Impact of creative capacity building of local innovators and communities on income, welfare and attitudes in Uganda: a cluster randomized control trial approach

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Note to readers

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Abbreviations and acronyms

BTVET	Business Technical and Vocational Institutions
CAADP	Comprehensive Africa Agriculture Development Programme
CBO	Community Based Organization
CCB	Creative Capacity Building
CDO	Community Development Officers
DIT	Directorate of Industrial Training
DID	Difference-In-Difference
DSIP	Development Strategy and Investment Plan
FGD	Focus Group Discussion
FD	Full Dose
GOU	Government of Uganda
HD	Half Dose
IFPRI	International Food Policy Research Institute
LG	Local Government
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MIT D-Lab	Massachusetts Institute of Technology D-Lab
MOs	Ministry of Education & Sports
NDP	National Development Plan
NGOs	Non-Government Organisations
RCT	Randomized control trial
SSA	Sub-Saharan Africa
STI	Science, Technology and Innovations
UNBS	Uganda National Bureau of Standards
UNDP	United Nations Development Programme
UPE	Uganda Primary Education
USDAF	The United States African Development Foundation
USE	Uganda Secondary Education

EXECUTIVE SUMMARY

Technologies and innovations are a key driver of human developments and competitiveness. Failure of imported technologies has galvanized efforts on technologies generated by close collaboration between external investors and local committees. The general objective of the study was to determine the impact of Creative Capacity Building (CCB) training on human welfare and local communities' perception on their ability to innovate. Specifically, the study targeted a number of major outcomes of CCB training namely, economic impacts, behavioral changes, attitudinal change and technology creation and use including policy influence.

CCB is a hands-on training approach whose students are community members with any educational level. CCB focuses on harnessing local creativity and indigenous knowledge in the technology design process, facilitating community innovations and invention. In skills training workshops, trainees work collaboratively to design and develop tools that meet their needs. The training encourages and trains people to make technologies that generate income, improve health and safety, save labour and time and change perceptions about themselves.

The research design generated a randomized sample of approximately 144 members in each district distributed as 48 members from 4 farmer groups selected randomly for the full dose treatment, 48 members from 4 farmer groups selected randomly for the half-dose treatment and 48 members from 4 farmer groups selected randomly for the control. The study aimed to address four evaluation questions including; the economic impacts of CCB on beneficiaries; the impact of CCB on change in behavior of beneficiaries due to participation in CCB; the impact of CCB on the attitudinal change of beneficiaries and the adoption rate of new technologies created by CCB.

Program intervention entailed pre-training discussions, technology demonstration; a technology design process comprised of problem identification, information gathering, and formulation of ideas, experimenting with the ideas and choosing the best idea. The program also engaged participants in building, testing and refining the technology prototypes and receiving feedback from potential users of the invention.

The results showed that CCB beneficiaries on average designed and made six tools, per group, which deferred by production system of CCB beneficiaries although the charcoal press was the most frequently designed tool across all the districts. Crop processing tools such as maize sheller, groundnut plucker, groundnut sheller and tuber slicer were most commonly designed underscoring the importance farmers attach to post harvest management and value addition.

Regarding ownership and usage of tools, the full treatment group owned and used more of the technologies designed compared to the half dose and the control groups, which is testimony that traditional methods of technology transfer have weak impact on ownership and use of CCB tools. The probability of designing and making tools increased by 55% among CCB full dose beneficiaries compared to 6 percent among half dose beneficiaries.

CCB training increased the number of economic activities by two for both full and half dose CCB beneficiaries. All CCB technologies saved labour by over 80 percent with the groundnut sheller offering the highest labour saving of 97 percent. CCB technologies also enhanced the equality in division of labour for agricultural activities giving women capacity to harvest fruits and men capacity to participate in seed cleaning activities. CCB training also enhanced the capacity of

trainees to fix broken tools by 60 percent for full dose beneficiaries and by 75 percent for half dose beneficiaries.

CCB training interventions positively and significantly impacted on household incomes for uncontrolled estimation although the impact was not significant for controlled difference in difference assessment. The non-significance can be attributed to the lagged impact of most of the tools developed. Creative capacity Building (CCB) training however positively and significantly impacted on crop income among the full dose CCB beneficiaries largely because most of the tools developed are for crop processing.

The impact of CCB training on the value of household assets was weak across all analytical approaches largely on account of the short time period (3 years) between intervention and impact assessment.

The policy utility of the study is the empirical evidence of methods to enhance vocational training of rural communities and promotion of local innovations. Results of this study can potentially guide implementation of Uganda's flagship policy the National Development Plan especially the skills development component of the pillar on Human Capital Development. At community level, the results of this study will greatly inform vocational training of local communities to spur local level technology innovation and development.

1.0 Introduction

Since the industrial revolution, technologies and innovations have driven human development and competitiveness and it is for this reason that countries that invest in research have correspondingly higher levels of innovations and human development (OECD, 2007). For example, Mauritius and South Africa have, respectively the highest ranking in innovations and human development in Sub-Saharan Africa (SSA) (UNDP, 2015, Cornell University et al; 2016). Particularly, local innovations, rather than importation of innovations, have driven development (OECD, 2007). Unfortunately, governments in SSA have not invested significantly in research and development. SSA has the second lowest Research and Development (R&D) intensity[1] (gross expenditure on R&D as percent of GDP) and the lowest human development index (UNDP, 2015; World Bank, 2015). The low investment in R&D forces countries to import most of the technologies (Haverkort and Rist, 2004). Even though imported technologies have been critical in economic development, some technologies have been found to be inappropriate due to cultural, social and economic reasons (Roose, Kabore, & Guenat, 1999).

A number of imported technologies did not work in Sub-Saharan Africa (SSA) because of inappropriate social-economic and bio-physical environment. Others did not work due to poor pricing policies, inadequate infrastructure, lack of skills to provide maintenance and advisory services and lack of functioning institutions. For example, the tractor and mechanization of agriculture yielded unimpressive results in many SSA countries because of small plots unfit for mechanization, lack of spare parts, maintenance skills and other operational services, weak infrastructure to allow commercialization, and poor economic performance after structural adjustment (Sines, 2007). In addition, large irrigation schemes that had been started to boost food production and exports to generate the much needed foreign exchange by African governments failed. Only 4% of cropland in SSA is currently irrigated, the lowest in the world (World Bank, 2008). Moreover, small irrigation projects financed by farmers and NGOs have higher returns than large scale irrigation (You et al. 2011) due to higher investment cost, poor planning and lack of maintenance (Binswanger and Pingali, 1989; Inocenda et al., 2007; World bank, 2008). Local people in SSA countries have shown some creativity and have improved lives through using traditional knowledge – defined as the accumulation of deep-rooted traditional norms, values and ideas (Dei, 2000).

Practitioners and policy makers agree that local innovations are sustainable and cost-effective for rural development. Examples of local innovations include the zai technology developed by Yacouba Savadogo, a farmer in semi-arid zone in Burkina Faso, to harvest water and store organic inputs and other soil nutrients using a planting pit (Roose, Kabore and Guenat, 1999). This showed that the Zai technology could increase yield of cereal crops by up to threefold and nutrient use efficiency by 60% (Fatondji et al., 2006).

In West Africa, farmers manage water run-off and prohibit salted water to reach rice farms under mangrove by building dykes. Management of mangrove for paddy production is an old innovation largely prompted by population pressure and climate change (Cormier- Salem, 1999). In Rwanda,

[1] Central Asia has the lowest R&D intensity (0.17% compared to SSA's 0.29%).

farmers use residues from banana beer production as organic fertilizer for their banana plantations. This method has significantly increased soil fertility in banana plantations in Rwanda (Van Damne, Barret, & Ansom, 2013).

Failure of imported technologies has prompted efforts to focus on technologies that are made in close collaboration between external inventors and local communities (Agrawal, 2004). Additionally, there are also increasing efforts to nurture the local community inventions and local knowledge and technology. Nurturing and developing local innovations, especially in the rural communities, have been limited especially in SSA. This is despite the crucial role played by technical and vocational education and training (TVET) in poverty alleviation, job creation and improvement of quality of life (UNESCO, 2004). Additionally, TVET has a big potential for modernizing agriculture and improving rural livelihoods (UNESCO, 2004). Developing countries have opportunities that could help them leapfrog innovation development if supportive policies and strategies are designed. One of such opportunities is the recent information technology development and globalization that has exposed developing countries to diverse international and domestic sources of knowledge and technologies (Ernest, 2002; OECD, 2007).

SSA countries have realized the importance of investing in R&D and have been designing policies and strategies for promoting local innovations. For example, the Comprehensive Africa Agriculture Development Programme (CAADP) fourth pillar is concerned with investment in agricultural R&D (Scoones, 2009). Accordingly, the vision of Uganda's medium-term National Development Plan (NDP) of 2010/11 - 2014/15 is "a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years through growth, employment and socio-economic transformation for prosperity."

This study was conducted with a broad objective of determining the impact of local innovations on human welfare and local communities' perception on their ability to innovate. The study evaluated the creative capacity building (CCB) approach which is a community-driven program that allows communities to identify and design their own tools, machines and other innovations that meet their priority needs. CCB focuses on harnessing local creativity and indigenous knowledge in the technology design process, facilitating community-based innovation and invention, with specific objectives of generating income, improve health and safety, save labor and time and change participants' perceptions about themselves (MIT, 2015). The design process is made by distilling key elements into a hands-on curriculum that is accessible at any educational level.

CCB is a unique intervention since it develops the capacity of participants to design and create their own tools and machines. This increases the community ownership of the technologies and is more likely to be sustainable given that it will be designed and maintained by local innovators. Therefore, CCB presents a framework through which anyone can become an active creator of technology and not just a recipient or user of technologies (MIT, 2015). Kulika – Uganda provided the CCB training in close collaboration with D-Lab, which is an innovation lab at the Massachusetts Institute of Technology (MIT).

The following questions were proposed and evaluated in this study.

(i) What are the economic impacts of CCB on beneficiaries? Economic impact of CCB was measured using a number of indicators including change in labor productivity, income generating activities, and household incomes.
(ii) What is the impact of CCB on the behavior of beneficiaries due to participation in CCB? This question was answered using qualitative approaches to measure the impact of CCB on beneficiaries' behavioral characteristics such as collective action, increased pursuit of vocational training by adults and readjustment of intra-household division of labor across sex.
(iii) What is the impact of CCB on the attitude change of beneficiaries? Qualitative methods were used to analyze the beneficiaries change in confidence to innovate and bring change in community, self-awareness and self-esteem.
(iv) What is the adoption rate of new technologies created by CCB? This was intended to measure an intermediate impact of CCB by determining the adoption rate of new tools, machines and other technologies developed in the community.

We used a stratified cluster sample, in which the country was divided into six regions and under each region fairly homogeneous clusters (districts) were randomly selected. The six regions represent Uganda's major) agro ecological zones - namely semi-arid zones in north-eastern, Savannah in the mid-northern region, rainforest in the central and humid highlands in the south-western and eastern regions (Nkonya et al.; 2008). This suggests that results from the six regions could apply to the major agro ecological zones and farming systems of Uganda.

The rest of the study is organized as follows. The next section discusses the CCB approach and its implementation. This is followed by discussion of the analytical approach used, followed by a discussion of data and data collection methods. To motivate discussion of the impact of CCB, a discussion of CCB, innovations made by the trainees is presented followed by a discussion of the results. Conclusion and policy implications are presented as the last section of this paper.

2.0 Intervention, theory of change and research hypotheses

The Creative Capacity Building (CCB) approach was implemented by Kulika-Uganda in nine randomly selected districts (clusters) of Uganda. In each of the selected districts, a total of six parishes were randomly selected. A sampling frame of all farmer groups in the six parishes was constructed. A random sample of xxx farmer groups was selected to participate in the two CCB treatments and the control. The first treatment involved teaching the skills to design and develop tools, machines and other technologies, while using community appropriate technologies to demonstrate the design process. This treatment was assumed to have the largest impact given that it involved the whole process from design to demonstration (hereafter known full-dose treatment). The second treatment followed the traditional technology promotion approach in which only demonstration of designed technologies was given to beneficiaries. Hereafter, the demonstration only treatment is referred to as half-dose treatment.

Each of the two treatments and control was replicated twice, i.e. two of the six randomly selected farmer groups (from each of the nine randomly selected districts) received the full dose, the other two received the half-dose treatment and the other two served as the control. From each farmer group, 24 households were selected randomly for the purposes of the impact evaluation.

The training helped trainees to develop skills for designing their own technologies for improving livelihoods. The technologies were identified in an initial meeting with the community in which major economic activities were discussed. The technologies required to enhance labor productivity and value addition of the selected economic activities were identified. Kulika, in collaboration with D-Lab which is a program at the Massachusetts Institute of Technology (MIT) then provided CCB training in using trained facilitators that resided in the villages of the participants.

The training program followed the following steps:

(i) A two week pre-randomization design tour was made by the research team, D-Lab and Kulika. The design visit helped to establish the nature of development pathway to understand the type of economic activities which the beneficiaries were engaged in, the labor-intensive and physically challenging activities and the likely technologies they would choose to address such challenges. This activity underscores CCB's demand-driven approach and involvement of community members in deciding on the training content.
(ii) Two types of interventions were planned. The first one (full-dose treatment) that include a CCB training and demonstrations of technologies. The second one (half-dose) included the traditional approach of demonstrating the technologies only and expecting community members to adopt them without participating in the design and development of the technology.
(iii) The CCB training workshop was held for four days to demonstrate the livelihood technologies and the basic principles of design. Awareness creation of local technologies and their adaptability was conducted and training was done on how to use/execute a given technology or process. Strategies for creating and making new technologies were discussed followed by challenging trainees to apply these skills to build and test prototypes of their own design. Subsequent training focused on the created technology prototypes and these trainings and interactions were done by a lead trainer and two village-based facilitators.
(iv) Follow-up and mentorship was done to help participants of the full-dose treatment muster their new skills and to design and build other technologies. The village-based facilitators provided technical advisory services but let the trainees do design and building of technologies.
(v) Kulika facilitates creation of community technology centers (CTCs), which increases access to tools and materials and raises visibility of appropriate technologies in the parish. The parish CCB mentors and trainers provide support to the CTCs. The CTCs are meant to continue providing CCB support services beyond the project period, further underscoring Kulika's programmatic, rather than - project approach.

Two treatment groups and one control group were randomly assigned to the selected farmer groups:

(i) **Full dose** – farmer groups which fully participated in the entire design process and hands-on skills-building workshops and demonstration of how the newly developed tools work and their advantages compared to the traditional tools.

(ii) **Half-dose** – farmer groups that received only demonstration on how the new tools work and their advantages compared to the traditional tools/practices. This mimics the traditional method of technology dissemination that has been used in SSA.

(iii) **Control**: farmer groups who were not exposed to any of the treatments.

The training for half-dose took two days for each farmer group. On the first day, participants facilitated by the trainer made preparations for the training, which involved identification of the training venue, and delivery to the venue of the necessary tools to be used in the demonstration. The second day involved demonstration of four technologies namely, energy saving stove, charcoal briquettes, ground paste maker and solar lantern. Follow-up visits were made to monitor the adoption of the demonstrated technologies.

For the full-dose treatment, participants were taken through all the eight steps of the design cycle that was delivered in the following 8 steps over four days: 1) problem identification, 2) gathering information, 3) thinking of ideas and experimenting, 4) choosing the best idea, 5) working out the details, 6) building the tool (prototype), 7) testing the tool, and 8) feedback. The programme content is described in Box 1.

BOX 1

Programme content

Day 1: Pre-training discussion, Technology demonstration training: Energy saving stove and charcoal briquettes, Groundnut paste maker, meat mincer, and solar lantern

Day 2: Introduction, Build it: charcoal stove, Design process: the design cycle, Gathering information and framing the problem

Day 3: Design process: thinking of ideas, choosing the best idea, working out the best details; Building the Selected technology

Day 4: Design process: Building and testing, refining and presenting the prototype; Plenary and feedback

Figure 1 depicts the theory of change developed by MIT D-lab and adapted for impact evaluation. Basic inputs required for the programme include trained staff to facilitate the process, curricula and monetary support to buy materials and basic tools used during the training. The facilitators need a modest facilitation in terms of transport and allowances. For the participants to undergo training, they require support with basic hand tools and seed money to buy materials used in the design process and refining the prototype. They are also provided with lunch but they can be mobilized to prepare their own meals. The immediate outcomes include participants acquiring knowledge and basic skills in wood and metal work, and tools and machines made from the training session. From MIT's experience and experience from this study, group cohesion where participants cooperate and have mutual trust is key for the achievement of these outcomes.

The intermediate outcomes include participants using the skills learnt to make their own tools and machines and fix broken ones. However, participants need access to capital to acquire basic tools such as hummer, tinsnips, pliers, wood saws, G-clamps, wood files, square, markers and vice, and materials to work with such as timber, square metal bars, metal sheets and nails. Local availability of these materials enhances adoption as participants will not spend much money on transport to procure these materials.

In the intermediate and long-run, communities in which CCB trainings are conducted achieve improved productivity, employment opportunities, division of labour, skills development and educational opportunities. Participants get empowered, build confidence and self-esteem, build networks and achieve problem solving skills and creativity. Government support for trainings and institutionalizing CCB curriculum in district programmes and projects are key in achieving these long-term outcomes.

The study, therefore, analyzed CCB on the following four major outcomes:

1. Economic impacts, which were measured using an array of indicators including change in income, income generating activities, employment, labor productivity, value addition, and others.

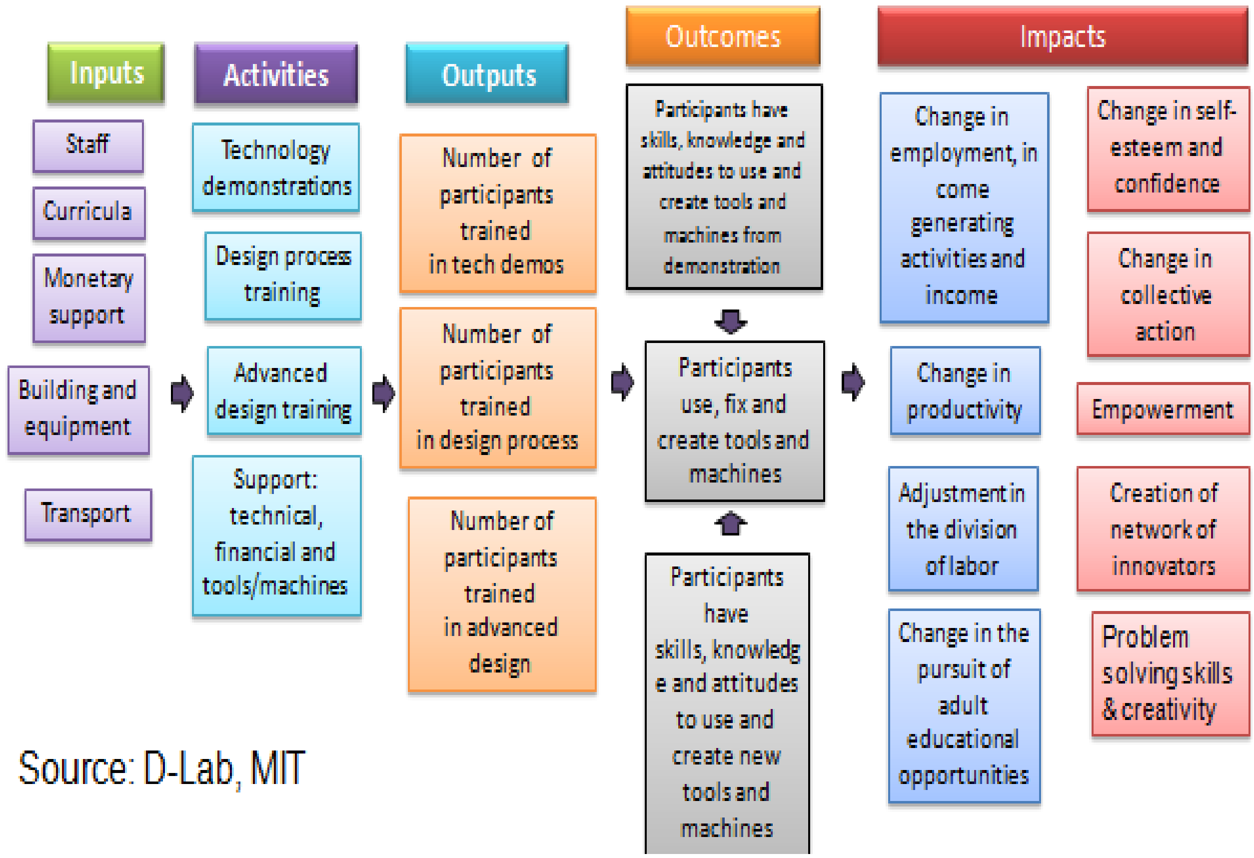
2. Behavioral changes: which were measured using qualitative approaches focusing on the impact of CCB on beneficiaries' behavioral characteristics such as collective action, increased pursuit of vocational training by adults and readjustment of intra-household division of labor across sex.

3. Attitudinal change: also measured using qualitative methods were used to analyze the beneficiaries' change in confidence to innovate and bring change in community self-awareness and self-esteem.

4. Technology creation and use: this intermediate impact of CCB was measured by determining the adoption rate of new tools, machines and other technologies developed in the community. It was also assessed based on qualitative methods.

Implementation of the study also aimed to achieve policy influence by involving policy makers right from the beginning and seeking their guidance and opinion on CCB. This study provides empirical evidence of methods to enhance vocational training of rural communities and promotion of local innovations. The empirical evidence is presented using methods and approaches which effectively communicate with policy makers and other key stakeholders.

Figure 1: Impact pathway - CCB Theory of Change



3.0 Context of the impact evaluation

The study was conducted on participants drawn from a random stratified sample of farmer groups selected from the four administrative regions of Uganda: western, central, eastern and northern. The mainstay in the country is agriculture, which is dominated by smallholder farmers whose livelihood depend mainly on subsistence crop production, cash crop production, livestock production , forestry and nonfarm activities (Pender, et al.; 2003). Livestock production is concentrated in the "cattle corridor" that runs from the southwest bordering with Rwanda to the northeast in Karamoja bordering with Kenya. Livestock represents 17% of the agricultural GDP. Most of the agriculture in the country is rain-fed and vulnerable to climatic shocks. Out of the 202,000 ha of potential irrigable land, only about 20,000 is under irrigation much of which is put to rice production. Besides, water scarcity in much of the rangelands is a major constraint even to livestock production. The average population growth at 3.4%, is well above the growth rate of food production, which averages 1% (Uganda Bureau of Statistics, 2002). Below is a description of the farming systems and social economic conditions of the four regions:

(i) Western region - Receives high bimodal rainfall (above 1200mm per year) in the highlands and medium rainfall in the lowlands. The major enterprises are bananas, coffee, beans and livestock in the highlands and sweet potatoes, millet, maize, beans, bananas and livestock production in the lowlands. The highlands have high population density and high market/road access while the lowlands have low population density and market access (Pender et al., 2003).

(ii) Central region – the region is located in areas around Lake Victoria. It receives high bimodal rainfall (above 1200mm per year). It has high market access and high population density. Banana-coffee is the most predominant cropping system. Maize and beans are also grown but mainly in the drier areas of Sembabule, Mitiyana, Kiboga, Nakaseke and Luwero districts. The region is the most urbanized region with major towns such as Mukono, Mpigi and Wakiso also most merged with the Kampala, currently the only city in the country. Livestock production is mainly by zero grazing and tethering except in the cattle corridor districts of Sembabule, Mubende, Kiboga, Nakaseke and Luwero.

(iii) Eastern region –eastern Uganda lies around Mount Elgon. It has high unimodal rainfall (above 1200 mm per year) in the highlands and moderate rainfall (800-1200mm per year) in the lowlands. Market access is high closer to the Kenya-Uganda border and Mbale city and moderate in the lowlands (Pender at al., 2003). Coffee, banana and cereal production dominate the highlands and cereal & tuber crop and livestock production are the major enterprises in the lowlands.

(iv) The Northern region can be subdivided into three sub regions based on difference in biophysical and socioeconomic characteristics:

a) North-eastern region (Karamoja area). This region is characterized by low rainfall (400-700mm/year) with mainly pastoral farming system. The region has the most severe poverty and low market access in the country. This region was dropped from the sampling frame because pastoralism is the main livelihood for households in the region. It would therefore be difficult to conduct a multi-period study on the same sample of households because they do not stay in the same area for over a year due to prolonged dry periods and households have to move to find grass and water for their animals. Besides, most of the tools identified in the pre-randomized design survey for use as demonstration in the CCB training do not apply to the households in the Karamoja region as they majorly depend on livestock.

b) North-central region – medium-low rainfall (700–1,200 mm/year), and low market access. The region's main production activities include coarse cereal, maize and tuber (sweet potatoes) and root crops (cassava). Livestock production is also a common enterprise in the region. The region experienced a 20-year civil war (1986-2006) – an aspect that left a toll on human development.

c) The north-western region. This region is characterized by Medium rainfall (900-1200mm/year) and low market access – though cross-border trade with South Sudan is improving market access in areas closer to the border. Major crops in the region are millet, tuber crops, tobacco and maize.

Under each of the five strata (regions & sub-regions) discussed above, a multi-stage cluster sampling was done. Population-weighted random sample of nine districts was taken from a total of 118 districts in Uganda, in which the central and western region were each allocated two districts, the east allocated three districts and one district each allocated to north-central and north-western sub-regions. Hence the multi-stage cluster design (without any targeting of particular communities) improves internal validity and our ability to generalize findings to other SSA regions sharing community characteristics similar to those represented in the Uganda sample.

The results of the CCB approach are likely to be applied in other parts of sub-Saharan African (SSA) countries for the following two reasons:

(i) Uganda's socio-economic and biophysical characteristics are comparable to an average SSA country. The 2011 human development index (HDI) for Uganda was 0.446 while SSA HDI was 0.463 (UNDP 2012). Likewise, the 2012 median of the global innovation index (GII) - defined as a new or significantly improved product (good or service) and a new process (Eurostat and OECD, 2005) for SSA was 25% while Uganda's GII was 25.1% (Dutta 2012). This suggests the level of Uganda's innovation is comparable to SSA's average range.

(ii) Given that Uganda has biophysical and socio-economic characteristics comparable to most other SSA countries, the results will also be potentially applicable to other countries. The five regions from which the study sites are located represent the major SSA agro-ecological zones - namely semi-arid zones in north-eastern, Savannah in the mid-northern region, rainforest in the central and humid highlands in the south-western and eastern regions (Nkonya et al 2008). This suggests that results from the six regions could apply to the major agro-ecological zones and farming systems in SSA.

4.0 Timeline

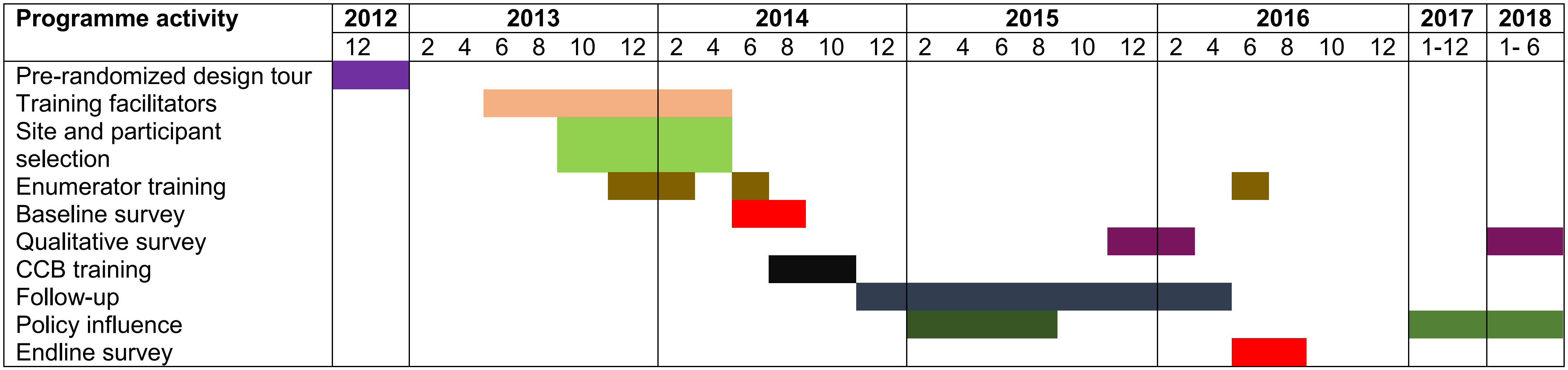
The key events on the timeline are depicted in Figure 2 while the details are described in Table 1.

Table 1: Timeline for implementation and impact evaluation of CCB interventions

No.	Activity	Date	Remarks
1	Pre-randomized design tour	January – May 2013	A two week pre-randomization design tour was made by the research team, D-Lab and Kulika to establish the nature of economic activities in which beneficiaries were likely to be engaged in and the types of technologies they were likely to choose.
2	Training of CCB facilitators	June 2013	Training of facilitators in the design cycle, at Kulika Training Centre
		October 2013	Training of facilitators, in facilitation skills and building confidence, at Kulika Training Centre
		Feb – Mar 2014	Preparing facilitators for community training sessions in test districts of Kamuli and Nakasongola

		Mar – Apr 2014	Training facilitators in the test districts of Nakasongola and Kamuli for 8 weeks
3	Site and participant selection	September – December 2013	Sampling of districts, parishes and CCB beneficiary and control households.
		February – May 2014	Selection of farmer groups. All members eligible for training but up to 24 members in each group interviewed during baseline survey qualify for CCB training
4	Baseline data collection		
4.1	Enumerators	December 2013 – February2014	Recruitment and training of enumerators
		June 2014	Retraining of enumerators due delay in baseline survey
4.2	Data collection	June – August 2014	Data collection, editing in the field, callbacks
4.3	Data analysis	September 2014	Data editing, processing and analysis
4.4	Baseline report	November - December 2014	Writing baseline report
5.0	CCB implementation	July – August 2014	Training participants in CCB in 9 districts by 18 facilitators and 4 district coordinators Commencement of design cycle Creating appropriate technology
	Monitoring	Sep 2014 – December 2015	Monitor progress among CCB beneficiaries to perform technical backstopping and endline survey
	Follow up support	Sep 2014 – Mar 2016	Continued technical support to CBB full-dose beneficiaries
6.0	Policy engagement	January – June 2015	Presentation of baseline report to Kulika, stakeholders and at conferences and workshops
7.0	Endline survey	June 2016	Enumerator recruitment and training
		July 15 – Aug 2016	Data collection
		Aug – Sep 2016	Data cleaning
		Oct 2016 – March 2016	Data processing, analysis and report writing
8.0	Policy influence	March 2017 -2018	Workshops, Conferences, Policy briefs, papers

Figure 2: Timeline



5.0 Evaluation: Design, methods and implementation

The study was conducted by researchers from Makerere University in collaboration with the International Food Policy Research Institute (IFPRI). All activities were agreed on internally between the research team and Kulika Uganda, which is the implementing agency and MIT D-lab scientists who developed the CCB Training. Participants of the study acknowledged receipt of letters and made written willingness to participate in the study (see Appendix 1 for the copy of the letter of consent).

5.1 Evaluation and identification strategy

We conducted a randomized controlled trial (RCT) to evaluate the impact of creative capacity building training on four major outcomes: behavioral change, attitudinal change, technology generation and economic benefits. The RCT design made it possible for selected households to be representative of the population of households in Uganda. Given that Uganda has biophysical and socio-economic characteristics comparable to most other SSA countries, the results are therefore potentially comparable to those of other countries.

We used mixed methods to analyse the impact of CCB using both the quantitative and qualitative methods in order to harness the advantage of each. The mixed method approach enhances external validity since it takes advantage of strengths of a variety of methods used in socio-economic research.

Qualitative methods

A qualitative assessment was undertaken to address three of the four major CCB impact outcomes namely; behavioral change, attitudinal change and technology generation. The impact of CCB on economic benefits was assessed on quantitative data as discussed in the quantitative methods section below. We used Focus group discussions (FGD) involving the CCB beneficiaries only. Qualitative approaches are better placed to analyze power dynamics within a community (Hesse-Biber, 2010), attitudes and perceptions that may not be captured using quantitative methods. According to Moore and Benbasat (1996) and Perez-Diaz (2003) understanding attitude and the behavior is best analysed using qualitative approaches. Qualitative approaches also provide rich and detailed information on how people experience, understand and determine adoption and livelihoods (Clifford, 2014).

Two qualitative assessments were conducted: a midline in December 2015 to January 2016 after close to one year and two months of programme implementation and the endline survey conducted in March - April 2018. The midline qualitative assessment was conducted by an intern from IFPRI. She held focus group discussions with selected individual members of 12 out of the 18 CCB groups due to financial and time constraints. The endline qualitative assessment was conducted by an independent consultant and used 16 of the 18 CCB full dose groups. Two groups were not surveyed because one group was reported to have disintegrated and most of its members had disappeared as a result of a conflict in the area the second group could not be located even after multiple visits. The focus group discussions centered on the CCB training and its impact on attitudes.

Considering the expected impacts on attitudes and behavioral change, we analysed the beneficiaries' perceptions about themselves, technologies developed and CCB training. Data were collected through semi-structured interviews, which allow discovery of unknown impact and information that is not expected and permits comparison of responses. All the interviews started with an easy and open question on participants' feelings and expectations about the training/project in order to make all participants comfortable. The interview then proceeded with the following points according to the hypothesis of the research design: expectations of participants, knowledge and skills acquired; challenges and solutions offered by groups, perceptions of technology and innovation before CCB and lessons learnt.

In order to avoid biased responses, questions were asked without examples. The interviews were conducted by the same team to avoid bias from different interviewers. The endline assessment was a cross-sectional qualitative study. Data were collected through focus group discussions (FGDs), key informant interviews and individual interviews. The research team set out to conduct FGDs with all the 18 full dose groups in the 9 project districts. Each district had two full dose groups with a membership of 24. For the FGDs, 8-12 members of each group were selected. Selection was based on a combination of factors: being an active member, holding a leadership position and gender. A more balanced group with women, men and the leadership of the group was well represented was selected. From the discussions, a member or two of each group making a technology were identified and individual interviews held with them.

The field data collection process began the central region, followed by the western, eastern and ended in the northern regions of Uganda. In each of the districts, key informant interviews were held with the District Production and Marketing Officer (DPMO) and the District Community Development Officer (CDO). In some of the districts including Sembabule, Isingiro, Rukungiri, Pallisa and Alebtong both the DPMO and CDO or their representatives were met. In others such as Mpigi, Soroti and Alebtong one of either the DPMO or CDO or representative was met. In Amuria, both the DPMO and CDO had travelled to Kampala. The key informant interviews focused on the level of awareness in the district leadership about the CCB training, its impact and sustainability. The research team sought to establish how much the relevant district departments knew about the CCB training, its impact and what plans they have for integration into their development plans.

FGDs were held with all the 16 groups accessible to the research team. Informed consent was sought on phone. Appointments with group leaders were made one to two days before the FGDS. The discussions were based on two broad issues articulated in the schedule in appendix 1. The coverage of CCB training and access to materials for applying what was learnt and the impact of the training on the beneficiaries. Questions focused on the background of the group, how the trainings were conducted and members access to materials for applying the new knowledge and skills. On impact of CCB project, questions focused on what benefits members gained as individuals and as groups and whether the training had provided opportunities for further training and how gender roles have changed at the household level as a result of the training. Specifically on technologies, the discussions brought out comparison based on labor saving, quality and price between the technologies made by members and those in the market and the traditional practices. All FGDs were recorded and highlights were summarized on flip charts to provide guidance in discussions. The questions were asked by the lead researcher in English and translated into the local language by the facilitator who had to be proficient in the local language. The research team had four facilitators one for each region given that the language spoken in each region is different. One other team member who summarized took notes in the discussions also had to be fluent in the local language. There was then a translator for the rest of the team members unable to understand the local language. In addition to the electronic recording, pictures of the technologies made and meeting set up were taken.

In the FGDs, one to two members who had technologies to show the research team were visited and individual interviews were held with such members. The interviews mostly focused on their level of access to local materials for making the technologies, the quantities produced and sold, marketing challenges and on how they use the money generated from the technologies they have made.

Qualitative data analysis

The information collected was largely qualitative. The analysis followed some basic principles of content analysis in qualitative studies. The recorded information was transcribed into text. Analysis of text then followed. Reading line by line, key issues in answers to each of the questions were identified and categorized and examined closely. From this, the key points that repeatedly came up from transcripts of different FGDs were identified. After identification of the key points, a second reading through the text was done but this time with a focus on the key points and their relationships with each other. From this a list of the key issues raised in the responses to question was generated. How the key points were articulated in the FGDs were established in the subsequent readings. The small portion of quantitative data on the comparison between the technologies developed and existing technologies in the market and local practices based on labor saving, quality and price was analyzed by determining the averages of ratings (1-5) of technologies for each region.

Quantitative methods

To ensure robustness of results, we use the following two identification approaches:

(i) As already discussed above, a randomized control trial (RCT) was used to design this study. Accordingly, our identification empirical approach assumes that randomization was fully achieved and the treatment and control groups are balanced in both observable and unobservable characteristics. Additionally, we assume that all changes in outcomes are due to treatment effects and all other changes are random and captured in the error term assuming unconditional independence assumption. Baseline and endline survey data collection was done to form a panel data that allows us to identify impact using the following model:

$$\Delta y = \beta_0 + \beta_1 FD + \beta_2 HD + e \qquad (1)$$

Where Δy= change in outcome of interest (Y) from baseline period 1 to endline period 2; FD = full dose treatment in which the treated groups received both CCB training and demonstration of the CCB technologies; HD = half dose treatment in which beneficiaries only received demonstration of the CCB technologies; e = random error, which is normally distributed; β_1 and β_2 are coefficients measuring the impacts of FD and HD on the outcome variable which are the measures of Difference in difference specification; *DiD* = $\left(y_2^T - y_1^T - \left(y_2^C - y_1^C\right)\right)$. Y_1^T and Y_2^T are levels of outcome Y in baseline and endline periods, respectively for the treatment group Y_1^C and Y_2^C are levels of outcome Y in baseline and endline periods, respectively for the control group.

(ii) If selection bias persists even after randomization, a controlled approach is necessary to achieve identification and address the bias assuming conditional independence assumption. We use an econometric approach to control for other covariates that affect the outcome Y.

$$\Delta y=\beta_0+\beta_1 FD+\beta_2 HD+X\theta+e \quad (2)$$

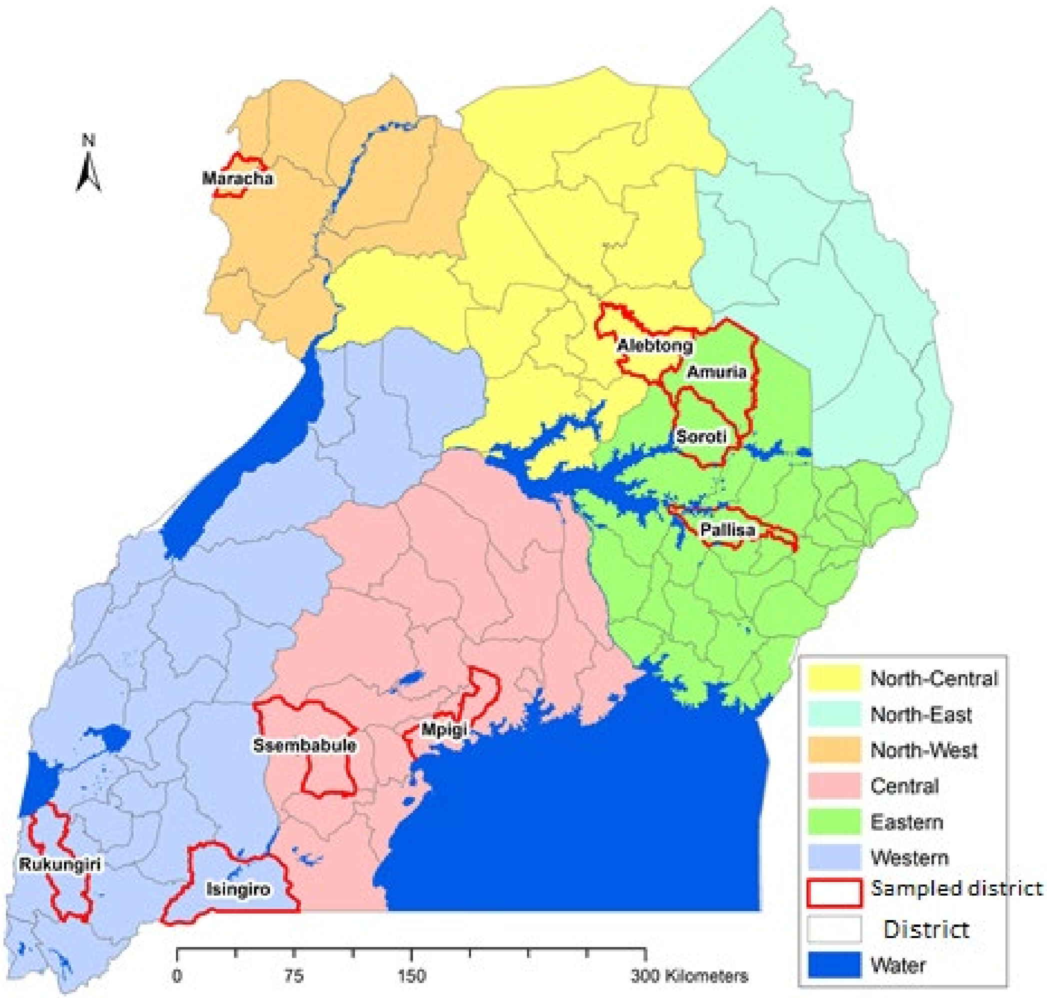
Where X = a vector of covariates affecting Y and participation in CCB, θ is a vector of coefficients associated with X. Other variables are as defined in equation (1). The X vector of covariates in equation 2 are intended to net out any imbalances between treated and control groups and this improves precision of the impact estimates. All covariates were taken at the baseline level to ensure that we don't include the treatment effects in the model. The X covariates included household head characteristics (age, education, sex, primary activity, whether ever attended vocational training) and household characteristics (number of adult males, number of adult females, value of non-land assets). For continuous outcomes, equations 1 and 2 were estimated by Ordinary Least squares estimation. Binary outcome were estimated using the linear probability model (LPM). We also estimated Probit models for the binary outcomes but the results are not reported because the coefficients were similar to those obtained from the LPM.

5.2 Sampling design and treatment assignment

The difference in socio-economic and biophysical characteristics discussed in the context section, guided the formation of regions and clusters. A stratified cluster random sampling was used in designing the random control trial (RCT) design. The country was divided into six clusters with fairly homogeneous biophysical and socio-economic characteristics. The first three clusters: Western region, central region and Eastern are among the four administrative regions used in government documents (e.g. Uganda Bureau of Statistics 2012). To reflect its major differences, the fourth region (i.e. the Northern region) was subdivided into three sub regions: North-eastern region, North-central region and north-western region.

Under each of the five strata (regions & sub-regions), a multi-stage cluster sampling was done. Population-weighted random sample of nine districts was taken from a total of 118 districts in Uganda, in which the central and western region were allocated two districts each, east allocated 3 districts and one district each for north-east and north-central (Figure 3), the north east was dropped from the sample.

Figure 3: Regions, sub-regions and sampled districts



We used two levels of clustering. The district level formed the first-stage clustering and the second-stage clustering was based on farmer groups within each of the selected districts. The selection of farmer groups was fused with the selection of parishes from each district. First, six parishes were randomly selected from each selected district. Second, a sampling frame of member groups was developed from all the selected six parishes, with the help of community leaders, from which a random selection of groups was done (Figure 4). The decision to use farmer groups instead of individual households was based on MIT-Dlab experience that CCB training is more effective on groups of farmers who have been previously working together compared to a group of farmers who have never worked together before. Groups with less than 10 members were dropped from the sampling frame as well as those whose membership could not be established. Groups of less than 24 members but above 10 were merged to generate one group with sufficient members for the CCB training.

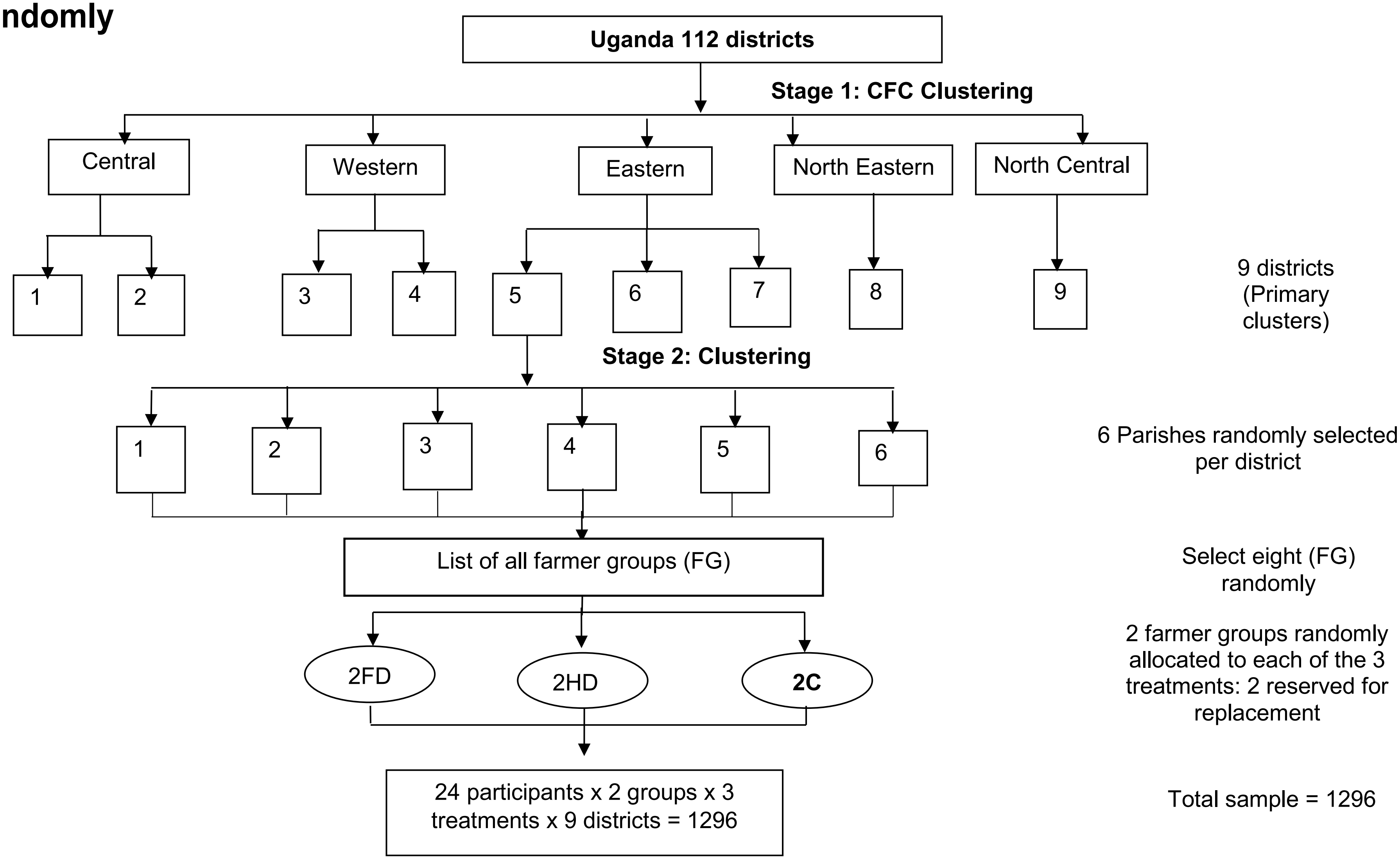
Eight groups were randomly selected from the sampling frame. Six out of the eight groups were then randomly assigned to the three treatment groups (2 each for Full dose, half dose and control). The two remaining groups were used for merging in case there were groups with less than 24 members to form one group or otherwise dropped. In each district, the survey team interviewed the first 24 members per group, based on availability of the respondents during the time of survey. This gave a total sample of 1296 member respondents (2 groups x 24 members x 3 treatments x nine districts) out of which the survey team managed to interview 1235 respondents (Table 3), this was a 95.3% realization of the planned sample which is quite a high coverage and success in the field.

Table 2: District level sample across treatment groups

District	Sample size (N)	% Full Dose	% Half Dose	% control
Pallisa	154	32	36	32
Rukungiri	131	34	31	36
Isingiro	139	25	39	36
Maracha	129	35	34	31
Mpigi	134	31	34	36
Soroti	135	30	33	37
Sembabule	135	34	30	36
Alebtong	144	35	33	33
Amuria	134	34	32	34
Total	1235	32	34	35

Figure 4: Sampling Design scheme

randomly



5.3 Sample size determination

Power calculations

Effect size: We did not have clear estimates of expected effect sizes, since beyond the 1st order effect of adopting the workshop technologies (which likely will have significant impacts on labor or production), we expect 2nd order effects due to farmers' own innovations – a sum of small effects resulting in aggregate labor savings or productivity outputs to be significant. Discussion with communities during the design field visits revealed that use of techniques, such as drip irrigation and vermin trap, increase crop productivity or reduced harvest loss by 50% to 100%. Additionally, literature review showed that training programs similar to CCB increased income and employment with an effect size ranging from 7% to 100%, with most of the programs witnessing an effect size of 20% to 100% (Blattman, et al., 2011; Benin et al., 2010; King et al., 2012; Attanasio et al., 2011). Based on this, we used effect size of 35%.

Intra – Cluster Correlation (ICC) estimation

We used the 2005/06 Uganda National Household Survey (UNHS) data and grouped farms by district and by farm size. Intra-cluster correlation (ρ) was calculated at parish and district levels and we obtained about 30 households per cluster and a power of 0.80. This is equivalent to the number of trainees which Kulika and D-Lab had proposed to train. The parish-level cluster size design for evaluating parish-level effects, also gives a sample of 30 participants in each parish for each treatment. The original plan was to use the parish for selecting individual households. This plan changed due to MIT D-lab's recommendation of using farmer groups. MIT D-lab also recommended selection of 24 participants per group as the most appropriate for CCB training.

We grouped farms by district and by farm size, and filtered these subgroups for outliers (log-transforming the data and iteratively filtering points having z-scores greater than 2 in the log scale). From this we obtained rough estimates of our quantities of interest in different districts. We noted that CCB training and the designed innovations may increase labor productivity and thus we expected variability to be lower in our own sample than observed in the UNHS. We used three districts where Kulika had CCB centers as examples.

Using the Optimal Design software (Raudenbush et al. 2011) and Fox et al.; (2009), intra-cluster correlation (ρ) was calculated at village, parish and district levels. However, observations at village level were very few, with a maximum possible sample in each village of 10, with only 1 or 2 observations in most villages. This led to noisy estimates of village level means and thus over-estimation of ρ. Estimates showed that, the ρ values of households within a village across districts, converged to around $\rho = 0.2$ as the size of the sample increases, though we noted again our expectation that even in the best cases, this is an overestimate due to low sampling rates in villages.

Of interest to us were the values for ρ-parish-household and ρ-district-parish. In the case of the former, we expected the larger populations to average out differences, reducing intra-cluster correlation, and the relatively small geographic area within districts to introduce little spatial variation; thus we expected ρ-parish-household to be smaller than ρ-village-household, and we estimated a value of 0.1 for design calculations.

Results

Sample size per cluster: At household level, a design with 9 district clusters and two replications per treatment of the full dose and half-dose treatments with effect size of 35%, we calculated about 30 households per cluster and a power of 0.80. This is equivalent to the number of trainees which Kulika and D-Lab have proposed to train. The parish-level cluster size design for evaluating parish-level effects, also gives a sample of 30 participants in each parish for each treatment.

Total sample: Our design generated a randomized sample of approximately 144 members in each district for baseline and endline data collection. As earlier noted, a random sample of 24 members was drawn from each of the two member groups selected for each treatment (full-dose, half-dose and control). The control group was used to measure the impact of the CCB treatments (full and half-dose treatments). Table 4 summarizes the sample size in each of the two treatment types and the control.

Table 3: Household sample size

	Full dose	Half dose	Control	Total
Baseline survey	402	419	430	1252
Endline survey	323	326	396	1045
% attrition	20%	22%	8%	17%

Source: Baseline and Endline Household Survey

5.4 Data

To evaluate the CCB program, the baseline survey was administered in June-July 2014 while the endline survey was implemented in August-September 2016. A total of 1252 households were surveyed at baseline and 1042 households at endline, resulting into an attrition rate of 17% (Table 4). Household surveys collected information on household characteristics, CCB trainee characteristics, ability to design and make tools and machines, ability to repair tools and machines, use of tools and machines in household livelihood activities, household economic activities, labor contributions of men and women in household production activities, crop productivity, livestock productivity, non-farm income participation and consumption and expenditure data. The questions were similar in most cases between those administered in the baseline and endline surveys to enable computation of net changes in impact analysis for the key outcomes used in this study.

The survey tool is included as a separate attachment and was administered using tablets to reduce on data entry errors. The data were collected by enumerators with first degree in agricultural economics, agriculture or agricultural engineering as the minimum level of education. The enumerators were trained in tablet use and administering the tool immediately before the baseline survey and endline survey. Selection of enumerators and allocation to different regions was determined by knowledge of local language. The whole survey team comprised of 28 members divided into four groups. Each of the four groups comprised of six enumerators and one supervisor. The supervisors obtained the data from the enumerators for auditing. The data were also sent to the national research supervisor and IFPRI data specialist for edit checks. Callbacks were made in case of missing data and any other anomalies. Codes for data entry were generated in advance to ensure uniformity. Uncoded data were entered directly and later coded by the IFPRI specialist. The data entry form was formatted in such a way that enumerators were obliged to first complete one question before proceeding to the next.

5.5 Strategies to manage bias

Hawthorn effects (treatment group behaving differently under observation): We minimized Hawthorn effects in our design by ensuring that the impact evaluation (IE) team is not explicitly linked to Kulika intervention, and that any activities done by both teams are independent. For example while training by Kulika was done in groups, the participants were independently interviewed in their households.

John Henry (JH) effects (non-treatment group behaving differently after knowledge of treatment): We addressed the issue of JH effects between treatment and control by selecting a sampling scale (parish) that keeps the risk of contamination between units in the sample low. Participants from the same farmer group belonged to the same treatment and were less likely to be in close proximity of another group since the listing was done at parish level and selection at district level (from a list of six randomly selected parishes). A total of 6 of approximately100 parishes in a district were selected, and our expectation is that diffusion of knowledge about the intervention will be very low outside of the parishes. Our design tour to selected districts also confirmed the low diffusion across parishes. Within parishes, for those parish group members not invited to participate in the workshop, the Kulika group frames the response to convey the message that training workshops are aimed at helping the community learn how to design solutions to its problems but Kulika is only able to invite a small number of randomly selected people, who are expected to train others in the district. The random selection was used to allay fears of favoritism in the selection.

Compliance with Encouragement: To ensure that the selected households participate in the CCB training, some basic facilitation was given to the participants during training. Kulika-Uganda designed a culturally appropriate means of compensating workshop participants by making the workshop broadly appealing. This also included receipt of finished technology products and the provision of meals, workshops tools given to participants as a group, and any transportation expenses during training. Training was limited to group selected participants and were facilitated by facilitators who resided in their local environment. The need to belong to the particular groups minimized the issue of non-invited participants attempting to join. Facilitation minimized the self-selection bias and therefore improved internal validity.

6.0 Programme: Design, methods and implementation

6.1 Key programme elements and activities

Creative Capacity Building (CCB) was developed and promoted by Massachusetts Institute of Technology (MIT-Dlab) as an approach to international development with a goal to train participants to create and adapt technologies that improve their lives and strengthen their communities. CCB enhances people's creativity and builds confidence among participants in creating technologies that can improve their livelihoods. The approach was first used in the post-conflict areas of northern Uganda in 2009. It was thereafter refined and expanded to be relevant beyond post-conflict areas. It is different from other design approaches in the sense that it encourages design by people living in poverty instead of designing for people living in poverty. The latter is top-down approach and the former is a bottom-up approach.

The implementation of the program involves a design process with key elements that include a hands-on curriculum that is accessible at any education level thereby presenting a framework through which anyone can become an active creator of technology and not just a recipient or user of technology.

The exercise began with a pre-training exercise for trainers/facilitators in the districts of Kamuli and Nakasongola. More than half of the total number of trained farmers in the pre-training had been able to make their own early versions (prototypes) of the different technologies. Three-quarters of the trained farmers' skills were developed especially in working with wood and metal.

After the pretesting of the curriculum in the two non-project districts, it was realized that the curriculum was too congested to be delivered in three days. Therefore, it was revised to be delivered in four days such that participants could have enough time to think through all the steps of the design cycle.

6.2 Programme content and delivery

The program was delivered through training sessions to participants in group sizes of 24 participants on average. Each group of 24 people was divided into 4 teams of six people each to enable them to actively participate in the design process. The groups were sampled by the research team and participating individuals from the groups were determined at the time of the baseline survey – those that had participated in the baseline survey. Kulika Uganda carried out a sensitization of the participants before the commencement of the trainings. All the participating individuals were registered and briefed about the training schedule.

Each district had four farmer groups of 24 participants each making a total of 36 groups (4 groups x 9 districts) and 864 trainees (4 groups x 9 districts x 24 participants). Two of the groups received full dose treatment (both training and demonstration) and the other two groups received half dose treatment (demonstration only). The treatments were administered as follows:

- Full dose treatment

  Full dose treatment entailed one day of preparation, 4 days of training and one day of demonstration whereas half dose treatment entailed one day of preparation and one day of demonstration.
  - ✓ 1 day for preparation
  - ✓ 4 days for training
  - ✓ 1 day for demonstration
- Half dose treatment
  - ✓ 1 day preparation
  - ✓ 1 day demonstration

The program content was delivered by community facilitators and district coordinators who had been trained by Kulika and MIT-Dlab. The facilitators had a minimum of certificate qualifications and the coordinators had a minimum of diploma and a maximum of Bachelor's degree. The trainers interacted regularly with the research team right from the beginning of the evaluation during training workshops for enumerators, monitoring, stakeholder workshops and meetings between Kulika, MIT-Dlab and the evaluation team from Makerere University and International Food Policy Research Institute (IFPRI).

The facilitators and coordinators were trained three times.

In the first round of training, they were taught to understand the full design cycle and how to apply it in real life situations. The trainings were conducted at Kulika centre.

During the second round of training, facilitators and coordinators learnt how to deliver the whole curriculum in the pre-testing districts (Kamuli and Nakasongola).

In the third round of training, the facilitators and coordinators came together for a final debriefing, they also reviewed the curriculum and translated it into local languages, namely, Luganda, Lugbara, Ateso, Langi, and Runyankole/Rukiga. Thereafter, they reported to their respective districts to implement the program activities.

The facilitators and coordinators were aware that they were participating in a research experiment right from project initiation. However, trainees were not aware that they were participating in the experiment. The implementing agency was different from the research team and the environment under which the programme and research were conducted were different. Participants were trained as a group in a central place usually under a big tree in the compound of one of the group member and occasionally in school or church premises. The trainings were delivered within the communities in a casual environment with flip chart and the chairs arranged in a semi-circle mostly under a tree. On the other hand, researchers found and interviewed the participants in their homes. Besides, there was limited interaction among the groups selected because they were far from each other.

The design cycle part of the training was delivered in four days of eight hours each and technology demonstration was delivered in one day of approximately six hours. During the training, there were games and plays designed to keep participants active and engaged during sessions. Participants were also provided with tea and lunch. Each group was maintained at 24 trainees in four teams of six members each. Teams worked together to design different technologies.

The materials required for the programme included timber, square metal bars, metal sheet, nails, hummer, tinsnips, pliers, wood saws, g-Clamps, wood files, square and markers and vice while technologies used in the demonstration included meat mincer, Solar lantern and Energy saving stoves.

After training, the facilitators and the coordinators had follow up meetings with the full dose and half dose groups. The follow-up meetings were designed to encourage group members to establish meeting dates so as to continue refining and making new technologies in response to the emerging farm challenges. Averagely, each group met once a week to do refinement and make new technologies. The facilitators timed their visits to each of the groups during designated meeting dates. Such visits provided groups with technical design guidance and review and delivery of needed materials for technology creation and refinement. Each full dose group was visited 4 times a month for six months after training. However, technical backstopping continued officially up to one year but the groups still make consultations up to now. The facilitators offered technical advice whenever they were called upon. The half dose groups received follow up visits only two to three times during the project period. The first visit was to identify a list of products or technologies participants wanted to buy that would be delivered in the subsequent one or two visits.

The program protocol was prescriptive as illustrated in the training curriculum. However, the participants made several prototypes in one session. This demonstrated that the participants had understood the design cycle. The technologies developed were also responding to challenges in their daily activities at household level.

Technology demonstrations were conducted using already existing technologies. These included energy saving stoves, charcoal briquettes, groundnut paste and solar lanterns. During the initial sensitization meetings with the farmers, it was noted that the participating groups did not grow rice, so the “rice de-husker” was dropped from the technologies for demonstration. Thereafter, there were no notable deviations from the protocol during the actual implementation of the program.

During the design cycle, participants were taken through the following eight steps of the design cycle one by one: problem identification, gathering information, thinking of ideas, experimenting, choosing the best idea, working out the details, building, testing and getting feedback
Follow-up visits: After the training, there were follow-up visits made by the facilitators and the coordinators to ascertain what the trainees were doing and also appreciate those areas where the groups needed additional help.

6.3 Attrition

The sample used in the impact analysis showed a 17% attrition rate from the original baseline sample. We assessed attrition bias by comparing baseline characteristics of the attritors and non-attritors and the results show that mean comparisons on most characteristics did not differ significantly as shown in Table 5. Attrition in the sample was therefore more random than non-random. The implication is that generally the endline sample despite attrition is still similar to the baseline sample and any inference from it can be generalized for the original population. Despite this favorable evidence of lack of serious attrition bias, we adjusted our impact estimates for attrition bias using a two-stage inverse probability weighted regression procedure (IPW) (Weuve et al 2012) – an approach that is increasingly used to correct selection bias in treatment effects studies that is referred to as double-robust estimators (Bang and Robins 2005; Robins, et al.; 1995; Robins 2000).

We present several impact estimates of CCB in the result tables to demonstrate robustness and sensitivity of our results to different econometric estimators under uncontrolled and controlled difference-in-difference. Robustness and sensitivity of impact results is shown in the results from the different approaches used to estimate impact. In all the impact results on all outcomes presented in this study, we find very robust findings, which strengthen our confidence in the results.

Table 4: Attrition bias

Pre-treatment characteristics	Non-Attritors	Attritors	(P-Value)
Female headed Household (%)	19.2	19.1	0.994
Age of household head	44.3	41.4	0.005***
Number of household members >15 years	3.3	3.2	0.558
Years of schooling of household head	6.5	6.3	0.396
Number of adult males in the household	1.2	1.3	0.651
Number of adult females in the household	1.3	1.4	0.433
Had any vocational training (% yes)	29.4	30.1	0.821
Value of non-land assets (000 UGX)	511.4	508.0	0.961
Consumption expenditure (million UGX)	2.42	1.95	0.004***

Note: UGX = Ugandan Shillings

Source: Baseline and Endline Household Survey

7.0 Impact analysis, results and discussion of the key evaluation questions

7.1 Baseline balance tests between the treatment groups and control groups

We test whether the experimental design of this study was effective in achieving balanced groups between the treatment and control across several pre-intervention household and individual characteristics. The results of the balance tests are shown in Table 6 and the statistical tests provide strong support for the success of the RCT design in being able to balance the groups across many characteristics. This gives credibility and strong internal validity to claim attribution of the CCB interventions to the observed changes in the outcomes that will presented in the later sections.

Table 5: Balance tests among treatment and control groups

Variable	Overall Sample	Full Dose	Half Dose	Control	Mean Equality Test Full Dose=Half Dose=Control (P-Value)	Mean Equality Test Full dose= Control (P-value)	Mean Equality Test Half dose= Control (P-value)	Mean Equality Test Full dose= Half dose (P-value)
Household members above 15 years	3.2 (1.8)	3.2 (1.7)	3.3 (1.7)	3.2 (1.9)	0.725	0.987	0.942	0.814
Household members below 15 years	7.3 (5.1)	7.5 (4.9)	7.2 (5.4)	7.2 (5.2)	0.568	0.713	1.000	0.750
Household size	10.5 (5.85)	10.6 (5.56)	10.4 (6.03)	10.4 (5.70)	0.8483	0.927	0.999	0.965
Age of household head	43.8 (13.4)	42.0 (12.8)	44.9 (13.8)	44.3 (13.4)	0.006***	0.047**	0.889	0.007***
Number of adult Males	1.2 (1.0)	1.2 (0.9)	1.3 (0.9)	1.2 (1.0)	0.3192	0.652	0.372	0.969
Number of adult Females	1.3 (0.9)	1.3 (0.9)	1.3 (0.9)	1.3 (1.0)	0.893	0.976	0.960	1.000
% Female headed households	19.2 (39.4)	16.1 (36.8)	17.4 (38.0)	23.7 (42.6)	0.011**	0.016**	0.058*	0.952
% Own smart phone	8.5 (28.1)	9.4 (29.3)	8.6 (28.1)	7.7 (26.6)	0.664	0.745	0.951	0.963
% Own cell phone	62.9 (48.3)	64.5 (47.9)	61.1 (48.8)	63.0 (48.3)	0.596	0.959	0.916	0.673
% Own bicycle	62.2 (48.5)	62.8 (48.4)	64.4 (47.9)	59.5 (49.1)	0.325	0.706	0.366	0.947
% Own radio	76.4 (42.5)	78.2 (41.4)	74.9 (43.4)	76..3 (42.6)	0.551	0.891	0.956	0.622
% receiving remittances	3.7 (18.8)	4.0 (19.6)	3.3 (18.0)	3.7 (18.9)	0.890	0.997	0.988	0.950
% received financial credit	26.7 (44.2)	28.5 (45.2)	26.3 (44.1)	25.3 (43.6)	0.567	0.656	0.987	0.842
% belonging to credit savings group	56.4 (49.6)	57.0 (49.6)	58.6 (49.3)	53.8 (49.9)	0.436	0.783	0.502	0.969
% belonging to Labor sharing group	2.7 (16.2)	3.0 (17.0)	2.9 (16.9)	2.2 (14.7)	0.783	0.898	0.917	1.000
% with vocational training	29.4 (45.6)	32.3 (46.8)	29.4 (45.6)	26.7 (44.3)	0.218	0.224	0.788	0.739

7.2 Qualitative results

We first present the results obtained from the qualitative study which only focused on CCB beneficiaries. This will help us to get a good picture of the innovations designed by the beneficiaries, their perception about themselves and their innovations as well as other important aspects.

Impact on behavioral characteristics and attitudinal changes

New knowledge and skills gained from CCB training: Three aspects of new knowledge and skills have been considered. These are what participants believed they gained as new knowledge and skills from participating in CCB, the most and least applicable of the new knowledge and skills.

Discussions with participants repeatedly brought out the following as new knowledge and skills gained from participation in CCB training: making a maize sheller, groundnut plucker and sheller, root tuber (sweet potato, potato and cassava) slicer, briquettes and juice blender. Others mentioned were making a seed cleaner, coffee pulping machine, coffee huller, baskets and bags, poultry cage, energy saving stove, seed planter, rake, wooden weighing scale, and fruit harvester. While many of these were mentioned in all regions, there were regionally specific knowledge skills highlighted. The making of the millet harvester was in the northern region and musical instrument in the eastern region. Specific to western region, were knowledge and skills in making bags and baskets among both men and women. Meanwhile acquisition of knowledge and skills in making a fruit harvester was mentioned in the eastern and northern regions.

Most applicable new knowledge and skills from CCB training: After listing, in no particular order, all the new knowledge and skills gained from attending CCB training, participants were asked to give the most applicable of them all. The most applicable and widely used was the Maize sheller. Members of most groups (10 out of 16) used maize shellers across the country. The second most applicable and highly rated technology was Briquettes making. Members of half (8/16) the groups interviewed knew briquette making and so made briquettes for sale. This was one of the most widely applicable technologies in all regions. Among the root tuber slicers, Sweet potato slicer, was rated the most applicable. Members of five of the groups in eastern and northern Uganda with whom discussions were held regularly used the sweet potato slicer. Other technologies rated highly were the Groundnut sheller and Plucker**.** The groundnut sheller was very applicable in leading groundnut growing areas mostly in eastern and northern Uganda. Carpentry and fabrication knowledge and skills in general were rated very highly and considered as one of the most enduring legacies of the project. Both men and women expressed gratitude for knowledge and skills in carpentry that they said is widely applicable in their livelihood activities. In all the regions, one of the key outcomes of the project mentioned was the knowledge and skills in wood and metal works among both men and women

The least applicable technology**:** Among the not so applicable and least preferred technologies was Cassava slicer**.** Some groups said the technology required a lot energy when the blade is not sharp and was thus more of a burden. Groups that found cassava least applicable were

Katobotobo Zone A and Kempungu and Murama Coffee Farmer's Association in Rukungiri district and Candibazu Women's group in Maracha district. Other technologies that were found to be less applicable especially in eastern and northern Uganda were the groundnut sheller and coffee huller**.** Coffee is not widely grown in northern Uganda and as such application of a technology made for coffee processing is expected to be limited. The Wooden weighing scale was also rated as least applicable in the two groups in Pallisa district, Rwantama youth Association and Apetet Family Care Association because of bulkiness especially during the rainy season. In Apete family care association the technology was used only when they are weighing meat in the trading center. The Seed planter was least applied in Katobotobo zone A group in Rukungiri and Okude Youth United group in Amuria. The machine was difficult to make because a lot of materials were needed and yet the demand was very low among the population. The Wheelbarrow was made by three groups including Apit Penyer in Alebetong, Candibazu Women group and Kibwera Kweyombeka. There was less enthusiasm for its use because making a wheel barrow required a lot of time and materials yet they were difficult to use in hilly areas. The **fruit harvester** was the least applicable because of its seasonal use.

Other benefits from CCB training

Asked if they attended similar trainings and what the differences with CCB might be, almost all the participants reported having not attended any similar training. It was expected that participation in the CCB training would motivate participants to pursue further vocational training in various related fields. Unfortunately this proved not be the case with the exception of one group member from Katende Youth group in Mpigi who enrolled for a diploma in civil engineering in Kyambogo University soon after the training. Participation in the CCB training made him realize his true passion for civil engineering. At the time of the interview he was in his second year at the university.

Apart from acquisition of knowledge, skills and start up tools and materials, the CCB training had other far-reaching benefits to individual group members and their groups. As individuals, participants benefited in several ways outlined below:

- ***Increased income*** from sale of products and hiring of tools made. Some farmers sold briquettes, bags and baskets, sprayers and hired tools they had made to members of their community. Members have also saved money from hiring carpenters.
- ***Reduced expenditures at home***: After the training members are able to make repairs that would have cost money in their homes. For instance, many reported that women are now able to do simple repairs on kitchen doors, benches and chairs at home. There is no spending on hiring tools to use at home. They do not have to pay for potato slicer, maize sheller, sprayers, ground nut plucker and briquette making tools unlike other people living in their communities.
- ***Reduced workload*** for members: With regard to the use of machines made after the training, many group members reported experiencing reduced workload. Take the case of maize shelling, a previously predominant activity for women. With the use of maize sheller, all family members get involved in maize shelling. Children were reported to enjoy the process of maize shelling. In general, the tools made have encouraged women, men and

children to take up roles previously for other gender in the households, thus reducing division of labor, saving labor and reducing workload in households.

- ***Employment of youth***: The youth who participated in these trainings are no longer idle. They engage in making tools and in agriculture. They make money through hiring tools made to those who need to use them.
- ***Improved standards of cooking***: The training in energy conservation using energy savers and briquettes has improved standards of cooking. Group members are now aware of the environmental and health hazards of using smoky firewood for cooking. They are more conscious of using energy saving stoves and strategies such as putting off the fire from the charcoal once cooking is complete to save the briquette or charcoal.

The CCB training has also had benefits at group level. Some groups have experienced a greater social cohesion and began working more closely. Their Credit and Saving Associations have been strengthened because members sell some of the items, hire tools, and make money. In many groups, the hiring of tools made by the group was at group level. The earnings from such sources went to the group savings account. The trainings, associated activities and increased networking among group members in which ideas taught in CCB training trainings are shared has resulted into increased popularity and visibility of the groups. Some groups are making good use of their popularity by starting businesses such as hiring chairs and tents for functions within their communities.

Changes in gender roles

More men involved in household chores: Men have been reported to participate more in household chores including cooking, particularly when women are away. For instance, it was indicated that many men are more willingly to participate in cooking when energy saving stoves and briquettes are used. They find it more convenient than firewood and ordinary charcoal.

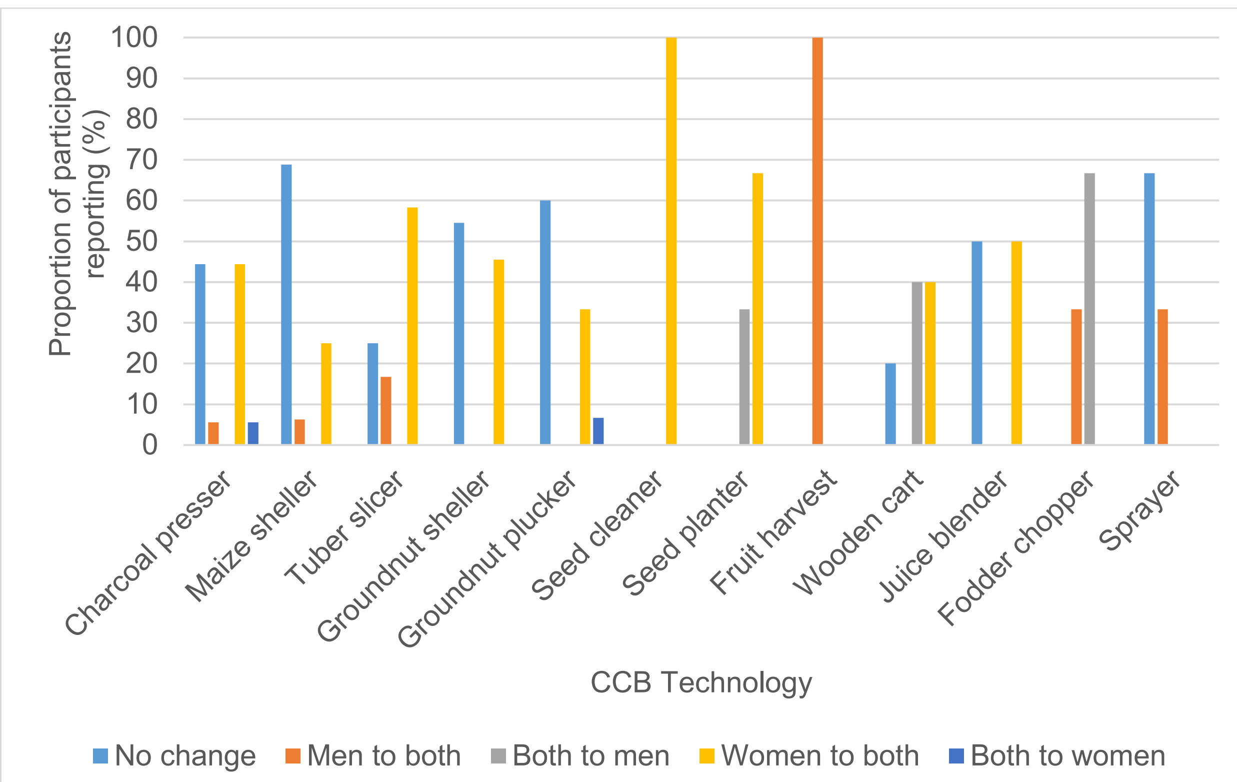
More women involved in traditionally masculine activities: With carpentry and fabrication skills acquired in CCB training, more women have become involved in activities predominantly occupied by men such as making cupboards, beds, fixing broken doors, windows and many other types of furniture at home. They have also become more active in constructing houses. Similarly, men are now more involved in apparently feminine activities such as weaving, making bags and baskets and making of stoves used for cooking.

Reduced division of labor in farm work: Farm work has become more egalitarian. Activities that were previously mostly left to one gender category are now more shared. For instance, cassava and sweet potato processing that previously was work for females can now be done by men using a slicer at leisure time instead of moving to hangout in trading centers. The use of the maize sheller has sharply increase participation of children in maize shelling, mainly a woman's activity at household. Men and children are now motivated to participate in shelling and winnowing, predominantly female activities, thus reducing the workload for women in the household. Similarly, the grass chopper has made it easy for women and children to participate in cutting grass for feeding animals, an activity that has mostly been done by men. Women can now also harvest fruits unlike before the fruit harvester was developed. Planting, harvesting, and shelling groundnuts and maize are joint activities for all gender categories in the household after CCB training. Furthermore, women now take active part in coffee pulping because the coffee pulping machine makes the work so easy.

More respect for women: Women have gained more respect from their husbands and the community as a result of the training. Husbands are more willingly to listen to their wives. This has also come as a result of their increased financial contribution to the household from the income they earn from sale of technologies and the savings made on charcoal from using briquettes. This respect is being reflected in shared decision-making at household level. This has reportedly also led to reduced domestic violence.

Results from Figure 5 show that CCB tools changed significantly most division of labor. Particularly, fruit picking from tall trees was specifically for men task due to its risk of falling off trees. The long-armed fruit picker enables women to perform fruit picking without climbing trees. Seed cleaning which was done exclusively by women (winnowing) could now be done by both men and women using the CCB seed cleaner. Some CCB technologies – including maize sheller, groundnut plucker and sprayer – did not significantly change division of labor. The results underscore the role that technologies could play in reducing the burdensome activities done by women and some hard labor activities done exclusively by men.

Figure 5: Change in division of labour due to CCB technologies



Source: FGD midline assessment

Impact pathways of the CCB project

From the main findings from this assessment, four pathways through which the CCB project has impacted the local communities can be discerned:

Productivity pathway: The innovations and technologies from CCB training have resulted into reduced drudgery from farm work and postharvest handling and have improved quality of produce. Participation in the trainings has also created youth employment. The youth in the project are active participants in designing and making new tools and equipment, thus contributing to the development of their local communities.

The income pathway: The CCB training has resulted into higher incomes among participants and their groups. Incomes have come from sale and hire of tools and equipment made from participating in the training. The new knowledge and skills have also reduced costs in the households in that services that were originally outsourced and paid for are now provided by family members. For instance, instead of hiring a carpenter to make and fix furniture at home, the women or men or both make the furniture and repair those broken thus saving money. Furthermore, because of their involvement in the training, participants do not have to pay to use the newly developed technologies and tools unlike non-members in the community.

The gender pathway: The CCB training altered gender relations and roles in significant ways. Men, who traditionally have left household chores have become much more involved in performing reproductive roles in the households. This includes cooking as a result of the ease associated with the use of energy saving stoves and briquettes instead of firewood. They have also become more involved in activities associated with income sources for women such as weaving bags and baskets. Similarly, women have made inroads in activities which were traditionally a preserve of men. These include carpentry and fabrication of tools leant from CCB training. Furthermore, the training have also led to a reduction in the division of labor on farm in ways that women's workload has been reduced. Men and children have increasingly taken on roles generally reserved for women such as shelling, winnowing and chipping using the new technologies made. Overall, the trainings have increased the participation of women within the household in decision making and their contribution to household income resulting into greater respect for them from their husbands and the community.

The social capital pathway: CCB trainings have increased the social capital of participating groups and members. The trainings have fostered closer working relations among group members. Regular meetings for group work have strengthened the bonds among group members. Such enhanced relations provide insurance against risks. It's from such networks that members can borrow from in times of stress. The trainings have also linked the groups to other organizations that provide information and other opportunities for the groups. The trainings, associated activities and increased networking among group members in which ideas taught in CCB training trainings are shared has resulted into increased popularity and visibility of some groups. Some groups are making good use of their popularity by starting businesses such as hiring chairs and tents for functions within their communities.

7.3 Quantitative results

Impact of CCB on number of tools used and type of activities done

Table 6 examines the impact of the CCB on the number of tools used. Compared to the control group, CCB has increased the number tools and machines used by 71% and by 64% for the FD and half dose beneficiaries respectively. The results are robust across uncontrolled and controlled approaches.

Table 6: Impacts of CCB on number of types of tools and machines used

Treatment	**Log (Number of types of tools-machines used)**					
	Uncontrolled DiD			**Controlled DiD**		
	No Clustering	With	With	No	With	With
FD	0.71***	0.71***	0.71***	0.71***	0.71***	0.70***
HD	0.64***	0.65***	0.63***	0.64***	0.64***	0.63***
Number of types of tools-machines used						
FD	1.4***	1.4***	1.4***	1.4***	1.4***	1.4***
HD	1.1***	1.1***	1.1***	1.1***	1.1***	1.1***

Note: 2SWR=Two-stage attrition weighted regression; FD=Full dose; HD=Half dose
*, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level
Source: Baseline and Endline Household Survey

Impact of CCB on designing and making tools was statistically significant. The probability of designing and making tools increased by 55% among CCB full-dose beneficiaries and by 6% among half-dose beneficiaries (Table 7). This was expected given that the hands-on full CCB training was more effective in imparting skills for designing and making tools. These results are consistent and robust across analytical methods.

Table 7: Impacts of CCB on the propensity to make & innovate tools/machines (marginal probabilities)

	Uncontrolled DiD			**Controlled DiD**		
	No clustering	**With Clustering**	**2SWR**	No clustering	With Clustering	2SWR
FD	0.55***	0.55***	0.55***	0.55***	0.55***	0.55***
HD	0.06**	0.06*	0.06**	0.06**	0.06**	0.07**

Source: Baseline and endline household survey

It would be interesting to determine how the control group compare with CCB in terms of ownership and use of the same tools designed by CCB beneficiaries. Table 8 reports ownership and use of tools that were designed by the CCB beneficiaries. No farmer in the control group owns a peanut or juicer and a very small share own charcoal press. This underscores the fact that these technologies are new but have local skills to design and make them. CCB beneficiaries have an opportunity to exploit this opportunity to produce charcoal press and market them locally and in other areas.

Table 8: CCB tools owned and used

	% Owning			P-value		% Using			P-value	
	FD	HD	CT	FD-CT	HD-CT	FD	HD	CT	FD-CT	HD-CT
Charcoal	4.0	0.0	0.08	0.001***	0.790	4.3	0.3	0.8	0.001***	0.954
Maize Sheller	22.3	1.8	1.5	0.001***	0.998	23.5	3.1	1.8	0.001***	0.887
Peanut	2.2	0.6	0.0	0.005***	0.754	2.2	0.6	0.0	0.005***	0.754
Juicer	0.0	0.3	0.0	1.000	0.459	0	0.3	0	1.000	0.459

Note: FD= full dose; HD=half dose, CT=Control treatment

Overall, the full treatment group owns and uses more of the technologies they design than the control group. However, the half dose group does not have a significant difference with the control group in terms of ownership and use of CCB tools. This further demonstrates that the traditional technological dissemination has weak impact on ownership and use of CCB tools.

We analyzed the impact of CCB on primary and secondary activities in order to determine how CCB technologies affected economic activities by comparing the full dose and half dose with the control group. Overall, there was no significant change in primary activity due to CCB training (Table 9). This was expected given that the CCB tools were enhancing what farmers do rather than helping them to engage in other economic activities. However, CCB training increased number of economic activities by two for both full and half CCB beneficiaries – an increase which is about 80% to 90% of the total number of economic activities done by households (Table 10). The increase in number of activities is significant and robust across controlled and uncontrolled methods.

For secondary activity, CCB led to a significant change in type of activity done. A significant share of full dose CCB beneficiaries switched to artisan activity involving tools. The major reason for switching to a new activity was acquisition of new vocational skills (Table 11). Switching to artisan work is justified by the acquisition of the new tools that could help farmers to do artisan work as a secondary activity. For example, acquiring tools design skills could have helped CCB beneficiaries to engage in making several tools.

Table 9: Change in primary and secondary activities of any household member

	Primary activity					**Secondary activity**				
Activity	FD	HD	CT	Paired test		FD	HD	CT	Paired test	
	Percent change			FD-CT	HD-CT	Percent change			FD-CT	HD-CT
What activities changed?										
Switched to:										
- Agric. production	33.3	35.6	45.1	0.293	0.444	29.3	28.7	36.6	0.671	0.581
- Agric. processing	0	0	0	-	-	2.7	0.0	0.0	0.120	1.000
- Agric. marketing	6.7	6.9	5.8	0.993	0.983	17.3	13.8	18.2	0.998	0.794
- Hospitality	2.7	1.1	1.9	0.978	0.972	0.0	1.1	0.0	1.000	0.484
- Artisan work	1.3	4.6	0.1	0.998	0.254	12.0	2.3	1.9	0.006***	0.999
- Formal employment	14.7	8.0	4.8	0.06*	0.811	4.0	1.1	0.9	0.367	1.000
- Wage employment	4.0	4.6	6.7	0.807	0.885	13.3	18.4	19.2	0.666	0.998

Note: FD= full dose; HD=half dose, CT=Control treatment
Source: Baseline and Endline Household Survey

Table 10: Impacts of CCB program on Number of Economic Activities Undertaken

	Log(Number of Economic Activities)					
	Uncontrolled DiD			**Controlled DiD**		
	No Clustering	With	With	No	With	With
FD	0.92***	0.92***	0.93***	0.92***	0.92***	0.92***
HD	0.84***	0.84***	0.83***	0.84***	0.84***	0.83***
Number of Economic Activities						
FD	2.3***	2.3***	2.3***	2.3***	2.3***	2.2***
HD	1.9***	1.9***	1.8***	1.8***	1.8***	1.8***

Note: 2SWR=Two-stage attrition weighted regression; FD=Full dose; HD=Half dose
*, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level
Source: Baseline and Endline Household Survey

Table 11: Major reason for change of primary and secondary activity

Reason	FD	HD	CT	Test FD-CT	Test HD-CT
Acquired new vocational skills	54	42.6	29.5	0.050**	0.502
Falling demand of products old activity	6	10.6	20.4	0.050**	0.387

Note: FD= full dose; HD=half dose, CT=Control treatment. Only reasons with significant differences are reported. *, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level
Source: Baseline and Endline Household Survey

By design, CCB sought to enable trainees to design, make and fix broken tools. Accordingly, CCB increased the number of tools-machines repaired by 60% in full dose households and 75% in the half dose households (Table 12). The results are robust across controlled and uncontrolled analyses.

Table 12: Impacts of CCB on tools-machines broken & repaired by household member

	Log(Number of tools-machines broken and repaired)					
	Uncontrolled DiD			**Controlled DiD**		
	No	**With**	**2SWR**	No clustering	With Clustering	2SWR
FD	0.59***	0.59***	0.58***	0.59***	0.59***	0.57***
HD	0.75***	0.75***	0.75***	0.76***	0.76***	0.75***
Number of tools-machines broken and repaired						
FD	2.4***	2.4**	2.2***	2.3***	2.3**	2.1***
HD	3.8***	3.8***	3.8***	3.9***	3.9***	3.8***

Note: 2SWR=Two-stage attrition weighted regression; FD=Full dose; HD=Half dose
*, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level
Source: Baseline and endline survey

Impact on asset value and household income

In this section we analyze impacts of CCB on household assets and household Income. Assets included only productive assets (transportation equipment, processing equipment, farm production implements, water harvesting equipment) but excluding land, livestock and household durables. The assets were expressed in nominal values at their current market values as perceived by the respondents. CCB impact on household assets is weak and not robust across analytical approaches. Only without clustering in both controlled and uncontrolled approaches does CCB shows significant impact on value of household assets of full-dose CCB beneficiaries (Table 13). This is expected given the short time of the project.

The impact of CCB on income was analyzed using three sources of income – crops, non-farm and livestock, all expressed in net terms after netting out cash expenses. We computed Crop income and livestock income from production output rather than from sales receipts. Overall, we find a weak impact of CCB on household income and this impact is through CCB impacts on crop income and non-farm income. The impacts were more significant on non-farm than on crop income, although in magnitude they were largest on crop income /crop productivity, the low statistical significance of crop income could have risen from a noisily distribution that is exacerbated in double difference estimates. The statistically significant results for nonfarm income are consistent with qualitative results that showed increased income from sale of products and hiring of tools made by CCB participants.

The CCB weak impact on overall household income has possible explanations. One explanation might be because of measurement errors in crop productivity, and exogenous constraints like drought which could have affected crop performance since weather shocks are covariate shocks and not idiosyncratic shocks.

Table 13: Impacts of CCB program on value of Household assets

	Log(Value of Household Assets)					
	Uncontrolled DiD			**Controlled DiD**		
	No clustering	**With Clustering**	**2SWR**	**No clustering**	**With Clustering**	**2SWR**
FD	0.58*	0.58	0.61**	0.65**	0.65*	0.69***
HD	-0.05	-0.05	-0.06	-0.04	-0.04	-0.06

Note: 2SWR=Two-stage attrition weighted regression; FD=Full dose; HD=Half dose
*, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level
Source: Baseline and endline survey

Table 14. Impacts of CCB on Crop Income, Livestock Income, Non-Farm Income and Total Household Income

	Uncontrolled estimation		Controlled estimation	
	With clustering	2SWR	With clustering	2SWR
Double Difference Estimates				
Crop Income (UG shillings)				
FD	824,257	784,550	687,180.5	656,686.1
HD	332,549	432,453	200,362.1	308,776.8
Single Difference Estimates				
Crop Income (UG shillings)				
FD	617533.9	839,181**	503126.5	717137
HD	-350,327.4	-258,722	-374,508.7	-311,902.5
Double Difference Estimates				
Livestock Income (UG shillings)				
FD	79,185	62,376	60,955.09	48,391.44
HD	-5,458	11,403	-15,461.55	6,426.817
Double Difference Estimates				
Non-Farm Income (UG shillings)				
FD	360,917***	308,548***	348490.1***	297642.6***
HD	151,274	103,443	130607.6	86059.3
Double Difference Estimates				
Household Income (UG shillings)				
FD	1,031,827	1,199,221*	1045259	1218952*
HD	104,156	196,850	106693.7	198577.9

Source: Baseline and endline household survey

*, ** & *** respectively means, associated statistic is significant at 0.1, 0.05 & 0.01 level

8.0 Discussion

Internal validity

Hawthorn effects (treatment group behaving differently under observation): We minimized Hawthorn effects in our design by ensuring that the impact evaluation (IE) team was not explicitly linked to Kulika, which was the implementing agency. By keeping the IE separate from the intervention, we minimized the perception of being observed among participants.

John Henry (JH) effects (non-treatment group behaving differently after knowledge of treatment): We addressed the issue of JH effects between treatment and control by selecting a sampling scale (parish) that keeps the risk of contamination between units in the sample low. A total of 6 of approximately100 parishes in a district were selected, and our expectation is that diffusion of knowledge about the intervention was very low outside of the parishes. Our design tour to selected districts also confirmed the low diffusion across parishes. Within parishes, for those parish members not invited to participate in the workshop, the Kulika group framed the response in a way that the training workshops were aimed at helping the community learn how to design solutions to its problems and that Kulika was only able to invite a small number of randomly selected people, who were expected to train others in the parish. The random selection helped to allay fears of favoritism in the selection.

Compliance with Encouragement: To ensure that the selected households participate in the CCB training, some encouragement was made. Kulika designed a culturally appropriate means of compensating workshop participants for their time, and making the workshop broadly appealing, in order to achieve high compliance. This also included receipt of finished technology products and the provision of meals and any transportation expenses during training. Registration was also required, minimizing the issue of non-invited participants attempting to join. The encouragement minimized the self-selection bias and therefore is likely to have improved internal validity.

External validity and scalability of CCB results

The RCT approach used in this study ensured that the results can be extrapolated across the entire population in Uganda. The results from qualitative and quantitative assessment show that CCB enabled participants were able to innovate a number of innovations based on the challenges they faced in their communities ranging from labour saving, energy saving and post-harvest handling, processing and management of crop and livestock products. The results show that participants were able to create win-win technologies that were both of superior quality and enabled labour saving compared to traditional practices and technologies available in the market. Given that most of the technologies were preliminary prototypes, the achieved quality and capacity to save labour showed that there is high potential to improve upon the technologies to achieve desired attributes.

There were differences in the number and types of technologies developed in the different regions, and these differed based on the differences in challenges and opportunities available implying possible development of trade opportunities. For example the central region is likely to excel in the production of charcoal briquettes given the opportunity cost of labour and cost of fuel wood. In the northern and eastern region, postharvest technologies will be key priority as farmers depend largely on annual crop production. In contrast, communities in the central and southwest are likely to excel in the production of coffee processing tools and post-harvest pasture management technologies due to the dominance of coffee and livestock in the production system.

The evidence from the CCB training in the present study is confirmation of the local communities' innovative capacity and ability to influence their welfare though technology innovation.

The new tools designed by local people reduced labor by at least 50% - an aspect which shows the large potential for making locally labor saving tools. Some tools also helped to change division labor – suggesting that CCB tools could alleviate the burdensome labor performed by women as well as hard labor performed by men only. CCB technologies also showed significant impact on crop income – suggesting their potential to alleviate poverty. CCB impact on livestock income and value of assets is weak. This was expected given that the technologies were mainly directed to addressing crop production activities. The three-year period is also too short to have significant impact on value of assets and other lagged impacts.

The combination of significant labour saving and an increase in crop income translate into great potential for CCB technologies to reduce household poverty among the beneficiaries as some of the labour saved could be invested in other income generating activities in addition to the increased crop income.

Most of the technologies innovated stand a chance to reduce Uganda's post-harvest loses are estimated in the range of 30-50 percent. This means that CCB training has a great potential to reduce post-harvest losses (and hence improve food security) in Uganda.

Furthermore, aflatoxin and other food contaminations occur largely during post- harvest crop management (Kaaya and Kyamuhangire, 2010. CCB training and the ensuing technologies also stand a chance of enhancing the health and nutrition of participating households.

The benefits of the CCB technologies to both innovators and communities could be further enhanced by designing local technology centres and aggressive marketing of innovations to generate more income for the innovators and increase awareness and access by other users.

Uganda's vision 2040 and the Second National Development Plan (NDP II) emphasize human capacity development as one of the key fundamentals to accelerate the country's transformation. At the heart of this strategy is the promotion of the Business Technical, Vocational Education and Training (BTVET) to harness Uganda's population dividend. The evidence generated in this study underscores the need to incorporate CCB training in the BTVET curriculum so as to build local capacity and scale up training within and beyond the 9 districts covered by this research.

"Technical training and vocational training (TVET) is the master key that can alleviate poverty, promote peace, conserve the environment, improve the quality of life for all and help achieve sustainable development" (UNESCO, 2012). This statement underlines the importance of the creative capacity building (CCB), which literary converts communities into vocational and innovation centers by building their capacity to design and make tools using locally available material. The CCB training in Uganda showed very strong and favorable reception in the 19 communities that benefitted from training. The approach showed that the local people have the capacity to design their own tools if given the capacity to change their own perception and self-esteem.

The results underscore the power of team work in coming up with creative ideas and innovative solutions. Creative capacity building training was implemented by training members of the same group with the perception that they shared the same problems. Paulus and Nijstad (2003) recognize the role team work play in the scientific process by taking advantage of diverse skills and knowledge. This is contrary to most research on creativity that has focused on individual creativity with little recognition of the social and group factors that influence the creative process, while emphasizing isolation and individual reflection as key factors in creative accomplishments (Because of team work, creative capacity (Ochse, 1990; Simonton, 1988; Paulus and Nijstad, 2003). Creative capacity building training demonstrated that local communities were capable of developing superior technologies that are cheap and require less labour to use compared to traditional and market available technologies.

The stakeholders that participated in the policy influence workshops appreciated the capacity of the participants of CCB training to come up with a number of technologies, from locally available resources that addressed a number of post-harvest handling and management challenges. Particularly, they appreciated the fact that CCB technologies enabled reduction of drudgery from women who multi-tusk in production and household reproductive activities. However, the participants cautioned that the approach was not able to handle serious challenges that affect agricultural production such as developing appropriate irrigation equipment to address climate change shocks and the need to liaise with the Uganda National Bureau of Standards (UNBS) to come up with certified quality products particularly those that have to do with post-harvest and food processing.

9.0 Specific findings for policy and practice

The discussions above will require policy interventions to transform the benefits of CCB into reality. An important question is how to mainstream CCB training in order to help sustain its impact. Two major challenges need to be addressed, the first being offering CCB training – equivalent to that offered by MIT D-Lab. There is need to build local capacity for institutions capable of offering CCB training. Such a role could be played by the vocational training centers in Uganda – which offer on-campus training to only young people who graduate from secondary schools. Vocational training institutions could expand their training to communities using the CCB model an approach that was used to implement one of the most successful education programs in Uganda namely, the Universal primary education (UPE). This was very successful in Uganda and could be used as a vehicle for offering CCB and other TVET programs.

The second challenge is production and marketing of tools and their parts. We can learn from success stories of production and marketing of local innovations in sub-Saharan Africa (SSA). Some of such success stories exist in the Democratic Republic of Congo (DRC). In eastern DRC, large wooden carts (chikudu) are produced by local innovators. The cart spare parts are also produced locally and marketed in local shops and dealers. Repair shops also are many in

Eastern DRC. Such an example could be replicated in Uganda for making and marketing CCB innovations. However, a deliberate investment in promoting CCB is required. The different stakeholders could take advantage of the use of media as cheap and quick means of accessing information. Such efforts will lead to using CCB and other forms of TVET as *master key* to achieving Uganda's 2040 Vision overarching goal of alleviating poverty and becoming an upper middle income country by 2032.

The results of CCB were shared with a number of policy makers and implementers in the country. The parliamentarians were very impressed with the low-cost approach used by CCB training and the impacts of the innovations. They saw the need to design strategies for out-scaling the CCB approach success story to other districts. To have such out-scaling, the MPs sought to know how the directorate of agricultural extension services were involved in implementing the CCB activities. They also sought to know how CCB approach could be integrated in the directorate of agricultural extension services. It was revealed to the MPs that the extension service providers were not involved in the CCB training or dissemination – an aspect which was due to the design of the study. However, there is an imperative of getting the extension service providers involved in the CCB innovation dissemination since most of the technologies are agricultural-oriented.

At the local government level, participants of the policy influence workshops, consistent with the parliamentarians' observation, expected irrigation innovations to have come out of the CCB process. This observation implies that drought is an important constraint of agricultural production that was overlooked by the CCB trained participants probably because it falls outside the capacity of local innovators. However, participants appreciated the need to build capacity to boost local innovations to improve productivity, incomes and sustainable exploitation of natural resources. They highlighted weaknesses at local government level that would affect the efficient scaling-out of CCB as an approach to bolster creativeness and innovations. Particularly, local governments lack mandate initiate policies and are rather considered as implementers.

Participants observed that funds currently allocated to the district production departments are strictly for disseminating technologies and cannot be channelled to innovation. They recommended that the Ministry of Agriculture – Extension Directorate funds the scaling-out of the CCB activities to other communities and districts that did not participate in the Kulika activities. However, they finally agreed that CCB training can be implemented as a dissemination approach where participants trained use their own resources to come up with own innovations. They recommended for extension staff to be availed and trained in the CCB curriculum. They also promised to tap into the youth livelihood, venture capital and women entrepreneurship funds to support local innovations and scaling-out of CCB to especially youth, artisans and women groups. They promised to start with the current CCB groups to help them commercialise their activities and link them to UNBS for certification of their products. They however observed that there is need for policy on patenting to reward and incentivise local innovators.

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Appendices

1. Letter of participant consent to participate in CCB study

CONSENT TO PARTICIPATE IN A STUDY

Evaluation of Technology Creation and Use Workshops

You have been asked to participate in a research study conducted by Dr. Bernard Bashaasha and Dr. Frederick Bagamba of the Department of Agriculture at Makerere University and Dr. Ephraim Nkonya of the International Food Policy Research Institute in the United States. The purpose of the study is to understand the effectiveness of a training method in fostering technology creation and use in your community. You were randomly selected as a possible participant in this study based upon your geographic location and your membership in a local social benefit organization. **Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate**.

- **Your participation is completely voluntary. You can choose not to participate**. If you choose to participate or to not participate you will not be penalized in any way or prohibited from participating in any other program or activity as a result of your choice. In this way, you can be assured that your decision to participate or to not participate will have no effect on your other work. You further have the right to ask us to exclude specific information or to end your participation at any time.

- If you agree to participate in this study, you will receive one of two types of trainings. The first is a 4-day technology design workshop; the second is a 1-day technology demonstration. The 4-day training will take place Monday-Thursday beginning promptly each day at 9:00 AM and ending between 4:00-5:00 PM. The 1-day training will take place on a Friday and will be approximately 3 hours long, beginning promptly at 9:00 AM. Trainings will be conducted in your local language, with some small amounts of English; lunch and snack will be provided on each day of the 4-day training; a light snack will be provided during the 1-day training. **If you agree to participate in this study, you are agreeing to participate fully in whichever training you are randomly assigned to attend.** This means you agree to arrive at the designated start time for the designated number of days.

- If you agree to participate in a training, you will be asked to provide basic information about your life, such as the size of your family, how you earn your living, what kinds of technologies you currently use in your daily life, and other general questions. **There will be 3 surveys of this kind**; one now, if you decide to participate in this study; a second in approximately 18 months from now; and the final survey approximately 3 years from now. Each survey will take approximately 2 hours of your time.

- **You will not be compensated or charged a fee** for participating in the trainings or in this study. Participants will not keep the technologies that are demonstrated but will be provided with information about where they can be purchased locally.

- **In the survey materials, you will not be identified by name, but you will be assigned a random number for identification and follow-up purposes.** Any information that is obtained in connection with this study and can be identified with you individually will remain confidential, unless you specifically give us permission to publish any identifying information. Copies of all materials related to you and your participation will be stored in a secure professional location.
- If you agree to participate, interviews that you give may be audio-recorded and photographs may be taken of you. **If you grant permission to be recorded or photographed, you have the right to revoke your permission at any time.**
- Your participation in the training activities will be completed by August 31, 2014; your interaction with the training facilitators will continue intermittently over 1 year following the training and be concluded by August 31, 2015; your participation in the overall investigation will be completed by December 31st, 2017.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Name of Subject ____

Signature of Subject ____ Date _____________

Signature of Investigator _____________________________________Date _____________

Please contact Dr. Bernard Bashaasha, bashaasha@agric.mak.ug, 0772-627-249, with any questions or concerns.

2. Field notes and other information from formative works

Study design and preparation

Sampling frame

Initially, the project team had planned to use a three-stage cluster sampling procedure where the districts formed the first-stage clustering and the parishes formed the second-stage clustering. Households would then be randomly selected from the selected parishes to form the treatment (full-dose and half-dose) and control samples. The first cluster comprised of nine districts randomly sampled from 118 districts in Uganda while the six parishes were randomly selected from each selected district. At each of the stages, more than one sample was drawn to give Kulika a chance to pick one that presented the least logistical problems.

However, D-lab, one of the partners that are implementing the training of the farmers in Creative Capacity Building (CBB) later complained about the training of individuals that are randomly selected from parishes. D-lab argued that their experience was with working with people who are interested and have been working together in groups and are already doing something for the community. Thus, instead of using a purely random pick approach to select participants from selected parishes, D-lab suggested using randomly selected farmer groups from which individuals would randomly be selected. Makerere proposed another approach, that of advertising on local radios for participants from the already selected parishes to come for the CCB training. This would probably attract only the willing participants interested in technology innovations and therefore weed out the less willing to participate in the process.

The Skype meeting of August 15, 2013, attended by Prof. Bernard Bashaasha, Markus, Ephraim and Fredrick discussed the three options for the selection of CCB participants; (1) the original selection design, in which individuals would be selected purely by random from the selected districts, (ii) D-lab proposal of selecting CCB participants from existing farmer groups, and (iii) Makerere proposal of posting an announcement in both treatment and control parishes inviting people to participate in CCB training. In the third option, which would likely attract only individuals interested in technology innovations, the announcement would be placed in both the treatment and control parishes but training would only be conducted in the treatment parishes. Later, based on the input from Howard, Kato and Andrew, it was agreed that the D-lab option of working with existing groups be adopted but select only those that deal in economic activities and exclude self-support groups (e.g. burial and religious groups). The justification for the selection of this option was D-lab's experience, which shows that CCB training is more effective when conducted to group members who know each other and have worked together before.

Given that few groups existed in a given parish, a decision was taken to use sub-counties, instead, to develop the group sampling frame. The justification for using subcounty level group sampling was to have a large sampling frame for groups. It was also observed that some groups span several parishes, which would make selection at the parish level tricky. It was agreed that that second stage clustering be redone at sub-county level as the parishes selected earlier could not be elevated to the sub-county level since more than one parish had been selected in case of some sub-counties. It was thus agreed that Makerere does a census of all groups from randomly selected sub-counties and later randomly select groups for selecting households that would participate in the survey. This was done in all districts originally selected for the CCB training.

Training in creative capacity building was to be done on randomly selected members of the selected groups. There were concerns by Makerere of the possibility of increasing costs due to moving from parish to sub-county level. However, Makerere went ahead to implement the selection of sub-counties from the previously selected districts and conduct a census of the groups in each of the selected sub-county (see Appendix 2 for the list of sub-counties selected).

However, it was later realized that Kulika recruited and trained facilitators based on the original sampling frame of parishes selected from the CCB districts (Appendix 1). Reverting to the new sample implied increased costs of operation for Kulika because the list of new sub-counties selected on the second round posed logistical problems to Kulika as most of the sub-counties were different from those on the old list and were far from where facilitators resided, which would tremendously increase the operational cost for Kulika. Besides, D-lab raised the issue of being mindful of the distribution of facilitators – if there are some facilitators that reside in parishes in which they were to do CCB training, there should be at least the same number of facilitators residing in parishes where technology demonstrations were to be done.

Discussion between Kofi (D-Lab) and Markus (3ie) resulted into a series of meetings and discussions between the different teams (Makerere, IFPRI and Kulika), which resolved that Makerere should revisit the census of farmer groups, this time using the parishes that had been selected using the first sampling approach.

Questionnaire development

The Torrance test was suggested and propagated by Andrew to capture the willingness and motivation by survey participants to initiate and implement innovative solutions to the problems they face in the daily life. However, the idea of using a Torrance test was abandoned because many parts of the Torrance test were perceived as irrelevant to the study. Besides, the test could end up testing creativeness of the respondents whereas the interest was in testing the motivation and willingness of CCB participants to solve the problems they face in life. The other concern was that the test had never been validated outside the USA. Based on these reasons, the test was abandoned and instead reverted to and revised the questions earlier proposed by Ephraim Nkonya. The full questionnaire is attached as a separate file.

3. Sample size and power calculations

Effect size: We did not have clear estimates of expected effect sizes, since beyond the 1st order effect of adopting the workshop technologies (which likely will have significant impacts on labor or production), we expect 2ndorder effects due to farmers' own innovations – a sum of small effects resulting in aggregate labor savings or productivity outputs to be significant. Discussion with communities during the design field visits revealed that use of tools such as drip irrigation, vermin trap, etc increase crop productivity or reduced harvest loss by 50% to 100%. Based on the literature, training programs similar to CCB increased income and employment with an effect size ranging from 7% to 100%, with most of the programs witnessing an effect size of 20% to 100% (Blattman, et al. 2011; Benin et al., 2010; King, et al. 2012; Attanasio et al 2011). Based on this, we used effect size of 35% as a basis for design.

Sample size per cluster

We used the 2005/06 agricultural household survey (UNHS) data collected by UBOS to compute the sample size per cluster. The UNHS data covered 7,417 households of which 5877 were agricultural households. To reflect the nature of CCB intervention of increasing labor productivity using tools and machine technologies, we looked specifically at total labor intensity (sum of household and hired labor inputs over cropped area, by household), production intensity (yield in kg of production over cropped area, by household), and labor productivity (yield in kg of production over sum of household and hired labor inputs). These quantities were all ratios of reported quantities subject to reporting error, and have a tendency to be noisy, resulting in larger standard deviations than might be expected by a smaller more focused survey.

We grouped farms by district and by farm size, and filtered these subgroups for outliers (log-transforming the data and iteratively filtering points having z-scores greater than 2 in the log scale). From this we obtained rough estimates of our quantities of interest in different districts. We noted that CCB training and the designed innovations may increase labor productivity and thus we expected variability to be lower in our own sample than observed in the UNHS. We used three districts where Kulika has CCB centers as examples.

Using the Optimal Design software (Raudenbush et al 2011) and Fox et al (2009), intra-cluster correlation (ρ) was calculated at village, parish & district levels. However, observations at village level were very few, with a maximum possible sample in each village of 10, with only 1 or 2 observations in most villages. This led to noisy estimates of village level means and thus over-estimation of ρ. Estimates showed that, the ρ values of households within a village across districts, converged to around ρ = 0.2 as the size of the sample increases, though we noted again our expectation that even in the best cases, this is an overestimate due to low sampling rates in villages.

Of interest to us are the values for ρ-parish-household and ρ-district-parish. In the case of the former, we expected the larger populations to average out differences, reducing intra-cluster correlation, and the relatively small geographic area within districts to introduce little spatial variation; thus we expected ρ-parish-household to be smaller than ρ-village-household, and we estimated a value of 0.1 for design calculations.

At household level, a design with 9 district clusters and two replications per treatment of the full dose and half-dose treatments with effect size of 35%, we got about 30 households per cluster and a power of 0.80. This is equivalent to the number of trainees which Kulika and D-Lab have proposed to train. The parish-level cluster size design for evaluating parish-level effects, also gives a sample of 30 participants in each parish for each treatment.

Our design generated a randomized sample of approximately 144 members in each district for baseline and endline data collection. As observed above, a random sample of 48 members was drawn from four member groups selected for each treatment sampling frame and invited to participate in the full-dose or half-dose treatment workshops. In each of the selected districts, four additional randomly selected farmer groups from the selected districts were selected from which a control group of 48 members were selected. In the four control groups, not any form of intervention was made. The control group will be used to measure the full impact of the CCB treatments (full and half-dose treatments).