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Impact of creative capacity building of local innovators and communities on income, welfare and attitudes in Uganda

July 2020

Impact Evaluation Report 124

Agriculture, fishing and forestry

International Initiative for Impact Evaluation

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3ie accepted the final version of the report *Impact of creative capacity building of local innovators and communities on income, welfare and attitudes in Uganda,* as partial fulfilment of requirements under grant PW2.08, awarded through Policy Window 2. The content has been copy-edited and formatted for publication by 3ie. Despite best efforts in working with the authors, some references could not be fully corrected. We have copy-edited the content to the extent possible.

The 3ie technical quality assurance team comprises Francis Rathinam, Deo-Gracias Houndolo, Radhika Menon, Stuti Tripathi, an anonymous external impact evaluation design expert reviewer and an anonymous external sector expert reviewer, with overall technical supervision by Marie Gaarder. The 3ie editorial production team for this report comprises Anushruti Ganguly and Akarsh Gupta.

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Funding for the Policy Window was provided by 3ie's donors, which include UK aid through the Department for International Development, the Bill & Melinda Gates Foundation and the Hewlett Foundation. A complete listing of all of 3ie's donors is available on the 3ie website.

Suggested citation: Nkonya, E, Bashaasha, B, Kato, E, Bagamba, F and Danet, M, 2020. *Impact of creative capacity building of local innovators and communities on income, welfare and attitudes in Uganda,* 3ie Impact Evaluation Report 124. New Delhi: International Initiative for Impact Evaluation (3ie). Available at: https://doi.org/10.23846/PW2IE124

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Summary

Technologies and innovations are key drivers of human development and competitiveness. The failure of imported technologies has galvanised efforts to develop technologies generated through close collaboration between external investors and local communities. The general objective of the study was to determine the impact of creative capacity building (CCB) training on human welfare and local communities' perceptions of their ability to innovate. Specifically, the study targeted a number of major outcomes of CCB training, namely: economic impacts; behavioural changes; attitudinal change; and technology creation and use, including policy influence.

CCB is a hands-on training approach whose students are community members of 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 randomised sample of approximately 144 members in each district. They were distributed as follows: 48 members from 4 farmer groups selected randomly for a full-dose treatment; 48 members from 4 farmer groups selected randomly for a half-dose treatment; and 48 members from 4 farmer groups selected randomly for a control. The study aimed to address four evaluation questions in order to establish the economic impacts of CCB on beneficiaries; the impact of CCB on changes in behaviour among beneficiaries due to participation in CCB; the impact of CCB on the attitudinal change of beneficiaries; and the adoption rate of new technologies created through CCB.

The programme intervention entailed pre-training discussions; a technology demonstration; and a technology design process comprising problem identification, information gathering, formulation of ideas, experimentation with these ideas and choosing the best idea. The programme also engaged participants in building, testing and refining 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, and this differed between different CCB groups based on the prevailing forms of agricultural production where beneficiaries lived (although the charcoal press was the most frequently designed tool across all the districts). Crop-processing tools such as maize shellers, groundnut pluckers, groundnut shellers and tuber slicers were the most commonly designed tools, underscoring the importance farmers attach to post-harvest management and value addition.

Regarding ownership and usage of tools, the full-dose group owned and used more of the designed technologies compared to the half-dose and control groups. This is evidence 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 percent among CCB full-dose beneficiaries, compared to 6 per cent 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 per cent, with the groundnut sheller offering the highest labour saving of 97 per cent. CCB technologies also enhanced equality in the 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 per cent for full-dose beneficiaries and by 75 per cent 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. CCB training, however, positively and significantly impacted on crop income among 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 (three 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 the 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 the community level, the results of this study will greatly inform vocational training of local communities to spur local-level technology innovation and development.

Acknowledgements

We acknowledge 3ie for funding this creative capacity building impact assessment study. Training of participants in creative capacity building was conducted by MITD-Lab and Kulika Uganda. We acknowledge the United States African Development Foundation for funding the training and thank the farmer groups for the time they put into this study. We are very grateful to the anonymous reviewers for their constructive comments on the proposal and impact evaluation report. The views expressed in this report are those of the authors only and not necessarily those of 3ie or its members.

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Abbreviations and acronyms

CCB	Creative capacity building
FGD	Focus group discussion
IFPRI	International Food Policy Research Institute
R&D	Research and development
RCT	Randomised control trial
SSA	Sub-Saharan Africa
TVET	Technical and vocational education and training

1. Introduction

Since the industrial revolution, technology and innovation have driven human development and competitiveness. It is for this reason that countries that invest in research have correspondingly higher levels of innovation and human development (OECD 2007). For example, Mauritius and South Africa are the highest-ranking countries for innovation and human development in Sub-Saharan Africa (SSA) (UNDP 2015; Cornell University et al. 2016). In particular, local rather than imported innovations have driven development (OECD 2007).

Unfortunately, governments in SSA have not invested significantly in research and development (R&D). SSA has the second-lowest R&D intensity (gross expenditure on R&D as a percentage of GDP)[1] and the lowest human development index (UNDP 2015; World Bank 2015). Low investment in R&D forces countries to import most of their technologies (Haverkort and Rist 2004). Even though imported technologies have been critical to economic development, some have been found to be inappropriate for cultural, social and economic reasons (Roose et al. 1999).

Despite low population densities in most farming systems on the African continent, mechanisation has surprisingly remained very low (Pingali 2007; Sheahan and Barrett 2017). For decades, research and development on agricultural mechanisation has continued to be neglected and less supported by countries and their partners (Diao et al. 2012). Nonetheless, governments in Africa have gained interest in agricultural mechanisation following the unprecedented 2008 food price spikes (FAO and UNIDO 2008; Kienzle et al. 2013; Mrema et al. 2008).

In addition, large irrigation schemes that African governments initiated to boost food production, as well as exports to generate much-needed foreign exchange, failed. Only 4 per cent of cropland in SSA is currently irrigated, which is the lowest percentage 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 costs, poor planning and lack of maintenance (Binswanger and Pingali 1989; World Bank 2008). Local people in SSA have shown creativity and improved lives through the use of traditional knowledge, which is defined as the accumulation of deep-rooted traditional norms, values and ideas (Dei 2000).

Practitioners and policymakers agree that local innovations are sustainable and cost-effective for rural development. Examples of local innovations include *zai* technology developed by Yacouba Savadogo, a farmer in the semi-arid zone of Burkina Faso, to harvest water and store organic inputs and other soil nutrients using a planting pit (Roose et al. 1999). *Zai* technology has been able to increase yields of cereal crops as much as threefold and nutrient use efficiency by 60 per cent (Fatondji et al. 2006).

In West Africa, farmers manage water run-off and prevent salt water from reaching rice farms in mangrove swamps by building dykes. The management of mangrove swamps for paddy production is an old innovation largely prompted by population pressure and climate change (Cormier-Salem 1999). In Rwanda, farmers use residues from banana

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

beer production as organic fertiliser for their banana plantations. This method has significantly increased soil fertility (Van Damne et al. 2013).

The 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). There are also increasing efforts to nurture local community inventions, knowledge and technologies. Nurturing and developing local innovations, especially in rural communities, has been especially limited 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. Additionally, TVET has great potential to modernise agriculture and improve rural livelihoods (UNESCO 2006).

Developing countries have opportunities that could help them leapfrog innovation development if supportive policies and strategies are designed. One such opportunity is the development and globalisation of information technology, which has exposed developing countries to diverse international and domestic sources of knowledge and technologies (Ernest 2002; OECD 2007).

SSA countries have realised the importance of investing in R&D and have been designing policies and strategies to promote local innovations. For example, the fourth pillar of the Comprehensive Africa Agriculture Development Programme is concerned with investment in agricultural R&D (Scoones 2009). Accordingly, the vision of Uganda's medium-term National Development Plan of 2010/2011–2014/2015 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’ (Government of Uganda 2010, p.1).

This study was conducted with the broad objective of determining the impact of local innovations on human welfare and local communities’ perceptions of their ability to innovate. The study evaluated the creative capacity building (CCB) approach, which is a community-driven programme 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, thereby facilitating community-based innovations and inventions with specific objectives of generating income, improving health and safety, saving labour and time, and changing 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 community ownership of technologies that are more likely to be sustainable given that they are designed and maintained by local innovators. Therefore, CCB presents a framework through which anyone can become an active creator of technologies and not just a recipient or user (MIT 2015). Kulika Uganda provided 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:

1. What are the economic impacts of CCB on beneficiaries? This was measured using a number of indicators including change in labour productivity, income-generating activities and household incomes.
2. What is the impact of CCB on the behaviour of beneficiaries due to their participation in CCB? This question was answered using qualitative approaches to measure the impact of CCB on beneficiaries' behavioural characteristics such as collective action, increased pursuit of vocational training by adults and readjustment of intra-household division of labour across the sexes.
3. What is the impact of CCB on beneficiaries' attitudes? Qualitative methods were used to analyse the change in beneficiaries' confidence to innovate and bring about change in their communities, as well as their own self-awareness and self-esteem.
4. 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. Under each region, fairly homogeneous clusters (districts) were randomly selected. The six regions represent Uganda's major agroecological zones: semi-arid in the northeast; savannah in north central; rainforest in Central region; and humid highlands in the southwest and Eastern region (Nkonya et al. 2008). This suggests that results from the six regions could apply to the major agroecological zones and farming systems of Uganda.

The rest of the study is organised as follows: The next section discusses the CCB approach and its implementation. This is followed by a discussion of the analytical approach used and a discussion of data and data collection methods. In order to prompt discussion about the impact of CCB, trainees' innovations are then presented, followed by a discussion of the results. Finally, a summary of findings and their implications on policy and practice are presented.

2. Intervention, theory of change and research hypotheses

The 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 54 farmer groups was selected to participate in the two CCB treatments and the control. The first treatment involved teaching participants 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 referred to as the full-dose treatment). The second treatment followed a traditional technology promotion approach, in which only demonstration of designed technologies was given to beneficiaries (hereafter referred to as the half-dose treatment).

Each of the two treatments and control were replicated (i.e. two of the six randomly selected farmer groups – from each of the nine randomly selected districts – received the full dose, two received the half dose and 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 to design 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 labour productivity and value addition of the selected economic activities were identified. Kulika Uganda, in collaboration with MIT's D-Lab programme, then provided CCB training using trained facilitators who resided in participants' villages.

The training programme followed the steps below:

1. The research team, D-Lab and Kulika Uganda made a two-week pre-randomisation design tour. This helped to establish the nature of the development pathway to understand the type of economic activities in which beneficiaries are engaged; the labour-intensive and physically challenging activities in which they are engaged; and the likely technologies they would choose to address such challenges. This activity underscores CCB's demand-driven approach and the involvement of community members in deciding on the training content.
2. Two types of interventions were planned: the first (full-dose treatment) included CCB training and demonstrations of technologies; the second (half-dose treatment) 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.
3. The CCB training workshop was held over four days to demonstrate livelihood technologies and basic principles of design. Awareness raising about local technologies and their adaptability was conducted, and training was given on how to use or carry out a given technology or process. Strategies for creating and making new technologies were discussed, then trainees were challenged to apply these skills in building and testing prototypes of their own design. Subsequent training focused on the technology prototypes they created. These trainings and interactions were undertaken by a lead trainer and two village-based facilitators.
4. Follow-up and mentorship helped participants in the full-dose treatment to muster their new skills and design and build other technologies. The village-based facilitators provided technical advisory services but let the trainees design and build technologies themselves.
5. Kulika Uganda facilitates the creation of community technology centres, which increase access to tools and materials and raise the visibility of appropriate technologies in the parish. Parish CCB mentors and trainers support the community technology centres, which are meant to continue providing CCB support services beyond the project period, further underscoring Kulika Uganda's programmatic, rather than project-focused, approach.

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

1. Full dose – farmer groups that fully participated in the entire design process and hands-on skill-building workshops, as well as receiving the demonstration as to

how the newly developed tools work and their advantages compared to the traditional tools and technologies.

2. Half dose – farmer groups that received only the demonstration. This mimics the traditional method of technology dissemination that has been used in SSA.
3. Control – farmer groups that were not exposed to any of the treatments.

Training for the half-dose treatment took two days for each farmer group. On the first day, facilitated by the trainer, participants made preparations for the training. This involved identifying the venue and delivering the necessary tools to be used in the demonstration. The second day involved demonstrating four technologies, namely: an energy-saving stove, charcoal press, ground paste maker, meat mincer, and solar lantern. Follow-up visits were made to monitor adoption of the demonstrated technologies.

For the full-dose treatment, participants were taken through the eight steps of the design cycle, which was delivered 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.

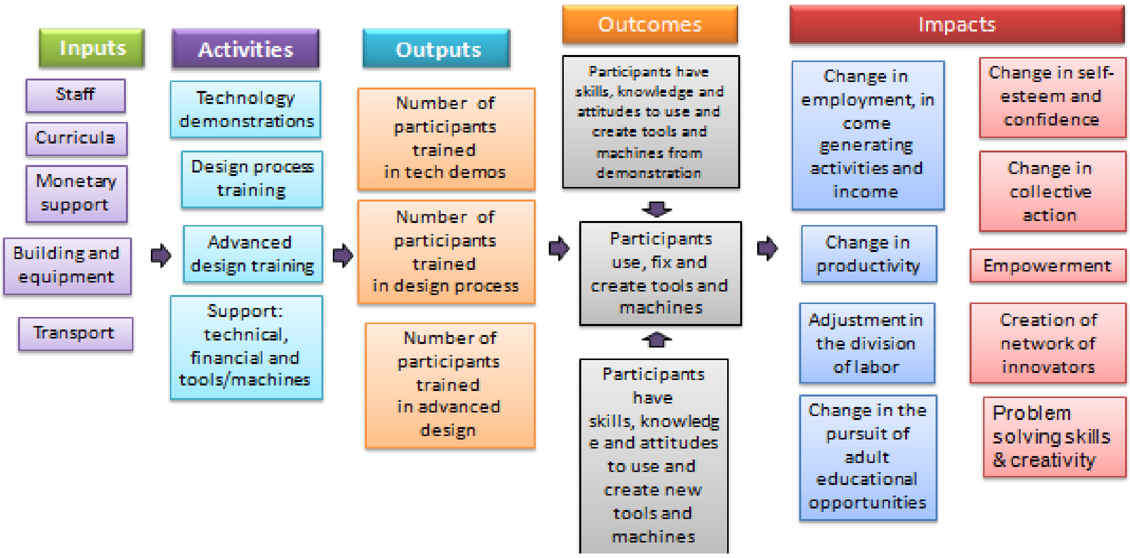
Box 1: Programme content

Day 1: Pre-training discussion; Technology demonstration training (energy-saving stove and charcoal press, 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 D-Lab and adapted for the impact evaluation. Basic inputs required for the programme include training of staff to facilitate the process, development of a curriculum, and monetary support to buy materials and basic tools used during the training. The facilitators need support in terms of transport and monthly stipend. For the participants to undergo training, they require support with basic hand tools as well as seed money to buy materials used in the design process and in refining their prototypes. They are also provided with lunch but can be encouraged to prepare their own meals.

The immediate outcomes include participants acquiring knowledge and basic skills in wood and metal work, and tools and technologies made from the training session. From MIT's experience and the experience of this study, group cohesion where participants cooperate and have mutual trust is key to achieving these outcomes.

Figure 1: Impact pathway – creative capacity building theory of change



Source: D-Lab, MIT

Intermediate outcomes include participants using the skills they learn to make their own tools and machines and fix broken ones. However, participants need access to capital to acquire basic tools (a hammer, tin snips, pliers, wood saw, G-clamp, wood file, square, marker and vice) and materials to work with (timber, square metal bars, metal sheets and nails). Local availability of these materials enhances their adoption, as participants will not spend much money on transport to procure them.

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 are empowered, gain confidence and self-esteem, build networks, and achieve problem-solving skills and creativity. Government support for trainings and institutionalising CCB curriculum in district programmes and projects are key in achieving these long-term outcomes.

Therefore, the study analysed the impact of 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, labour productivity, value addition and others.
2. Behavioural changes, which were measured using qualitative methods focusing on the impact of CCB on beneficiaries' behavioural characteristics such as collective action, increased pursuit of vocational training by adults and readjustment of intra-household division of labour across the sexes.
3. Attitudinal change, which was also measured using qualitative methods to analyse the beneficiaries' confidence to innovate and bring changes in community self-awareness and self-esteem.
4. Technology creation and use, an 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 start 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 that effectively communicate findings to policymakers and other key stakeholders.

3. Context of the impact evaluation

The study was conducted using participants drawn from a random stratified sample of farmer groups, which were 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 livelihoods depend mainly on subsistence crop production, cash crop production, livestock production, forestry and non-farm activities (Pender et al. 2003).

Livestock production is concentrated in the 'cattle corridor', which runs from the southwest border with Rwanda to the northeast in Karamoja, on the border with Kenya. Livestock represents 17 per cent of agricultural GDP. Most agriculture in the country is rainfed and vulnerable to climatic shocks. Out of the 202,000 hectares of potential irrigable land, only about 20,000 hectares are under irrigation, and many of these are used for rice production. Also, water scarcity in much of the rangelands is a major constraint even to livestock production. Average population growth, at 3.4 per cent, is well above the growth rate of food production, which averages 1 per cent per annum (UBOS 2002).

Below is a description of the farming systems and socio-economic conditions of the four regions:

1. Western – This region receives high bimodal rainfall (above 1,200 millimetres 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 a high population density and high market and road access, while the lowlands have a low population density and market access (Pender et al. 2003).
2. Central – This region encompasses the areas around Lake Victoria. It receives high bimodal rainfall (above 1,200 millimetres per year). It has high market access and a high population density. Coffee and banana are the dominant crops in the region. Maize and beans are also grown, but mainly in the drier areas of Sembabule, Mitiyana, Kiboga, Nakaseke and Luwero districts. It is the most urbanised region, with major towns such as Mukono, Mpigi and Wakiso almost merged with Kampala, Uganda's capital city. Livestock production is mainly carried out through zero grazing and tethering, except in the cattle corridor districts of Sembabule, Mubende, Kiboga, Nakaseke and Luwero.
3. Eastern –This region encompasses the areas around Mount Elgon. It has high unimodal rainfall (above 1,200 millimetres per year) in the highlands and moderate rainfall (800–1,200 millimetres 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 and tuber crop and livestock production are the major enterprises in the lowlands.
4. Northern – This region can be subdivided into three subregions based on differences in biophysical and socio-economic characteristics:

a) Northeast subregion (Karamoja area) – Characterised by low rainfall (400–700 millimetres per year), with a mainly pastoral farming system. This region has the most severe poverty and low market access in the country. It 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 over the course of a year due to prolonged dry periods and households having to move to find grass and water for their animals. Also, most of the tools identified in the pre-randomised design survey for use in the demonstration of the CCB training do not apply to households in the Karamoja region, as they mainly depend on livestock.
b) North central subregion – Characterised by medium-low rainfall (700–1,200 millimetres per year) and low market access. The region's main production activities include farming coarse cereal, maize and tubers (sweet potatoes) and root crops (cassava). Livestock production is also a common enterprise. The region experienced a 20-year civil war (1986–2006), which took a toll on human development.
c) Northwest subregion – Characterised by medium rainfall (900–1,200 millimetres per 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 selected strata (three regions and two subregions) discussed above, a multi-stage cluster sampling was done. A population-weighted random sample of nine districts was taken from a total of 118 districts in Uganda, in which Central and Western regions were each allocated two districts, Eastern region was allocated three districts, and one district each was allocated to the north central and northwest subregions.

Hence, the multi-stage cluster design (without any targeting of particular communities) improves internal validity and our ability to generalise findings to other SSA regions that share community characteristics similar to those represented in the Uganda sample.

The results of the CCB approach are likely to apply to parts of other SSA countries for two reasons:

1. Uganda's socio-economic and biophysical characteristics are comparable to an average SSA country. The 2011 human development index for Uganda was 0.446 and for SSA it was 0.463 (UNDP 2012). Likewise, the 2012 median of the global innovation index – defined as a new or significantly improved product (good or service) and a new process (Eurostat and OECD 2005) – for Uganda was 25.1 per cent and for SSA it was 25 per cent (Dutta 2012). This suggests the level of Uganda's innovation is comparable to SSA's average range.
2. Given that Uganda has biophysical and socio-economic characteristics comparable to most other SSA countries, the results will also potentially be applicable to other countries. The five strata in which the study sites are located represent the major SSA agroecological zones, namely: savannah in the north central region; rainforest in Central region; and humid highlands in Eastern region and the southwest (Nkonya et al. 2008). This suggests that results from the three regions and two subregions could apply to the major agroecological zones and farming systems in SSA.

4. Timeline

The key events on the timeline are depicted in Table 1. Table 2 describes them in more detail.

Table 1: Timeline

Programme activity	2012	2013						2014						2015						2016						2017	2018
	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	1–12	1–6
Pre-randomised design tour																											
Training facilitators																											
Site and participant selection																											
Enumerator training																											
Baseline survey																											
Qualitative survey																											
CCB training																											
Follow-up																											
Policy influence																											
Endline survey																											

Table 2: Timeline for implementation and impact evaluation of creative capacity building interventions

No.	Activity	Date	Remarks
1	Pre-randomised design tour	Jan–May 2013	Two-week pre-randomisation design tour by the research team, D-Lab and Kulika Uganda to establish the nature of economic activities in which beneficiaries were likely to be engaged and types of technologies they were likely to choose
2	Training of CCB facilitators	June 2013	Training of facilitators in design cycle at Kulika Training Centre
		Oct 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	Sept–Dec 2013	Sampling of districts, parishes and CCB beneficiary and control households
		Feb–May 2014	Selection of farmer groups; all members were eligible for training but up to 24 members in each group interviewed during baseline survey qualify for CCB training

No.	Activity	Date	Remarks
4	Baseline data collection		
4.1	Enumerators	Dec 2013–Feb 2014	Recruitment and training of enumerators
		June 2014	Retraining of enumerators due to delay in baseline survey
4.2	Data collection	June–Aug 2014	Data collection, editing in the field, call-backs
4.3	Data analysis	Sept 2014	Data editing, processing and analysis
4.4	Baseline report	Nov–Dec 2014	Writing baseline report
5	CCB implementation	July–Aug 2014	Training of participants in CCB in 9 districts by 18 facilitators and 4 district coordinators Commencement of design cycle Creation of appropriate technology
	Monitoring	Sept 2014–Dec 2015	Monitoring progress among CCB beneficiaries to perform technical backstopping and endline survey
	Follow-up support	Sept 2014–Mar 2016	Technical support provided to CCB full-dose beneficiaries during the period
6	Policy engagement	Jan–June 2015	Presentation of baseline report to Kulika Uganda, stakeholders and at conferences and workshops
7	Endline survey	June 2016	Enumerator recruitment and training
		July 2015–Aug 2016	Data collection
		Aug–Sept 2016	Data cleaning
		Oct 2016–Mar 2016	Data processing, analysis and report writing
8	Policy influence	Mar 2017–2018	Workshops, conferences, policy briefs, papers

5. 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 impact evaluation study acknowledged receipt of letters and made written statements of their willingness to participate in the study (see Appendix 1 for a copy of the letter of consent).

5.1 Evaluation and identification strategy

We conducted a randomised control trial (RCT) to evaluate the impact of creative capacity building training on four major outcomes: behavioural 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 quantitative and qualitative methods to harness the advantage of each. The mixed-methods approach enhances external validity, since it takes advantage of the strengths of a variety of methods used in socio-economic research.

5.1.1 Qualitative methods

A qualitative assessment was undertaken to address three of the four major CCB impact outcomes, namely: behavioural change, attitudinal change and technology generation. The impact of CCB on economic benefits was assessed through quantitative data, as discussed in the quantitative methods section below. We used focus group discussions (FGDs) involving CCB beneficiaries only.

Qualitative approaches are preferable when analysing power dynamics within a community (Hesse-Biber 2010), and attitudes and perceptions that may not be captured using quantitative methods. According to Moore and Benbasat (1996) and Perez-Diaz (2003), attitudes and behaviours are best analysed using qualitative approaches. Qualitative approaches also provide rich and detailed information on livelihoods and how people experience, understand and determine the adoption of new technologies and (Clifford 2014).

Two qualitative assessments were conducted: the midline assessment in December 2015–January 2016 after close to one year and two months of programme implementation; and the endline survey in March–April 2018. The midline qualitative assessment was conducted by an IFPRI intern, who held FGDs with selected individual members from only 12 out of the 18 CCB groups due to financial and time constraints.

The endline qualitative assessment was conducted by an independent consultant, using 16 of the 18 CCB full-dose groups. Two groups were not surveyed: one group was reported to have disbanded and most of its members had disappeared because of conflict in the area; the second group could not be located even after multiple visits. The FGDs were centred on the CCB training and its impact on attitudes.

Considering the expected impacts on attitudes and behavioural change, we analysed beneficiaries' perceptions about themselves, technologies developed and CCB training. Data were collected through semi-structured interviews, which would allow discovery of unknown impacts and unexpected information, and permit comparison of responses.

To make participants feel relaxed, all the interviews started with an easy and open question on participants' feelings and expectations about the training or project. The interview then proceeded with the following points, according to the hypothesis of the research design: participants' expectations; knowledge and skills acquired; challenges and solutions offered by groups; perceptions of technology and innovation before CCB; and lessons learnt.

To avoid biased responses, questions were asked without providing examples. To avoid bias from different interviewers, the same team conducted all interviews. The endline assessment was a cross-sectional qualitative study. Data were collected through FGDs, key informant interviews and individual interviews.

The research team set out to conduct FGDs with all 18 full-dose groups in the 9 project districts; each district had 2 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 group member, holding a leadership position and gender. The criteria used to select the FGD members created well-balanced groups with women, men and the leadership of the group well-represented. From these discussions, 1–2 members from each group making a technology were identified, and individual interviews held with them.

The field data collection process began in Central region, followed by Western, Eastern and Northern regions. In each of the districts, key informant interviews were held with the district production and marketing officer and the district community development officer. In some districts, including Sembabule, Isingiro, Rukungiri, Pallisa and Alebtong, both officers and their representatives were met.

In Mpigi, Soroti and Alebtong, either one officer or representative was met. In Amuria, both the district production and marketing officer and the district community development officer had travelled to Kampala. The key informant interviews focused on the level of awareness among the district leadership about the CCB training, its impact and sustainability. The research team sought to establish how much district departments knew about the CCB training, its impact and what plans they had for integration into their development plans.

FGDs were held with all 16 groups accessible to the research team. Informed consent was sought by phone. Appointments with group leaders were made 1–2 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 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.

With regard to the impact of the CCB project, questions focused on what benefits members gained as individuals and as groups, whether the training had provided opportunities for further training, and how gender roles had changed at household level as a result of the training. With regard to technologies, the discussions brought out comparisons of labour savings, quality and price of technologies made by members and those in the market, and comparisons with traditional practices.

All FGDs were recorded and highlights were summarised on flip charts to provide guidance in discussions. The lead researcher asked questions in English, which were translated by a facilitator who was proficient in the local language. The research team had four facilitators, one for each region, given that the local language in each region is different. One other team member, who took notes in the discussions and summarised them, also had to be fluent in the local language. There was also a translator for those team members who were unable to understand the local language. In addition to audio electronic recordings, photos were taken of the technologies made and meeting set-up.

In the FGDs, 1–2 members who had technologies to show the research team were visited and interviewed. Interviews mostly focused on the interviewees' level of access to local materials to make the technologies; the quantities they produced and sold; marketing challenges; and how they used the money generated from the technologies they had made.

5.1.2 Qualitative data analysis

The information collected was largely qualitative. The recorded information was transcribed into text. Analysis of text followed basic principles of content analysis in qualitative studies. Reading line by line, key points that came up repeatedly in answers to each of the questions were identified, categorised and examined closely. A second reading of the text focused on relationships between the key points.

In this way, a list of the key issues raised in the responses was generated. The ways in which key points were articulated in the FGDs are established in the subsequent readings.

5.1.3 Quantitative methods

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

1. As discussed above, an RCT was used to design this study. Accordingly, our empirical identification approach assumes that randomisation was fully achieved, and the treatment and control groups are balanced in both observable and unobservable characteristics. Additionally, it is expected that all changes in outcomes are due to treatment effects and all other changes are random and captured in the error term that is assumed to be unconditionally independent. We use both baseline and endline survey data 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 a demonstration of the CCB technologies; e = random error, which is normally distributed; and β_1 β and β_2 β are coefficients measuring the impacts of FD and HD on the outcome variable, which are the measures of difference-in-difference (DiD) specification:

$$DiD = \left(y_2^T - y_1^T - \left(y_2^C - y_1^C\right)\right).$$

where y_1^T and y_2^T are levels of outcome y in baseline and endline periods, respectively, for the treatment group; and y_1^C and y_2^C are levels of outcome y in baseline and endline periods, respectively, for the control group.

2. If selection bias persists even after randomisation, a controlled approach is necessary to achieve identification and address the bias under the conditional independence assumption. We use an econometric approach to control for other covariates that affect the outcome y:

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

where X = a vector of covariates affecting y and participation in CCB; and 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 is intended to net out any imbalances between treated and control groups, and this improves precision of the impact estimates. All covariates are taken at the baseline level to ensure that we do not include the treatment effects in the model.

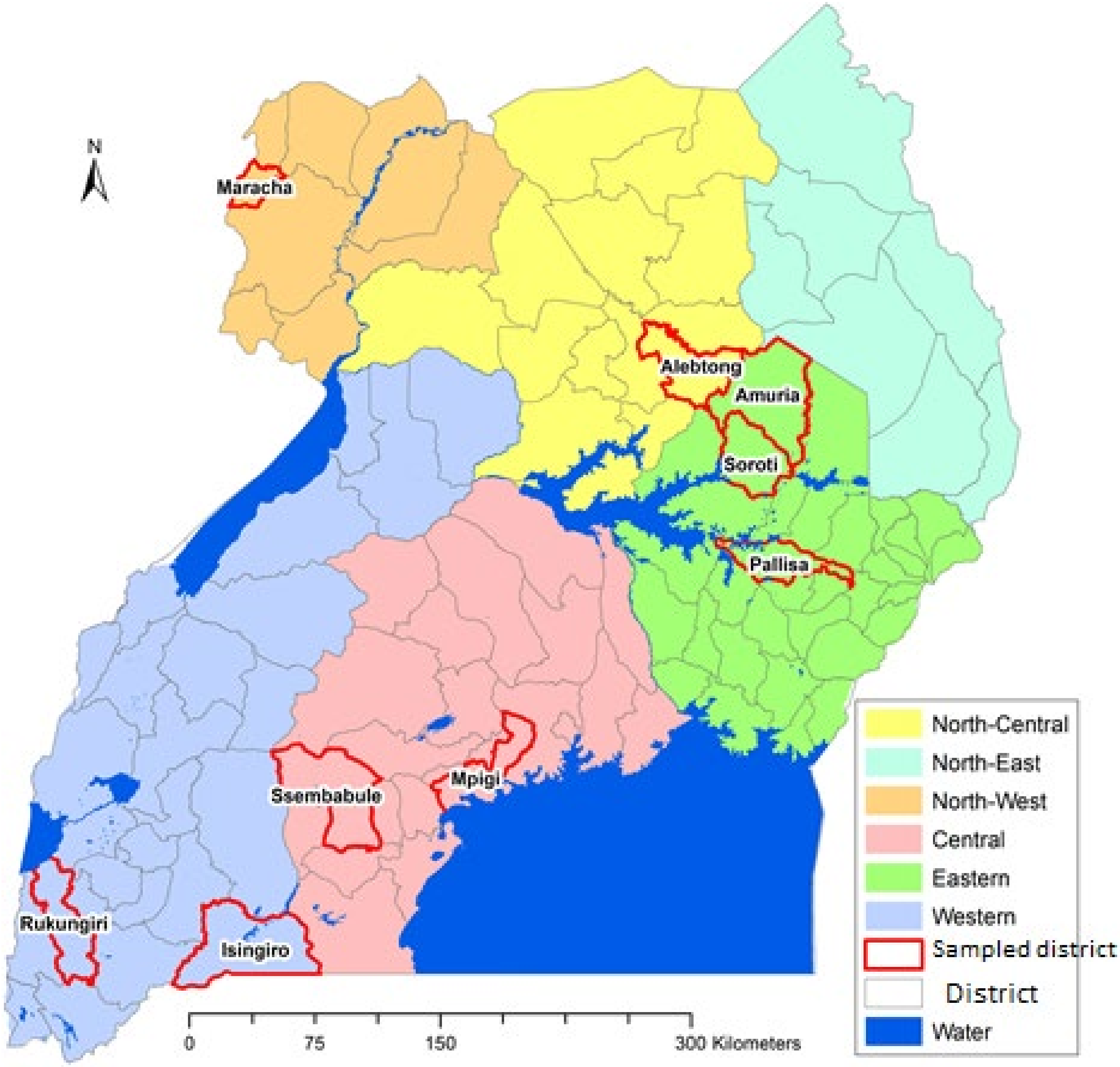
The X covariates include household head characteristics (age, education, sex, primary activity, whether they ever attended vocational training) and household characteristics (number of adult males, number of adult females, value of non-land assets). For continuous outcomes, Equations 1 and 2 are estimated by ordinary least squares estimation. Binary outcomes are estimated using the linear probability model. We also estimate probit models for the binary outcomes, but the results are not reported because the coefficients are similar to those obtained from the linear probability model.

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 RCT. The country was divided into six clusters with fairly homogeneous biophysical and socio-economic characteristics. The first three clusters (Western, Central and Eastern regions) are among the four administrative regions used in government documents (e.g. UBOS 2012). To reflect its major differences, the fourth region (Northern region) was subdivided into three subregions: northeast, north central and northwest.

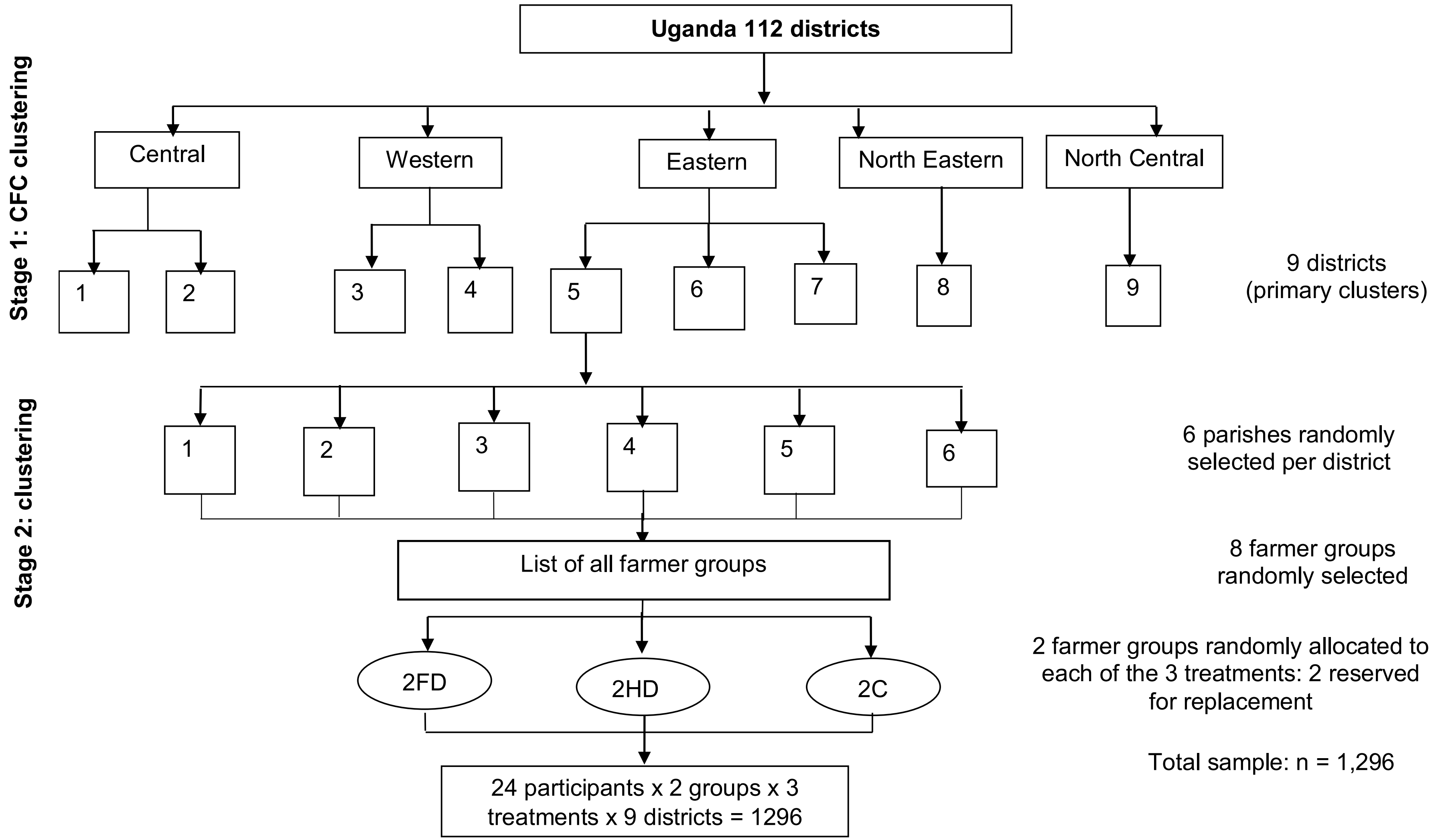
Under each of the five strata, a multi-stage cluster sampling was done. A population-weighted random sample of nine districts was taken from a total of 118 districts in Uganda, in which Central and Western regions were allocated two districts each, Eastern region was allocated three districts; the northwest and north central subregions were allocated one each (Figure 2); and the northeast was dropped from the sample.

Figure 2: Regions, subregions 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 six parishes selected, with the help of community leaders, from which a random selection of groups was undertaken (Figure 3).

Figure 3: Sampling design scheme



The decision to use farmer groups instead of individual households was based on D-Lab's experience that CCB training is more effective on groups of farmers who have previously worked together, as compared with groups of farmers who have never worked together before. Groups with fewer than 10 members were dropped from the sampling frame, as well as those whose membership could not be established. Groups of fewer than 24 members but more than 10 were merged to generate one group with sufficient members for the CCB training.

Eight groups were randomly selected from the sampling frame. Out of the 8 groups, 6 were then randomly assigned to the 3 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 fewer 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 1,296 member respondents (2 groups x 24 members x 3 treatments x 9 districts), of whom the survey team interviewed 1,235 respondents (Table 3). This was 95.3 per cent of the planned sample, which represents a high coverage and success in the field.

Table 3: 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	1,235	32	34	35

5.3 Sample size determination

5.3.1 Power calculations

Effect size

We did not have clear estimates of expected effect sizes. Beyond the first-order effect of adopting the workshop technologies, which are likely to have significant impacts on labour or production, we would expect second-order effects due to farmers' own innovations – a sum of small effects resulting in aggregate labour savings or productivity outputs – to be significant.

Discussion with communities during the design field tour revealed that use of particular technologies, such as drip irrigation and vermin traps, increased crop productivity or reduced harvest loss by 50–100%. Additionally, the literature review showed that training programmes similar to CCB increased income and employment with an effect size ranging 7–100%, with most programmes experiencing an effect size of 20–100% (Blattman et al. 2011; Benin et al. 2010; King et al. 2012; Attanasio et al. 2011). Based on this, we used an effect size of 35 per cent.

Intra-cluster correlation estimation

We used data from the 2005/2006 Uganda National Household Survey (UBOS 2006) and grouped farms by district and 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 Kulika Uganda and D-Lab had proposed to train at the beginning of the project.

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 D-Lab's recommendation to use farmer groups. D-Lab also recommended selecting 24 participants per group as the most appropriate for CCB training.

We grouped farms by district and farm size and filtered these subgroups for outliers (log-transforming the data and iteratively filtering points that had z-scores greater than two 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 could increase labour productivity; thus we expected variability to be lower in our own sample than that observed in the Uganda National Household Survey. We used three districts where Kulika Uganda had community technology centres as examples.

Using Optimal Design software (Raudenbush et al. 2011), intra-cluster correlation (ρ) was calculated at village, parish and district levels. However, observations at the village level were very few, with a maximum possible sample in each village of 10, with only 1–2 observations in most villages. This led to noisy estimates of village-level means and a consequent over-estimation of ρ. Estimates show that the ρ values of households within villages across districts converge to around $\rho = 0.2$ as the size of the sample increases, though we note 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 any 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 estimated a value of 0.1 for design calculations.

5.3.2 Results

Sample size per cluster

At household level – using a design with nine district clusters and two replications per treatment of the full- and half-dose treatments with an effect size of 35 per cent – we calculated about 30 households per cluster and a power of 0.80. 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 randomised sample of around 144 members in each district for baseline and endline data collection. As noted above, 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 summarises the sample size in each of the two treatment types and the control.

Table 4: Household sample size

	Full dose	Half dose	Control	Total
Baseline survey	402	419	430	1,252
Endline survey	323	326	396	1,045
Attrition (%)	20	22	8	17

5.4 Data

To evaluate the CCB programme, the baseline survey was administered in June–July 2014 and the endline survey in August–September 2016. A total of 1,252 households were surveyed at baseline and 1,045 households at endline, resulting in an attrition rate of 17 per cent (Table 4).

Household surveys collected information regarding: 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; labour contributions of men and women in household production activities; crop productivity; livestock productivity; non-farm income participation; and consumption and expenditure data. The questions administered in the baseline and endline surveys were similar in most cases in order 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 data entry errors. The data were collected by enumerators who had a first degree in agricultural economics, agriculture or agricultural engineering as a 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 languages.

The whole survey team comprised 28 members divided into four groups. Each group comprised enumerators and one supervisor. The supervisors obtained the data from the enumerators for auditing. The data were also sent to a national research supervisor and IFPRI data specialist for edit checks. Call-backs 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 complete each question before proceeding to the next.

5.5 Strategies to manage bias

5.5.1 Hawthorne effects (treatment group behaving differently under observation)

We minimised Hawthorne effects in our design by ensuring that the impact evaluation team was not explicitly linked to the Kulika Uganda intervention, and that any activities done by both teams were independent. For example, while training by Kulika Uganda was done in groups, the participants were independently interviewed in their households.

5.5.2 John Henry effects (non-treatment group behaving differently after knowledge of treatment)
We addressed the issue of John Henry effects between treatment and control groups by selecting a sampling scale (parish) that kept 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 with other groups since the listing was done at the parish level, and selection was performed at the district level (from a list of six randomly selected parishes).

A total of 6 out of approximately 100 parishes in a district were selected, and our expectation was that the diffusion of knowledge about the intervention would be very low outside of the parishes. Our design tour to selected districts also confirmed low diffusion across parishes. Within parishes, group members not invited to participate in the workshop were dissuaded from joining the training workshops by Kulika Uganda.

This was done by explaining the aim of the training workshops – to help each community learn how to design solutions to its problems – and also that Kulika Uganda could only to invite a small number of randomly selected people to participate, who were expected to train others in the district. The random selection was used to allay concerns of favouritism in the selection.

5.5.3 Compliance with encouragement
To ensure that the selected households participated in the CCB training, basic facilitation was given to participants during training. Kulika Uganda designed a culturally appropriate means of compensating workshop participants by making the workshop broadly appealing. This included allowing participants to keep finished technology products, providing meals, giving workshop tools to participants as a group, and paying for their transportation expenses from home to the training venue.

Training was limited to selected group participants and led by facilitators who resided in their local community. The necessity of belonging to particular groups minimised the issue of non-invited participants attempting to join. Facilitation minimised self-selection bias and therefore improved internal validity.

6. Programme: design, methods and implementation

6.1 Key programme elements and activities

D-Lab developed and promoted CCB as an approach to international development, with the goal of training participants to create and adapt technologies that would improve their lives and strengthen their communities. CCB enhances people's creativity and builds confidence among participants to create technologies that can improve their livelihoods.

The approach was first used in 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 a top-down approach and the former is a bottom-up approach.

Implementation of the programme involves a design process with key elements that include a hands-on curriculum that is accessible at any education level. It thereby presents a framework through which anyone can become an active creator of technologies and not just a recipient or user of them.

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

After pre-testing the curriculum in the two non-project districts, Kulika Uganda realised that the curriculum was too congested to be delivered in three days. They therefore revised the curriculum to be delivered in four days, so participants would have enough time to think through all the steps of the design cycle.

6.2 Programme content and delivery

The programme was delivered through training sessions to groups of 24 participants on average. Each group of 24 people was divided into 4 teams of 6 people each to enable them to actively participate in the design process.

In each of the nine districts, 4 farmer groups of 24 participants each were selected, making a total of 36 groups (4 groups x 9 districts) and 864 trainees (4 groups x 9 districts x 24 participants). The farmer groups and participants from each group were sampled by the evaluation team just before the baseline survey. Two groups in each district received the full-dose treatment (both training and demonstration) and the other two groups received the half-dose treatment (demonstration only). The treatments were administered as follows:

- Full-dose treatment: 1 day of preparation, 4 days of training, 1 day of demonstration
- Half-dose treatment: 1 day of preparation, 1 day of demonstration

The programme content was delivered by community facilitators and district coordinators who had been trained by Kulika Uganda and D-Lab. The facilitators had at a minimum a certificate, and the coordinators had at a minimum a diploma (up to a 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 Uganda, D-Lab and the evaluation team from Makerere University and 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 the Kulika Training 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 programme activities.

The facilitators and coordinators were aware that they were participating in a research experiment right from the outset of the project. However, trainees were not aware that they were participating in the experiment. The implementing agency was different from the research team, and the environments 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 members, and occasionally in school or church premises. The trainings were delivered within the communities in an informal environment, with a flip chart and chairs arranged in a semi-circle. However, researchers found and interviewed participants in their homes. There was limited interaction among the groups selected because they were far apart.

The design cycle part of the training was delivered in four eight-hour days and the technology demonstration was delivered in one six-hour day. 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 4 teams of 6 members each. Teams worked together to design different technologies.

The materials required for the programme included timber, square metal bars and metal sheets; tools included a hammer, nails, tin snips, pliers, wood saw, G-clamp, wood file, square, marker and vice. The technologies used in the demonstration included an energy-saving stove and charcoal press; a groundnut paste maker; a meat mincer and a solar lantern.

After training, the facilitators and the coordinators had follow-up meetings with the full-and half-dose groups. The follow-up meetings were designed to encourage group members to establish meeting dates to continue refining and making new technologies in response to the emerging farm challenges. On average, each group met once a week to refine 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, as well as review and delivery of materials needed for technology creation and refinement.

Each full-dose group was visited times a month for six months after training. Technical backstopping continued officially for up to one year, but the groups still make consultations with the facilitators even now. The facilitators offered technical advice whenever they were called upon. The half-dose groups received follow up visits only 2–3 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 1–2 visits.

The programme protocol was prescriptive, as illustrated in the training curriculum; however, participants made several prototypes in one session. This demonstrated that they understood the design cycle. The technologies developed also responded to challenges in their daily activities at the household level.

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

During the design cycle, participants were taken through its eight steps one by one: identifying a problem; gathering information; thinking of ideas and experimenting; choosing the best idea; working out the details; building the prototype; testing the prototype; and getting feedback.

After the training, the facilitators and coordinators made follow-up visits to check what the trainees were doing and to understand those areas where the groups needed additional help.

6.3 Attrition

The sample used in the impact analysis showed a 17 per cent attrition rate from the original baseline sample. We assessed attrition bias by comparing baseline characteristics of attritors and non-attritors. The results show that mean comparisons on most characteristics did not differ significantly, as shown in Table 5.

Table 5: 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 household	1.2	1.3	0.651
Number of adult females in 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.
*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01.
Source: baseline and endline household surveys.

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 generalised for the original population. Despite this favourable evidence of a lack of serious attrition bias, we adjusted our impact estimates for attrition bias using a two-stage inverse probability-weighted regression procedure (Weuve et al. 2012). This approach is increasingly used to correct selection bias in treatment effects studies 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 results tables in the following section to demonstrate the robustness and sensitivity of our results to different econometric estimators under uncontrolled and controlled difference-in-difference. In all the impact results on all outcomes presented in this study, we find very robust findings from the different approaches used, which strengthen our confidence in the results.

7. Impact analysis, results and discussion of key evaluation questions

7.1 Baseline balance tests between treatment and control groups

We test whether the experimental design of this study was effective in achieving balanced groups between treatment and control across several pre-intervention household-level and individual-level characteristics. The results of the balance tests are shown in Table 6.

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 later sections.

Table 6: 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 > 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 < 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 smartphone	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 (mobile) 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

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)
% receiving 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 labour-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

Source: Baseline survey data.

Note: *, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01.

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 perceptions about themselves and their innovations, as well as other important aspects of the training outcomes.

7.2.1 Impact on behavioural characteristics and attitudinal changes

- **New knowledge and skills gained from CCB training –** Three aspects of new knowledge and skills have been considered. These are: (1) what participants believed they gained in terms of new knowledge and skills from participating in the CCB training; (2) the most applicable of their new knowledge and skills; and (3) the least applicable of their new knowledge and skills.

  Discussions with participants repeatedly identified the following as new knowledge and skills gained from participation in CCB training: making a maize sheller, a groundnut plucker and sheller, a root tuber (sweet potato, potato and cassava) slicer, a charcoal press and a juice blender. Others mentioned making a seed cleaner, a coffee-pulping machine, a coffee huller, baskets and bags, a poultry cage, an energy-saving stove, a seed planter, a rake, a wooden weighing scale, and a fruit harvester.

  While many of these were mentioned in all regions, there were also regionally specific knowledge and skills highlighted. Making a millet harvester was mentioned in Northern region, and musical instruments were mentioned in Eastern region. Specific to Western region were knowledge and skills in making bags and baskets, among both men and women. Meanwhile, the acquisition of knowledge and skill to make a fruit harvester was mentioned in Eastern and Northern regions.
- **Most applicable new knowledge and skills gained from CCB training –** After listing (in no particular order) the new knowledge and skills gained from attending CCB training, participants were asked to name the most applicable. 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 a charcoal press for making briquettes. Members of half the groups interviewed (8 out of 16) knew how to make briquettes and made them to sell.

  Among the root tuber slicers, the sweet potato slicer was rated the most applicable. Members of five of the groups in Eastern and Northern regions 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 regions.

  Carpentry and fabrication knowledge and skills in general were rated very highly and considered as some of the most enduring legacies of the project. Both men and women expressed gratitude for knowledge and skills in carpentry, which they said are widely applicable in their livelihood activities. In all regions, one key programme outcome that participants mentioned was knowledge and skills gained in woodwork and metalwork among both men and women.

- **Least applicable technology gained from CCB training –** Among the least applicable and least preferred technologies was the cassava slicer. Some groups said the technology required a lot energy if the blade was not sharp and was thus more of a burden. Groups that found the cassava slicer least applicable were Katobotobo Zone A, Kempungu and Murama Coffee Farmers' 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 regions, were the groundnut sheller and coffee huller. Coffee is not widely grown in Northern region, so it is to be expected that the application of a technology made for coffee processing will be limited. The wooden weighing scale was also rated as least applicable by the two groups in Pallisa district – Rwantama Youth Association and Apetet Family Care Association – because of its bulkiness, especially during the rainy season. In the Apetet Family Care Association, the technology was only used to weigh meat in the trading centre.

  The seed planter was least applied by Katobotobo Zone A group in Rukungiri and the Okude Youth United group in Amuria. The machine was difficult to make because a lot of materials were needed, and the demand was very low among the population. The wheelbarrow was made by three groups including Apit Penyer in Alebtong, Candibazu Women's Group and Kibwera Kweyombeka. There was less enthusiasm for its use because making a wheelbarrow required a lot of time and materials, and is difficult to use in hilly areas. The fruit harvester was the least applicable because of its seasonal use.

7.2.2 Other benefits of creative capacity building training

Asked if they had attended similar trainings and what the differences from CCB might have been, almost all participants reported not having attended any similar training. It was expected that participation in 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 realise 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 for individual group members and their groups. As individuals, participants benefited in several ways:

- ***Increased income*** – From selling products and hiring out tools they had made. Some farmers sold briquettes, bags, baskets and sprayers and hired out tools they had made to members of their community.
- ***Reduced expenditures at home*** – Since the training, members are able to make repairs in their homes that would otherwise have cost money. For instance, many reported that women are now able to do simple repairs on kitchen doors, benches and chairs at home. There is no expenditure on tool hire for use at home. They do not have to pay for sweet potato slicers, maize shellers, sprayers, groundnut pluckers or briquette-making tools, unlike other people living in their communities. Members have also saved money because they did not need to hire carpenters.

- ***Reduced workload for members*** – With regard to the use of machines made after the training, many group members reported reduced workloads. For example, maize shelling was predominantly undertaken by women; however, with a maize sheller, all family members get involved. Children reportedly enjoy the process of maize shelling. In general, the tools made have encouraged women, men and children to take up roles in households previously done by the other gender, thus reducing division of labour, saving labour and reducing the household workload.
- ***Employment of young people*** – The young people who participated in these trainings are no longer unemployed. They engage in making tools and in agriculture. They make money by hiring tools they have made to those who need them.
- ***Improved standards of cooking*** – The training in energy conservation using energy-saving stoves and charcoal 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, as well as strategies such as dousing the fire once cooking is complete to save the briquettes or charcoal.

The CCB training has also had benefits at the group level. Some groups have experienced greater social cohesion and have begun working together more closely. Their credit and savings associations have been strengthened because members sell some of the items they make and hire out tools to make money. In many groups, hiring out tools made by the group was done at the group level. The earnings from such sources went to the group savings account.

The trainings, associated activities and increased networking among group members (through which ideas taught in CCB training trainings are shared) have resulted in the increased popularity and visibility of the groups. Some groups are making good use of their popularity by starting businesses such as hiring out chairs and tents for functions within their communities.

7.2.3 Changes in gender roles

- ***More men are 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 willing to participate in cooking when energy-saving stoves and briquettes are used. They find it more convenient than using firewood and ordinary charcoal.
- ***More women are involved in traditionally male 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 and beds, or 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 female activities, such as weaving, making bags and baskets, and making cooking stoves.
- ***Reduced division of labour in farm work*** – Farm work has become more egalitarian. Activities that were previously mostly left to one gender are now shared more equally. For instance, cassava and sweet potato processing that was previously women’s work can now be done by men using a slicer during leisure

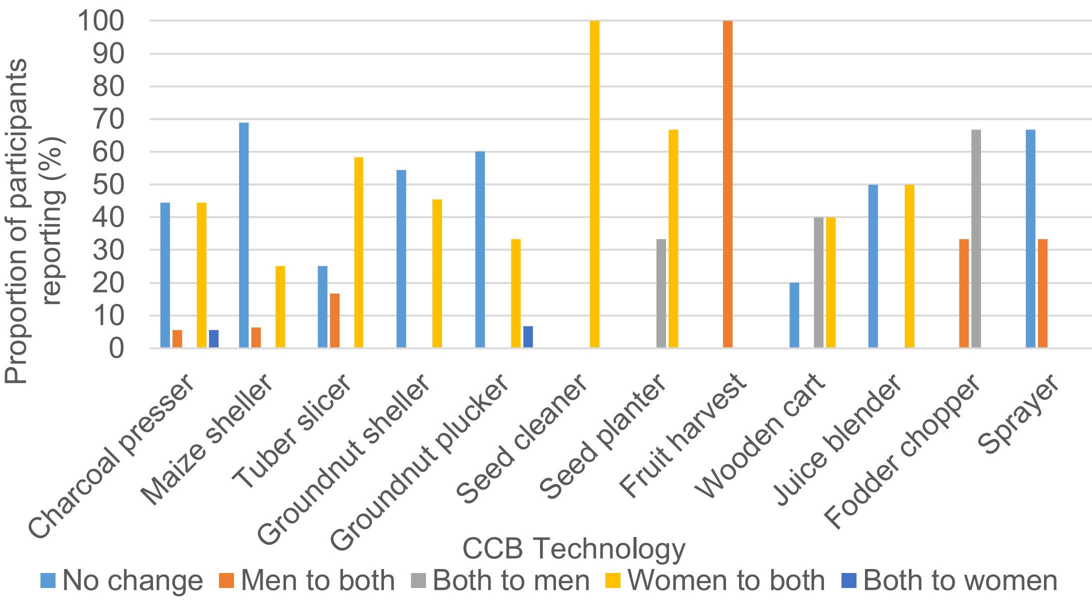
time, instead of moving to hang out in trading centres. Use of maize shellers has sharply increased children's participation in maize shelling, which was mainly a woman's activity in households. Men and children are now motivated to participate in shelling and winnowing, thus reducing women's household workload.

Similarly, the grass chopper has made it easy for women and children to participate in cutting grass as feed for animals, an activity that has mostly been done by men. Women now also harvest fruits, whereas they did not before the fruit harvester was developed. Since the CCB training, planting, harvesting, and shelling groundnuts and maize have become joint activities for all gender categories in the household. Furthermore, women now take an 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 willing to listen to their wives. This has also come as a result of women's increased financial contribution to the household from the income they earn from sale of technologies, and savings made on charcoal from using briquettes. This respect is being reflected in shared decision-making at the household level and has reportedly also reduced domestic violence.

Results in Figure 5 show that CCB tools have significantly changed the division of labour for most tasks.

Figure 4: Change in division of labour due to creative capacity building technologies



Source: FGD midline assessment

In particular, fruit picking from tall trees was specifically a task for men due to the risk of falling out of trees. The long-armed fruit picker enables women to perform fruit picking without having to climb the trees. Seed cleaning (winnowing), which was done exclusively by women, is now performed by both men and women using the CCB seed cleaner. However, some CCB technologies – including the maize sheller, groundnut plucker and sprayer – have not significantly change the division of labour. The results underscore the role that technologies could play in reducing the burdensome activities done by women and some labour-intensive activities performed exclusively by men.

7.2.4 Impact pathways of the creative capacity building programme

From the main findings of this assessment, four pathways can be discerned, by which the CCB programme has had an impact on local communities:

1. **Productivity pathway** – The innovations and technologies from CCB training have reduced the time spent on farm work and in post-harvest handling and improved the quality of produce. Participation in the trainings has also created youth employment. The young people involved in the programme are active participants in designing and making new tools and equipment, thus contributing to the development of their local communities.
2. **The income pathway** – CCB training has resulted in higher incomes among participants and their groups. Incomes have come from selling and hiring out tools and equipment made as a result of participation in the training. New knowledge and skills have also reduced the cost of services that were originally outsourced and paid for, which are now provided by family members. For instance, instead of hiring a carpenter to make and fix furniture at home, women or men or both make or repair broken furniture themselves, 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-group members in the community.
3. **The gender pathway** – The CCB training has altered gender relations and roles in significant ways. Men, who traditionally left household chores to women, have become much more involved in performing reproductive roles in households, including cooking, as a result of the ease associated with using 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 into activities that were traditionally the preserve of men. These include carpentry and tool manufacture, learnt during the CCB training. The training has also reduced the division of labour on farms in ways that have reduced women's workloads. Men and children have increasingly taken on roles generally reserved for women, such as shelling, winnowing and chipping using the new technologies. Overall, the trainings have increased women's participation in household decision-making and their contribution to household income, resulting in greater respect from their husbands and the community.
4. **The social capital pathway** – The 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 bonds among group members. Such enhanced relations provide insurance against risks. It is from such networks that members can borrow in times of stress.

   The trainings have also linked the groups to other organisations that provide information and opportunities for the groups. The trainings, associated activities and increased networking among group members (through which ideas taught in CCB trainings are shared) have resulted in the increased popularity and visibility of groups. Some 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

7.3.1 Impact of creative capacity building on the number of tools used and type of activities done

Table 7 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 per cent and 64 per cent for full- and half-dose beneficiaries, respectively. The results are robust across uncontrolled and controlled approaches.

Table 7: Impacts of creative capacity building on number of types of tools and machines used

Treatment	Log (number of types of tools or machines used)					
	Uncontrolled DiD			Controlled DiD		
	No clustering	With clustering	With 2SWR	No clustering	With clustering	With 2SWR
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 or 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***

Source: Baseline and endline household surveys
Note: 2SWR = two-stage attrition-weighted regression; DiD = Difference-in-difference; FD = full dose; HD = half dose.
*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.

The impact of CCB on designing and making tools was statistically significant. The probability of designing and making tools increased by 55 per cent among CCB full-dose beneficiaries and by 6 per cent among half-dose beneficiaries (Table 8). This was expected, given that 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 8: Impacts of creative capacity building on the propensity to make and innovate tools and 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**

Note: 2SWR = two-stage attrition-weighted regression; DiD = difference-in-difference; FD = full dose; HD = half dose.
*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.
Source: Baseline and endline household surveys

It would be interesting to determine how the control group compares with CCB in terms of ownership and use of the same tools designed by CCB beneficiaries. Table 9 reports ownership and use of tools that were designed by CCB beneficiaries. No farmer in the control group owns a groundnut sheller or juicer, and a very small number own a charcoal press. This underscores the fact that these technologies are new, but skills to design and make them exist locally. CCB beneficiaries have an opportunity to exploit this opportunity to produce charcoal presses and market them locally and in other areas.

Table 9: Creative capacity building 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 press	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
Groundnut sheller	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.

*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.

Source: Baseline and endline household surveys

Overall, the full-dose treatment group members own and use more of the technologies they design than the control group. However, the half-dose group members are not significantly different from 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 analysed the impact of CCB on primary and secondary activities to determine how CCB technologies affected economic activities by comparing the full- and half-dose groups with the control group. Overall, there was no significant change in primary activity due to CCB training (Table10). This was expected, given that the CCB tools enhanced what farmers do rather than helping them to engage in other economic activities.

Table 10: 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	
	% change			FD-CT	HD-CT	% change			FD-CT	HD-CT
What activities changed?										
Switched to:										
Agricultural production	33.3	35.6	45.1	0.293	0.444	29.3	28.7	36.6	0.671	0.581
Agricultural processing	0	0	0	–	–	2.7	0.0	0.0	0.120	1.000
Agricultural 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
Waged 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.

*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.

Source: Baseline and endline household surveys

However, CCB training increased the number of economic activities by two for both full- and half-dose CCB beneficiaries – an increase of about 80–90% of the total number of economic activities done by households (Table 11). The increase in the number of activities is significant and robust across controlled and uncontrolled methods.

Table 11: Impacts of creative capacity building programme on number of economic activities undertaken

	Log (number of economic activities)					
	Uncontrolled DiD			**Controlled DiD**		
	No clustering	With clustering	With 2SWR	No clustering	With clustering	With 2SWR
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***

Source: Baseline and endline household surveys

Note: 2SWR = Two-stage attrition weighted regression; DiD = difference-in-difference; FD = full dose; HD = half dose.

*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.

For secondary activities, CCB led to a significant change in the type of activity done. A significant share of full-dose CCB beneficiaries switched to an artisan activity involving tools. The major reason for switching to a new activity was the acquisition of new vocational skills (Table 12). Switching to artisan work is justified by the acquisition of new tools that could help farmers to do artisan work as a secondary activity. For example, acquiring tool design skills may have helped CCB beneficiaries to engage in making several tools.

Table 12: Major reason for change of primary and secondary activities

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 for products from old activity	6	10.6	20.4	0.050**	0.387

Source: Baseline and endline household surveys.

Note: FD = full dose; HD = half dose; CT = control treatment.

Only reasons with significant differences are reported.

*, ** and ***, respectively mean, associated statistics are significant at 0.1, 0.05 and 0.01 levels.

By design, CCB sought to enable trainees to design, make and fix broken tools. Accordingly, CCB increased the number of tools and machines repaired by 60 per cent in full-dose households and 75 per cent in the half-dose households (Table 13). The results are robust across controlled and uncontrolled analyses.

Table 13: Impacts of creative capacity building on broken tools and machines repaired by household members

	Log (number of tools and machines broken and repaired)					
	Uncontrolled DiD			**Controlled DiD**		
	No clustering	With clustering	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 and 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***

Source: Baseline and endline household surveys.

Note: 2SWR = two-stage attrition-weighted regression; DiD = difference-in-difference; FD = full dose; HD = half dose.

*, ** and ***, respectively, mean associated statistics are significant at 0.1, 0.05 and 0.01 levels.

7.3.2 Impact on asset value and household income

In this section we analyse impacts of CCB on household assets and income. Only productive assets (transportation equipment, processing equipment, farm production implements, water-harvesting equipment) were included. Land, livestock and household durables were excluded. The value of assets was expressed in nominal values at current market values as perceived by 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 show significant impact on the value of household assets of full-dose CCB beneficiaries (Table 14). This is expected, given the short life cycle of the project.

Table 14: Impacts of the creative capacity building programme on the 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; DiD = difference-in-difference; FD = full dose; HD = half dose.

*, ** and ***, respectively mean, associated statistics are significant at 0.1, 0.05 and 0.01 levels.

Source: Baseline and endline household surveys

The impact of CCB on income was analysed using three sources of income: crops, non-farm and livestock, all of which were 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 income than crop income. Although in magnitude they were largest on crop income and crop productivity, the low statistical significance of crop income could have arisen from a noisy distribution, which is exacerbated in double-difference estimates. The statistically significant results for non-farm income are consistent with qualitative results, which showed increased income from the sale of products and hiring out of tools made by CCB participants.

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

Table 15: Impacts of creative capacity building on crop, livestock, non-farm and total household income

	Uncontrolled estimation		**Controlled estimation**	
	With clustering	2SWR	With clustering	2SWR
Double-difference estimates				
Crop income (UGX)				
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 (UGX)				
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 (UGX)				
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 (UGX)				
FD	360,917***	308,548***	348490.1***	297642.6***
HD	151,274	103,443	130607.6	86059.3
Double-difference estimates				
Household income (UGX)				
FD	1,031,827	1,199,221*	1045259	1218952*
HD	104,156	196,850	106693.7	198577.9

Source: Baseline and endline household surveys.
Note: 2SWR = two-stage attrition-weighted regression; FD = full dose; HD = half dose; UGX = Ugandan shillings.
*, ** and ***, respectively mean, associated statistics are significant at 0.1, 0.05 and 0.01 levels.

8. Discussion

8.1 Internal validity

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

8.1.2 John Henry effects (non-treatment group behaving differently after knowledge of treatment):

We addressed the issue of John Henry effects between treatment and control groups by selecting a sampling scale (parish) that kept the risk of contamination between units in the sample low. A total of 6 out of approximately 100 parishes in a district were selected. Our expectation was that diffusion of knowledge about the intervention would be very low outside of the parishes. Our design tour to selected districts confirmed low diffusion across parishes.

Within parishes, for those parish where members were not invited to participate in the workshop, the Kulika Uganda group framed their response to explain that the training workshops aimed to help the community learn how to design solutions to its problems, and Kulika Uganda 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 concerns of favouritism in the selection.

Compliance with encouragement: To ensure that the selected households participated 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 transportation expenses during training. Registration was also required, minimising the issue of non-invited participants attempting to join. The encouragement minimised the self-selection bias, and therefore is likely to have improved internal validity.

8.2 External validity and scalability of creative capacity building 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 assessments show that CCB-enabled participants were able to innovate a number of innovations based on the challenges they faced in their communities, ranging from saving labour and energy to post-harvest handling and processing and managing crop and livestock products.

The results show that participants were able to create win-win technologies that were of superior quality and also enabled labour saving, compared to traditional practices and technologies available in the market. Given that most of the technologies were prototypes, the quality achieved and the technologies' capacity to save labour showed that there is strong potential to improve on technologies made by participants to achieve desired attributes.

There were differences in the number and types of technologies developed in different regions. These varied based on the differences in challenges and opportunities available, implying possible development of trade opportunities. For example, Central region is likely to excel in the production of charcoal briquettes, given the opportunity cost of labour and cost of fuel wood.

In Northern and Eastern regions, post-harvest technologies will be key priorities as farmers depend largely on annual crop production. In contrast, communities in Central region and the 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 regional production system.

Evidence from the CCB training in the present study is confirmation of local communities' capacity to innovate and ability to influence their welfare though technological innovation. The new tools designed by local people reduced labour by at least 50 per cent, an aspect which shows great potential for locally made labour-saving tools. Some tools also helped to change division of labour, suggesting that CCB tools could alleviate burdensome tasks performed by women, as well as hard labour performed by men only.

CCB technologies also showed a significant impact on crop income, suggesting their potential to alleviate poverty. CCB's impact on income from livestock and value of assets is weak. This was expected, given that the technologies were mainly directed at addressing crop production activities. The three-year period is also too short to have a significant impact on the value of assets and other lagged impacts. The combination of a significant reduction in labour and an increase in crop income translates into great potential for CCB technologies to reduce household poverty among beneficiaries, as some of the labour saved could be invested in other income-generating activities, in addition to increased crop income.

Most of the technologies innovated stand a chance of reducing Uganda's post-harvest losses, which are estimated in the range of 30–50%. This means that CCB training has great potential to reduce post-harvest losses (and hence improve food security) in Uganda. Also, aflatoxin and other types of food contamination largely occur during post-harvest crop management (Kaaya and Kyamuhangire 2010). CCB training and the resulting technologies also may enhance 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 aggressively marketing innovations to generate more income for the innovators and increase awareness among and access by other users.

Uganda's Vision 2040 and the Second National Development Plan emphasise human capacity development as one of the key fundamentals in accelerating the country's transformation. At the heart of this strategy is the promotion of business, technical and vocational education and training to harness Uganda's population dividend. The evidence generated in this study underscores the need to incorporate CCB training in the business, technical and vocational education and training curriculum to build local capacity and scale up training within and beyond the nine districts covered by this research.

According to UNESCO, '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 CCB, which converts communities into vocational and innovation centres by building their capacity to design and make tools using locally available materials. The CCB training in Uganda showed a very strong and favourable reception in the 19 communities that benefitted from it.

The results underscore the power of teamwork 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. Nijstad and Paulus (2003) recognise the role teamwork plays in the scientific process, as it takes advantage of diverse skills and knowledge. This is contrary to most research on creativity, which has focused on individual creativity with little recognition of social and group factors that influence the creative process, while emphasising isolation and individual reflection as key factors in creative accomplishments (Ochse 1990; Simonton 1988; Nijstad and Paulus 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 who participated in the policy influence workshops appreciated the ability of the CCB training participants to come up with a number of technologies from locally available resources that addressed a number of post-harvest handling and processing challenges. Particularly, they appreciated that CCB technologies enabled a reduction in drudgery for women who multi-task with regard to production and household reproductive activities.

However, the participants cautioned that the approach was not able to handle serious challenges that affect agricultural production. These include development of appropriate irrigation equipment to address climate change shocks and the need to liaise with the Uganda National Bureau of Standards to come up with certified quality products, particularly those to do with post-harvest and food processing.

9. Specific findings for policy and practice

The discussions above will require policy interventions to transform the benefits of CCB training into reality. An important question is how to mainstream CCB training to sustain its impact. Two major challenges need to be addressed, the first of which is offering a CCB training equivalent to that which D-Lab offered. There is a need to build local capacity for institutions capable of offering CCB training.

Such a role could be played by vocational training centres in Uganda, which currently only offer on-campus training to young people who have graduated from secondary school. Vocational training institutions could expand their training to communities using the CCB model. This approach was used to implement one of the most successful education programmes in Uganda, namely Universal Primary Education. This could be used as a model to offer CCB and other TVET programmes.

The second challenge is the production and marketing of tools and their parts. We can learn from success stories in the production and marketing of local innovations in SSA. One such story comes from eastern Democratic Republic of Congo, where local innovators build large wooden carts (*chikudu).*The carts' spare parts are also produced locally and marketed by local dealers and in local shops. There are also many repair shops.

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 the ‘master key’ to achieving Uganda’s Vision 2040, with the overarching goal of alleviating poverty and becoming an upper middle-income country by 2032.

The results of the CCB programme were shared with policymakers and implementers in the country. Parliamentarians were very impressed with the low-cost approach used in CCB training and the impacts of the innovations. They saw the need to design strategies for scaling out the CCB approach’s successes to other districts. To have such out-scaling, the parliamentarians wanted to know how the Directorate of Agricultural Extension Services was involved in implementing CCB activities, and how the CCB approach could be integrated into the directorate. The parliamentarians were told that the design of the study meant that extension service providers were not involved in the CCB training or dissemination. However, there is an imperative to involve them in CCB innovation dissemination since most of the technologies are agriculturally oriented.

At local government level, consistent with the parliamentarians’ observations, participants in the policy influence workshops expected irrigation innovations to have come out of the CCB process. This implies that drought is an important constraint of agricultural production that CCB-trained participants overlooked, probably because it falls outside the capacity of local innovators.

However, participants appreciated the need to build capacity for boosting local innovations to improve productivity, incomes and sustainable exploitation of natural resources. They highlighted weaknesses at the local-government level that would affect the efficient out-scaling of CCB as an approach to bolster creativity and innovation. In particular, local governments lack the mandate to initiate policies and are instead considered to be implementers.

Participants observed that funds currently allocated to district production departments are strictly for disseminating technologies and cannot be channelled into innovation. They recommended that the Ministry of Agriculture’s Directorate of Agricultural Extension Services should fund the out-scaling of CCB activities to communities and districts that had not participated in the Kulika Uganda activities. However, they agreed that CCB training could be implemented as a dissemination approach where trained participants use their own resources to come up with innovations.

They recommended that the CCB curriculum and training be made available to extension staff. They also promised to tap into youth livelihood, venture capital and women’s entrepreneurship funds to support local innovations and out-scaling of CCB, especially to young people, artisans and women’s groups. They promised to start with the current CCB groups to help them commercialise their activities and link them to the Uganda National Bureau of Standards for certification of their products. However, they observed that a policy on patenting to reward and incentivise local innovators is needed.

Appendixes

Appendix A: Letter of participant consent to participate in study

https://www.3ieimpact.org/sites/default/files/2019-12/PW2.08-Impact-of-CCB-Uganda-Appendix-A-Letter-of-participant-consent.pdf

Appendix B: Field notes and other information from formative works

https://www.3ieimpact.org/sites/default/files/2019-12/PW2.08-Impact-of-CCB-Uganda-Appendix-B-Field-notes-and-other-information-from-formative-works.pdf

Appendix C: Sample size and power calculations

https://www.3ieimpact.org/sites/default/files/2019-12/PW2.08-Impact-of-CCB-Uganda-Appendix-C-Sample-size-and-power-calculations.pdf

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