chairman	AGMARK
12	Dr Lusike Wasilwa	Director Crop Systems	KALRO
13	Dr Mercy Kamau	Senior Research Fellow	Tegemeo Institute
14	Dr Tim Njagi	Research Fellow	Tegemeo Institute
15	Dr.Dennis Otieno	Researcher Fellow	Tegemeo Institute
16	Dr.Festus Murithi	Director	KALRO
17	Dr.Jackson Langat	MLE Officer	Tegemeo Institute
18	Dr.Lilian Kirimi	Senior Research Fellow	Tegemeo Institute
19	Dr.Mary Mathenge	Director	Tegemeo Institute
20	Dr.Priscilla Wainaina	Post-doctoral Researcher	Tegemeo Institute
21	Dr.Tsedeke Abate	Leader, DTMA	CIMMYT
22	Edward Johnstone		
23	Elizabeth Randiga	Farmer	Siaya County
24	Emilia Tjertrom	Assistant Professor	UC Davis
25	Ephiphania Kinyumu	Senior Research Associate	Tegemeo Institute
26	Eric Njue	Researcher	Tegemeo Institute
27	Fraciah Nyokabi	Adm.Assistant	Tegemeo Institute
28	Francis Mago Gagogo	Farmer	Kirinyaga County
29	Fred Rattunde	Consultant	Seed for Change
30	Fredrick Siele	Services Marketing Manager	NCPB
31	Geoffrey Kiarie	Accountant	Tegemeo Institute
32	Geoffrey Kimani	Farmer	Muranga County
33	Grace Gitu	Seed Expert	AFSTA
34	Grace Kirui	County Director of Agriculture	Nakuru County
35	Hillary Bii	Research Associate	Tegemeo Institute
36	Hon. Albert Mwaniki	CEC for Agriculture, Livestock & Fisheries	Muranga County

	NAME	DESIGNATION	AFFILIATION
37	Hugo de Groote	Principal Scientist	CIMMYT
38	Isaac Muyendo	County Director of Agriculture	Siaya County
39	James Githuku	Senior Research Associate	Tegemeo Institute
40	James Njeru	Research Associate	CIMMYT
41	Jared Odhiambo Odera	Deputy County of Director Agriculture	Migori County
42	Joel Muiwiri	Farmer	Meru County
43	John Mburu Mukundi	Research Associate	Tegemeo Institute
44	John N.Nyaga	County Director of Agriculture	Embu County
45	Joseph Saka	Farmer-	Homabay County
46	Joyce Makau	Research Associate	Tegemeo Institute
47	Judy Kimani	Communication & Outreach Officer	Tegemeo Institute
48	Julia Franklin	Global Sourcing Director	One Acre Fund
49	Lilian Gichuru	Ass. Programme Officer	AGRA
50	Marenya, Paswel	Researcher	CIMMYT
51	Martin Leboo	Portfolio Associate	ACUMEN Fund
52	Mary Karanja	Assistant Director of Agriculture	MOALF
53	Mary Nduru	SDA	MOALF
54	Michael Carter	Prof. Agricultural and Resource Economics & Director, BASIS Innovation Lab	UC Davis
55	Michael Kibebe	Consultant - Seed Specialist	Agri Experience
56	Mildred Sande	County Director of Agriculture	Kakamega County
57	Miltone Ayieko	Researcher	Tegemeo Institute
58	Mulinge Mukumbu	DCOP	USAID/KAVES
59	Nancy Laibuni	Policy Analyst	KIPPRA
60	Nancy Nguru	M & E Officer	Agriculture-Muranga County
61	Njeri Karani	Program Officer	Rural Outreach Program
62	Noel Templer	Client Assignment & Research Manager	Agri Experience
63	Nyando V.Violet	Agriculturalist	KENAFF
64	Patrick Macharia	IT Administrator	Tegemeo Institute
65	Patrick Oketa	Director	Acumen
66	Philemon Kiprono	Senior Economist	Ministry of Internal Security
67	Prof. Rose Nyikal	Professor	University of Nairobi
68	Prof.Afred Kibor	Ag.DVC R&E	Egerton University
69	Rosemary Nyamu	County Director of Agriculture	Kiambu County

	NAME	DESIGNATION	AFFILIATION
70	Rowan Cantter	Seed Systems Lead	One Acre Fund
71	Saleem Esmail	CEO	Western Seed Company
72	Samuel Kebokero Marwa	Farmer	Migori County
73	Samul Bird	Graduate PHD Student	UC Davis
74	Sylvia Mwichuli	VP Communications & Knowledge Management	ICED
75	Tabitha Ajwang	County Director of Agriculture	Homa Bay
76	Timon K.Moi	SPRO	KALRO