Final report

International Growth Centre

Scoping study

Using network theory to promote adoption of new agricultural technologies in Sierra Leone

Barbara Cardona
Kurtis Lockhart
Anthea Piong

August 2019

When citing this paper, please use the title and the following reference number:
F-19081-SLE-1

DIRECTED BY LSE UNIVERSITY OF OXFORD

FUNDED BY UKaid from the British people

Acknowledgements

We would like to acknowledge first and foremost our team of dedicated enumerators in Freetown, Bo, and Mile 91 who braved the Sierra Leonean rainy season to collect data for this report. We'd also like to thank Mr. Foday Melvin Kamara -- the Managing Director of FINIC -- along with his team of local engineers and mechanics who fabricated and helped install the maize dryers on very tight timelines. Melvin also gave incredibly helpful advice around possible design improvements. Additionally, we are grateful to the many people in the private sector and government who we interviewed for this report; they graciously provided both their time and countless thoughtful insights. Finally, we thank the broader Warc team -- including Warc's farm management team and farmers in Tormabum -- who provided sage advice throughout that has enhanced this final report.

We are thankful for the financial support of the International Growth Centre and the Stanford Seed Program.

Contributors

Kurtis Lockhart

Kurtis Lockhart is a PhD candidate in political science at the University of Oxford and a Research Fellow at the Charter Cities Institute. At Oxford he's taught both quantitative methods and African politics. In the field, he has previously worked as a Research Manager for WARC Africa in Sierra Leone, and for the ELIMU Impact Evaluation Center in Kenya where he managed the implementation of several randomized control trials across many different sectors (health insurance, rural electrification, tax administration, and legal aid). Kurtis has also completed consulting projects with both Oxford Development Consultancy. He holds an MSc in Development Management from the London School of Economics, as well as a BA in Economics and Development Studies (First Class Honors) from McGill University.

Barbara Cardona

Barbara Cardona is a senior at Stanford University pursuing a BS in Management Science and Engineering with a concentration in Organizations, Technology and Policy. She's also studied at the University of Oxford, focusing on comparative international education policy. As part of the Seed Program at Stanford's Graduate School of Business, Barbara completed consulting projects in Sierra Leone with Warc Africa.

Anthea Piong

Anthea Piong came to Sierra Leone as a Princeton in Africa Fellow (2018-19) where she led Monitoring & Evaluation projects for WARC's consulting arm. Her interest is in utilising data and design to communicate impact and work for the social good. She is now a full-time member of the WARC team, working on their growing portfolio of internal and external data collection and M&E projects. She holds a Master of Public Policy from Georgetown University.

1. Introduction

Globally, 80% of the extreme poor are concentrated in rural areas and 65% are employed in agriculture (World Bank, 2016). Therefore, interventions focused on improving agricultural outcomes have the greatest potential to reduce poverty, increase incomes, and boost the livelihoods of the world's poor.

The centrality of agriculture to poverty reduction efforts is reflected in the development agendas of governments, multilaterals, and major donor agencies. The UN has promulgated Sustainable Development Goal 2 (SDG2), which seeks to eradicate hunger, ensure food security, and promote sustainable agriculture (Kaplinsky, 2016). Additionally, the World Bank emphasizes market access and fostering efficient agricultural value chains[1] as one of its top policy priorities (World Bank, 2008).

In recent years, an increasingly large pool of randomized control trials (RCTs) -- or field experiments -- have pointed to the promise of *bundled* interventions, which address multiple constraints within particular agricultural value chains simultaneously. For example, Bandiera et al. (2017) find that offering a bundle of services to smallholders (asset transfer, skills training, and a subsistence allowance) significantly improves incomes and other livelihood outcomes among women in rural Bangladesh. Similarly, Deutschmann & Tjernstrom (2018) show that the bundle offered by One Acre Fund to farmers in rural Kenya (seed and fertilizer inputs, credit, weekly training, and market access during the off-season) significantly improves maize yields and increases overall farm profits.

This report overviews the key findings from a feasibility study conducted in Sierra Leone that tested one such proposed bundled intervention. Specifically, the bundled intervention that this report seeks to validate consists of three main activities: (i) *rural electrification*, (ii) *access to productive farming technology*, and (iii) *extension services and improved market access*. Given the intervention's focus on the provision of renewable electricity along with electrified farming technology, this project lies within the Energy research agenda of the International Growth Centre (IGC), and is funded through IGC's Small Projects Form.

This feasibility study ultimately aims to inform a larger, scaled-up randomized control trial (RCT) that will rigorously estimate the impact of this proposed bundled intervention across hundreds of rural villages throughout Sierra Leone.

The report is structured as follows: section 2 provides a background on the particular features and the motivating factors behind the bundled intervention. Section 3 overviews the three main activities carried out as part of this feasibility study and the key findings uncovered by each activity. And section 4 concludes.

[1] Value chain here is defined as "the range of linked activities that bring a product from initial production to end consumption" (Kaplinsky & Morris, 2001).

2. Background

The proposed bundle of services that the research team seeks to test in Sierra Leone is motivated by several factors.

The underlying motivation stems from the fact that in 2016 food imports comprised of 28.5% of all merchandise imports in Sierra Leone (UN Comtrade, 2016). Relatedly, poultry imports made up 34% of all animal products imported into Sierra Leone in 2017 -- the largest in this category by a significant margin. If egg imports (a poultry by-product) are included, then this number increases to 49% of all animal product imports (UN Comtrade). This has implications for food security within Sierra Leone, as poultry (along with fish) constitutes the country's most important source of protein.

Poultry is largely imported in Sierra Leone because the animal feed required to produce poultry domestically is not available in adequate supply. Interviews with poultry farmers and animal feed producers indicate that the key bottleneck preventing the production of feed domestically is the lack of reliable quantities of maize (a main ingredient).

Both of these products (poultry and maize) can be produced in Sierra Leone given prevailing agronomic conditions. Furthermore, government policy currently supports the overarching aim of domestic production of poultry and maize. However, despite these two facts, large import bills for both poultry and maize remain the status quo.

Based off of findings from this feasibility study, the barriers to producing poultry and maize domestically are *not* agronomic. The implication is that such barriers can be addressed by informed interventions targeted to the local context.

The activities carried out by this feasibility study point to two key barriers in poultry and maize production: (i) *information barriers*, and (ii) *coordination barriers*. The proposed bundled intervention aims to address both (i) and (ii).

Firstly, information barriers exist that impede the adoption of good agricultural practices (GAP) like optimal input utilization (e.g., modern seed varieties, adequate fertilizer, mechanized farming) and proper crop rotation. The activities carried out for the feasibility study suggest that these information barriers can be addressed through targeted extension services that have been tested and refined by a local agriculture company (Warc Africa) over the course of 9 years operating in the Sierra Leonean context (see Appendix 3).

Secondly, coordination barriers within the maize value chain in Sierra Leone manifest themselves in two main forms:

1. A lack of coordination between government and private sector actors that prevents would-be Sierra Leonean maize farmers from accessing two key technological inputs to

commercialized maize production: (a) rural electricity, and (b) farming machinery that requires this electricity to process maize into higher value-added forms.
2. A lack of coordination between would-be maize farmers and poultry/animal feed producers (potential end buyers of maize) that prevents these maize farmers from accessing the necessary markets for their produce.

The activities carried out for the feasibility study indicate that the above coordination barriers can be resolved.

First, by partnering with an existing rural electrification program under UNOPS that is providing solar-powered electricity to hundreds of villages across the country, would-be maize farmers in selected villages can begin to put this electricity to productive use. In addition to rural electrification, the proposed bundle also seeks to coordinate the distribution of electrified maize processing machinery to selected villages. Electrified farming machinery will allow for the production of value-added maize at the scale required by end buyers (e.g., poultry/animal feed producers).

Second, the bundled intervention also proposes to coordinate the marketing of this processed maize to poultry/animal feed producers (who require reliable quantities at specific market standards).

The study outlined in the next section ultimately aims to test the feasibility of the various activities involved in the bundled intervention (overviewed above). In short, the bundled intervention consists of the following activities:

Figure 1: Typology of bundled intervention

	Type of Barrier	Bundled Intervention Solutions
1	**Information Barrier**	Targeted extension services to would-be maize farmers.
2	**Coordination Barrier**	Solar-powered rural electrification.
3	**Coordination Barrier**	Distribution of electrified maize processing machinery.
4	**Coordination Barrier**	Coordinating market access to end buyers.

3. The Feasibility Study

As part of this study, three main activities were carried out to verify the suitability of the proposed bundled intervention to the local Sierra Leonean context, as well as ensure its overall feasibility.

1. A Smallholder Farmer Survey was conducted.

2. Semi-structured interviews with Key Value Chain Actors were performed.
3. The prototype of the electrified maize processing machine (a maize dryer) was fabricated and installed in two rural villages.

This section briefly overviews the rationale for each of these three activities, as well as the high-level findings.

3.1 Smallholder Farmer Survey

3.1.1 Smallholder Farmer Survey: Background

To begin, a Smallholder Farmer Survey was conducted with a sample of 1,068 rural farmers across 6 villages in both the Northern and Southern Provinces in Sierra Leone. This survey took place between September 2nd and September 13th, 2019. The 3 villages surveyed in Northern Province were Rochains, Rochains-Malal, and Ropolonbana. The 3 villages surveyed in Southern Province were Gerehun, Mattru, and Torbu.

Figure 2: Sampled villages

Village	Region	Respondents
Gerehun	Southern	238
Mattru	Southern	234
Torbu	Southern	158
Rochains	Northern	137
Rochain-Malal	Northern	151
Ropolonbana	Northern	150

The motivation behind the Smallholder Farmer Survey was to ensure that the proposed bundled intervention addresses key constraints that smallholders themselves report facing in their everyday lives.

The villages were selected via purposive sampling. Sampling was split across the Northern and Southern Provinces (and across villages within these two provinces) because interviews with key value actors indicated that the North is perceived as the “maize belt”, whereas the South is seen as dominated by rice farming. Therefore, we wanted representativeness across both geographic areas. The three Northern villages are all in the surrounding areas around Mile 91. The three Southern villages are in the surrounding areas around Bo.

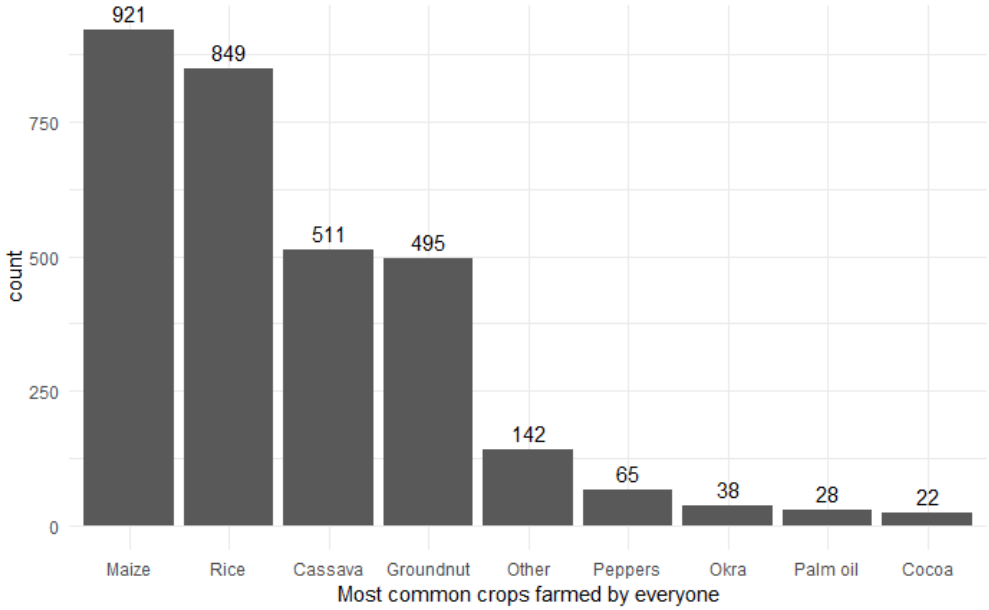
On top of this representativeness, these villages had five additional characteristics: (1) they were large enough to allow at least ~150 surveys to be conducted in each (while small and remote

enough to still classify as rural), (2) they were located somewhat near larger towns/cities (Mile 91/Bo) which could serve as 'headquarters' for our enumerator teams, (3) they were accessible (an important consideration during rainy season), (4) they were proximate to several key value chain actors that the research team endeavored to interview (see section 3.2), and (5) the Northern and Southern village clusters were relatively near to each other (2-3 hours by tarmaced highway) while still being in separate provinces. All of these factors served to improve the administration of the research project while minimizing research costs.

Before commencing enumeration in each village, the research team would engage in sensitization. This included identifying the local chief, explaining the purpose of the project, and soliciting the chief's permission to conduct surveys with smallholders in the village. All chiefs that the research team approached gave their permission to enumerate in their villages. Once permission was ascertained the research team agreed on the enumeration dates for that particular village with the chief, we requested that the chief spread the word about the upcoming surveying exercise on those agreed upon dates, and we asked that the chief request that his community members cooperate with the enumerators.

Broadly, as Figure 3 below shows, maize and rice are by far the top farmed crops among the surveyed smallholders (followed distantly by cassava and groundnuts). See Appendix 4 for an overview of the Smallholder Farmer Survey questions.

Figure 3: Most farmed crops



This trend holds across both Northern and Southern villages, which goes against the perception among interviewed key value chain actors who labeled the Northern Province as "the maize belt", and the South as predominantly engaged in rice farming. In fact, most farmers produced both rice and maize (only 14 did not grow either rice or maize). Only 126 smallholders out of the 1,068 surveyed did *not* farm maize, indicating that maize farming is not a new concept across surveyed

regions. There's also no clear indication that Southern villages have taken up maize farming more recently than Northern villages (further disproving "the maize belt" perception).

This lack of accurate knowledge about even such rudimentary information as the key crops grown in different geographies points to the poor quality of government information on the state of its own agriculture sector. Such a dearth of accurate information, in turn, negatively impacts the quality of government extension services. Lackluster government extension came up repeatedly in interviews with private sector actors operating in the Sierra Leonean agriculture sector.

3.1.2 Smallholder Farmer Survey: Key Findings

i) Top Challenges

Figure 4 below shows the top three challenges reported by all surveyed smallholders (in order of the top challenge reported).

Figure 4: Top challenges reported by smallholder farmers

		Top	Second	Third
1	**Pests**	214	142	157
2	**Lack of machinery**	203	79	49
3	**Fertilizer**	191	219	147
4	**Credit**	94	159	68
5	**Seeds**	85	120	143
6	**Lack of labor**	30	34	52
7	**Lack of farm inputs (tools)**	14	39	53
8	**Lack of storage**	14	30	61
9	**Land**	11	10	19
10	**Market access**	9	17	32
11	**Other**	11	20	63
12	**Refused to answer**	1	0	0

13	**Don't know**	0	1	3

In terms of the proposed activities that make up the bundled intervention, Figure 2 clearly illustrates that a lack of electrified farming machinery is the second most reported top challenge among our sample of smallholder farmers (behind pests).

Additionally, several other reported challenges can be considered to stem from a lack of mechanized farming equipment or electrified technology. For example, access to labour-saving farming machinery could address the lack of access to farm laborers that was reported as the sixth top challenge among the surveyed smallholders. Moreover, some mechanized farming machinery would no doubt replace certain manual farm implements/tools that were reported as the seventh most cited top challenge. Thus, the survey results suggest that a bundled intervention that includes the distribution of electrified farming machinery would indeed resolve a key everyday challenge that smallholders reported facing.

On top of this, several of the top challenges reported by the smallholders stem from information barriers (e.g., lack of knowledge about effective pest control remedies, optimal fertilizer use, and/or the best seed varieties to use given local growing conditions). Such information barriers could be resolved with the prudent application of targeted extension services, as proposed by the bundled intervention (see Appendix 3).

ii) Maize as Cash Crop, Rice as Subsistence Crop

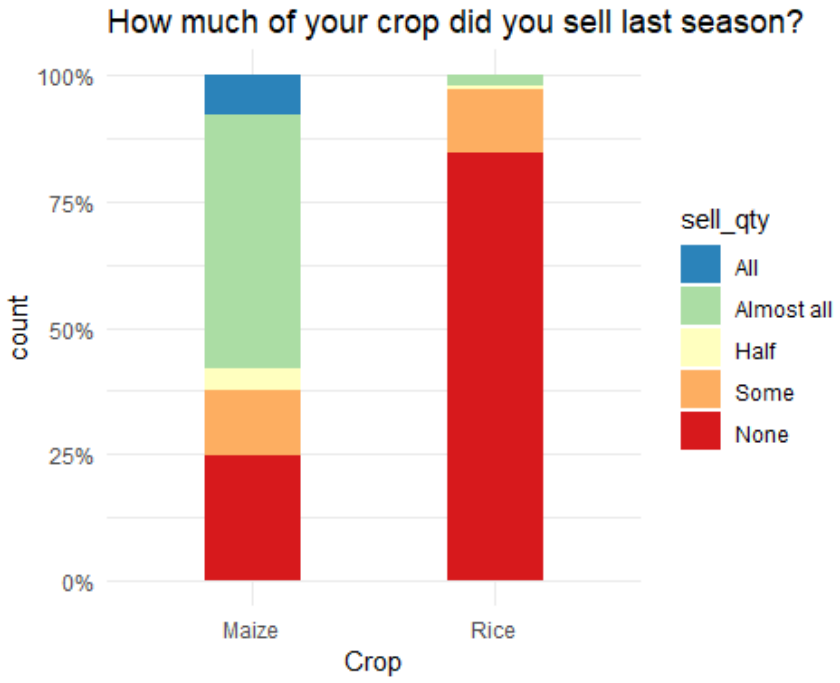
A second key finding from the smallholder survey is that maize is farmed as much more of a cash crop when compared to rice, which was largely grown for subsistence/consumption purposes (see Figure 5a, Figure 5b, and Figure 5c below).

Figure 5a: Maize as cash crop, rice as subsistence crop

How much of your crop did you sell last season?

	All	**Almost all**	**Half**	**Some**	**None**
Maize	72	464	39	119	227
Rice	1	16	8	107	717

Figure 5b

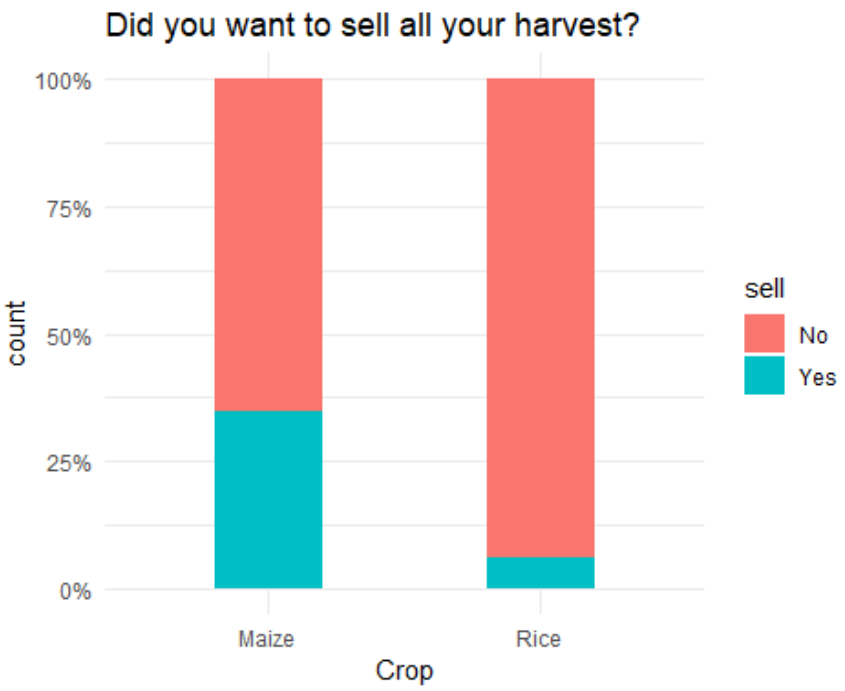


A full 536 of 921 maize farmers reported selling “All” or “Almost all” of their harvest (58.2%). On the other hand, only 17 of 849 rice farmers reported selling “All” or “Almost all” of their harvest (2%).

Figure 5c (below) further establishes that maize in Sierra Leone is much more of a cash crop, with 34.9% of all maize farmers reporting that they wanted to sell *all* of their maize harvest. In contrast, only 6% rice farmers reported that they wanted to sell all of their rice harvest.[2]

[2] Note that this question is only asked to those smallholders who wanted to sell at least some of their harvest. Those that reported not wanting to sell *any* of their harvest (most rice farmers) were not asked this question.

Figure 5c: Maize as a cash crop, rice as subsistence crop



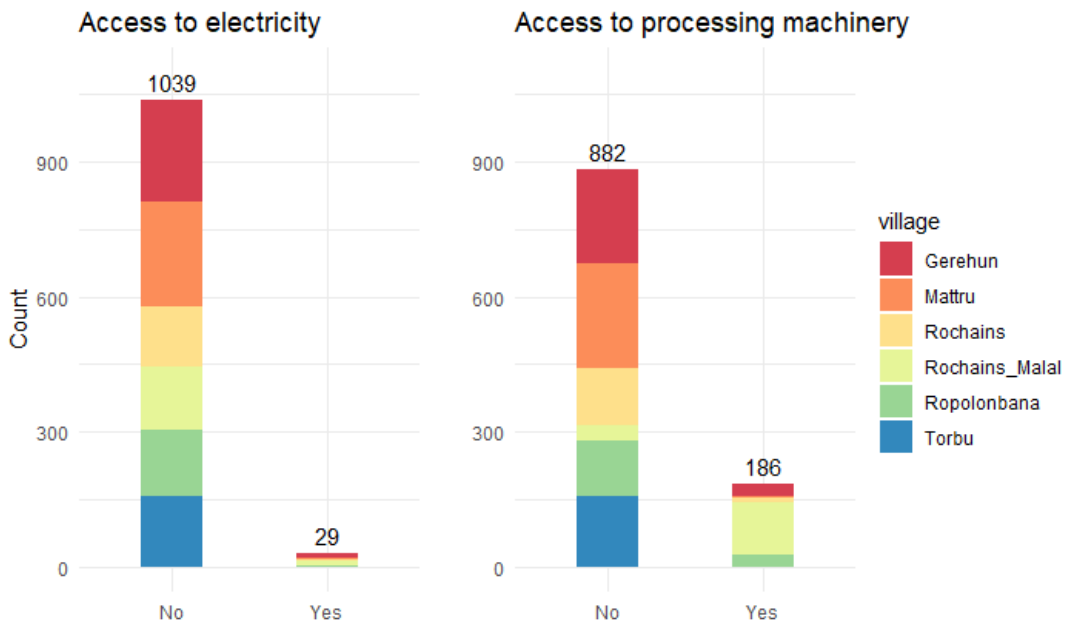
In sum, promoting the adoption of cash cropping by incentivizing a transition to maize farming (as opposed to subsistence rice farming for consumption) aligns with the broader push from governments and donor agencies to foster agricultural transformation through commercializing the sector (ACET, 2017).

iii) Access to Rural Electricity and Mechanized Farming Technology

Lastly, the third high-level finding from the smallholder survey is that access to both electricity and mechanized farming technology in the rural communities sampled is severely restricted.

Figure 6 below shows smallholder access to electricity and to post-harvest processing machinery across the six rural villages surveyed.

Figure 6: Access to electricity and processing machinery among smallholders



Only 186 of the 1,068 smallholders surveyed reported having access to post-harvest processing machinery (17.4%). Even fewer smallholders surveyed, 29 (only 2.7%), responded that they had access to electricity.

These responses have several implications. First, they point to a pervasive lack of electricity in rural areas. This fact of life is already well reported across the developing world, and sub-Saharan Africa in particular (see Lee et al., 2016; Lee et al., forthcoming; Aklin et al. 2017). Second, as more smallholders reported having access to processing machinery than having access to electricity, it can be surmised that a lot of the processing machines are either *not* electrified (i.e., manual) and thus less efficient, or they *are* electrified (typically through diesel-powered generators) but they are *shared* with the broader community (i.e., the respondent's household does not own the machine, and thus typically has to pay to rent it).

Figure 6 therefore clearly illustrates a demonstrable need for both rural electrification and for electrified processing machinery among the surveyed smallholders.

3.2 Semi-Structured Interviews with Key Value Chain Actors

"Sometimes it will be very difficult for the farmers to meet my demand. The availability of maize in large quantities [varies] every season." --Mohamed Sesay, Maize Wholesaler

3.2.1 Semi-Structured Interviews with Key Value Chain Actors: Background

On top of smallholder farmers, 19 semi-structured interviews were conducted with key actors throughout the maize and poultry value chains. This was done because while smallholders

provide important insights into the unique challenges they face farming in rural Sierra Leone, they are concentrated upstream, at the very beginning of the value chain. Their insights therefore must be complemented by that of other key actors throughout the value chain (from smallholder all the way to end buyer/consumer) in order to form a holistic picture of the most significant obstacles across the chain, and in turn draw more coherent inferences that can inform the proposed bundled intervention.

Selection of the key value chain actors was done through snowball sampling. As WARC Africa has been operational in Sierra Leone for almost a decade, several value chain interviewees were referred to us from WARC's existing network of farmers, input suppliers, government officials, and/or WARC employees. Following introductions to these individuals the research team would schedule semi-structured interviews with them. At the end of each interview the researcher(s) would ask the interviewee for references to other relevant actors they believe would be informative to speak with.

A list of the key value chain actors interviewed as part of this feasibility study is given in Appendix 1.

3.2.2 Semi-Structured Interviews with Key Value Chain Actors: Findings

i) Top Challenges

Figure 7 below shows the top three challenges reported by key value chain actors (in order of the top challenge reported).

Figure 7: Top challenges reported by key value chain actors

	Top	Second	Third	Total Points
Unavailability of Key Inputs	4	3	1	19
Market Access	3	3	1	16
Lack of Storage	3	1	1	12
Finance	2	-	2	8

Source: Key value chain actors were interviewed and asked "What are the top three challenges that you face regarding maize?" Each cell gives the number of value chain actors that listed a particular constraint in that particular rank order. Total points is based on a scoring system, whereby a constraint that was listed as 1st receives 3 points, 2nd receives 2 points and 3rd receives 1 point. Analysis is restricted to constraints with over 8 points.

Unavailability of Key Inputs

Key value chain actors reported that a lack of access to key inputs like modern seed varieties, fertilizer, and farming equipment is a major hurdle that prevents production increases, yield improvements, and overall agricultural transformation. Because they lack access to adequate financing (discussed more below) farmers are prevented from continuously buying improved seeds, which forces them to reuse seeds for multiple seasons, significantly reducing yields. Another problem is the lack of fertilizer. Farmers depend on the Sierra Leone's Ministry of Agriculture and Forestry (MAF) to provide seeds and fertilizer (for free or at significantly subsidized rates) and oftentimes the quantities provided are insufficient, thus lowering production levels come harvest. These insufficient quantities then result in farmers buying fertilizer locally and at unsubsidized rates. Because this locally bought fertilizer tends to be more expensive as a result of being unsubsidized, farmers often purchase smaller amounts than required for optimal planting, again negatively affecting yields (Haja, Interview). Lastly, farmers largely lack access to pre-harvest and post-harvest machinery (e.g., tractors and processing equipment) or to insecticides, which obliges them to hire temporary farm laborers in order to prepare the land and take care of pre-harvest pests. This practice is both inefficient (when compared with the mechanized alternative) and costly for smallholders.

Market Access

Many rural producers face serious difficulties in accessing markets to sell their goods. Market access for smallholders is constrained by high transportation costs, lack of market information, and an inability to meet specific market standards required by end buyers (both quantity and quality requirements). Transportation costs are often exorbitant and roads are either absent or inaccessible, especially during the rainy season (4 to 5 months of the year). These high transaction costs limit farmers' ability to price their goods competitively in the market. Another key barrier is poor market information on the part of both sellers and buyers. The majority of actors throughout the value chain do not know who produces what, where, when, and how much (Ahmed Nanoh, Interview). Farmers oftentimes are unable to provide buyer names or contact information and said that buyers generally took the initiative to seek out their produce when needed. Such ad hoc marketing methods prevent farmers from being able to properly coordinate their operations to align with buyers' demand, and in turn inhibit the ability of farmers to have reliable quantities ready for would-be buyers. All of these uncoordinated, ad hoc market transactions have the end result of impeding any emergence of scale, keeping smallholders from graduating to larger, more commercialized levels of production. Lastly, smallholder market access is severely hampered by their inability to meet the quality and quantity requirements of modern markets. Larger end buyers (poultry/animal feed producers) have disproportionate bargaining power over smallholder producers: they can simply import maize if the quality and quantity of smallholder produce fails to meet their standards. Poultry farmers interviewed reported importing their maize from Mali and Guinea as local farmers have not been able to supply the quantity demanded (Joseph, interview). Oftentimes these imports of foreign maize result in reduced local maize prices, further pricing Sierra Leonean smallholders out of the market.

Therefore, in contrast with the Smallholder Farmer Survey (discussed in section 3.1) that listed market access quite low down on smallholders' self-reported list of challenges, our interviews with key value chain actors suggest that barriers to accessing the market are indeed a significant problem for maize farmers. The value chain actors interviewed are likely in a better place to adjudicate issues of market access, as many of them are downstream buyers (i.e., they *are* the market for smallholders' produce). Indeed, the fact that smallholders do *not* consider this a challenge could itself be a considerable problem, as it indicates farmers are generally unaware of the frustration downstream buyers often experience when purchasing from smallholders. As such, a bundled intervention that includes the facilitation of market access (through guaranteeing prices and end buyers in advance, and coordinating market transactions) would help address this problem.

Lack of Storage

Not having a suitable location to store their crops forces smallholder producers to sell their maize right away (and thus unprocessed and often at a lower price). The status quo method of drying maize on a large, flat surface via heat from the sun is both time-consuming and near impossible during the rainy season. As such, farmers often prefer to sell their maize on the cob to passersby. Selling maize unprocessed by the unit does not allow farmers to obtain maximum prices for their harvest. Storage constraints also limit producers' ability to sell in the off-season when they could fetch better prices (see Deutschmann & Tjernstrom, 2018). Obviously *cold* storage would be optimal to both preserve the harvest longer *and* keep away unwanted pests, but the almost total lack of reliable electricity in rural areas prevents the use of cold storage (Mellor, 2018: p. 120-21). Given this reality, the type of solar-powered rural electrification proposed by the bundled intervention would be a welcome remedy for the lack of [cold] storage.

Additionally, wholesalers and aggregators buy maize in bulk in order to meet the demand of the poultry farmers. However, when these wholesalers are unable to sell all of the maize they purchase and they lack a location to store the unsold maize upon return, they are then forced to either sell at lower prices or to sell to poultry farmers by credit (or risk losing the maize to theft, pests, or time). Therefore, the lack of [cold] storage can limit the amount that wholesalers purchase from farmers (Mohamed Sesay, Interview).

Lastly, inadequate storage leads to pests damaging the harvest. A lack of proper storage facilities forces farmers to store their harvest locally in places like their homes or another open location where there is a high risk of theft or of pests destroying a large portion of the produce. Production is often constrained by the lack of storage facilities since this can generate high rates of post-harvest losses (Alaska, interview).

Finance

Rural enterprises involved in microfinancing are predominantly informal and are often unresponsive to farmers' needs. Financial institutions in Sierra Leone are not accessible to agribusinesses or smallholders due to high interest rates, onerous collateral requirements, short

loan periods that do not align with the harvest calendar, and a dearth of specialists within the banks who are familiar with the agriculture sector (Ahmed Nanoh, Interview). As a result, this lack of adequate access to formal financial services traps smallholders in a vicious cycle of low productivity, low yields, and persistent poverty.

Farmers are cash poor, which inhibits them from investing in the necessary input supplies such as fertilizer, seeds, and farming equipment that increase yields and incomes. In some rural communities in Sierra Leone there exist government (MAF) sponsored farming groups called Agricultural Business Centers (ABCs), which provide farmers with extension services, serve as an aggregation center for produce, and some ABCs have also evolved to provide financial services (Jane & Mohamed, Interview). Nevertheless, these centers were only brought up by two value chain actors and do not seem to be widely available to smallholders across Sierra Leone. Most farmers interviewed, however, were members of at least one village savings group (sou sou groups). Nevertheless, these groups are informal, typically small in size, and only provide access to very infrequent, non-interest earning lump sum payouts.

Figure 8: Generic Agricultural Value Chain

In sum, the discussion in section 3.2 points to a lack of coordination across the entire maize value chain (Figure 8) as the ultimate obstacle towards agricultural transformation. First, at the upstream end of the chain, key inputs are often either (i) too expensive for smallholders to access, (ii) are simply not supplied because the costs incurred by input suppliers in remote areas typically outweigh the benefits, or (iii) inputs (when available) are used sub optimally by smallholders due to a lack of information. Second, one step downstream in the chain are the smallholder maize producers who are scattered across remote areas, and are producing maize of unreliable quantities and poor quality (implying smallholders are *not* cost-effective producers for downstream buyers). Third, the processors, wholesalers, and marketers downstream from the smallholders often engage in ad hoc, uncoordinated market transactions with maize farmers that typically means their buying is not appropriately timed to smallholder supply. Fourth, end buyers (individual consumers or poultry farmers) at the downstream end of the chain in Figure 8 demand maize that meets particular market standards/preferences. To solve these coordination problems at each node of the maize value chain, the proposed bundled intervention acknowledges that a chain coordinator is needed. The role of chain coordinator is often filled by government extension officers, however, Sierra Leonean extension services are chronically underfunded and therefore lack the resources to reach much of the country's rural population. To that end, Warc's extension services can fulfill this role of chain coordination. These services are overviewed in Appendix 3.

3.3 Installation of Electrified Farming Machinery in Two Rural Villages

In addition to the Smallholder Farmer Survey and the semi-structured interviews with Key Value Chain Actors, the third activity of the feasibility study involved the fabrication and installation of a novel maize processing machine in two rural villages (Tormabum and Segbwema).

This fabrication and installation was conducted because, as part of the proposed bundled intervention, the research team intends to coordinate the distribution of electrified maize processing machinery to rural villages newly connected to electricity (by the UNOPS solar grid program). Specifically, this electrified maize processing technology comes in the form of a maize dryer machine designed by a team of engineers from Stanford University for maximum affordability.

Why a maize dryer machine? Four main reasons: (1) smallholders have little access to farming machinery and reported this as the second greatest challenge they face as farmers (see section 3.1.2), (2) maize is much more of a commercialized crop than rice -- the other primary staple crop in Sierra Leone that is predominantly a subsistence crop (see section 3.1.2), (3) maize must be dried to a certain moisture content in order to be stored for extended periods of time (otherwise the maize spoils quickly), and (4) drying the maize allows it to be processed into more value-added products like cornmeal and corn flour that could potentially fetch higher prices.

Because the maize dryer machine is a new prototype, testing it in a real-world context in rural Sierra Leone was seen as essential before a broader scale-up. This testing accomplishes several essential elements. First, testing the maize dryer machine in a real-world context ensures that the prototype functions as expected when connected to electricity generated by the UNOPS solar grids (and allows the team to verify the exact specifications needed in order to actually “plug into” the grid). Second, installation in Sierra Leonean villages allows us to both uncover the necessary administrative processes that the eventual scale-up must follow and to identify the local stakeholders that any future installations must secure approvals from before proceeding. Third, testing the prototype allows the engineering team to iterate on the design and to finalize a detailed step-by-step installation guide that can help inform future installations (see Appendix 2 for the installation guide).

4. Recommendations

This feasibility study helped provide evidence that can be used to inform tangible programmatic recommendation not just for the scale-up of this specific research study, but more generally for similar bundled agricultural technology interventions. It is hoped that these recommendations will help in the design of a more effective and sustainable set of interventions, which when bundled together, will lead to reduced poverty, increased income, and improved livelihood outcomes among smallholder farmers and their wider communities.

These recommendations have been grouped into the following five categories:

a) Promote the Transition to Maize

The evidence gathered suggests that the transition to maize within rural communities in Sierra Leone will lead to increased commercialization, and this transition is more likely to succeed if effectively bundled with the other interventions described in this document. Promoting the adoption of cash cropping by incentivizing a transition to maize farming also aligns with the broader push from governments and donor agencies to foster agricultural transformation through commercializing the sector.

b) Design a Strategic Plan for the Provision of Key Inputs

It is recommended that a strategic plan be designed to ensure the reliable and sustainable provision of key inputs to farmers receiving the bundled intervention. These inputs include: modern seed varieties, fertilizer, and the maize milling equipment. The research indicates that a bundled intervention that includes the distribution of electrified farming machinery would likely resolve key everyday challenge that smallholders reported facing. However, evidence collected from both the Smallholder Farmer Survey and the semi-structured interviews highlight challenges around connecting farmers with key inputs of modern seed varieties, fertilizer, and electrified farming equipment.

It is vital that such a plan be prepared in consultation with the various levels of formal and informal leadership present at a village level in order to overcome elite capture risks that were suggested during interview discussions and uncovered during the installation of the maize dryer machine in two rural villages. This sensitization process will likely require up front, labor-intensive conversations with individual villages, as each village has its own set of power structures and local dynamics. However, it is possible that the sensitization process may be streamlined with a clearer understanding of similar interests that are evident across villages.

Additionally, it is recommended that further in-situ testing of the electric maize mills be undertaken in collaboration with local engineering experts (e.g., FINIC). During the installation of the maize dryer, potential improvements with the fans and electric motors were identified. Additionally, it is recommended that scale-up testing be undertaken in additional villages to determine if there are other village-specific improvements that may be required.

c) Evaluate Additional Opportunities for Electricity Use

As prior research tends to indicate, the provision of electricity in highly impoverished communities does not appear to have significant impact on social welfare within the communities (Lee et al., 2016; Lee et al., forthcoming; Aklin et al., 2017). Accordingly, we recommend taking a holistic view to the design of a bundle of interventions to optimize the potential impact of electricity. Specifically, in addition to the provision of electric maize mill technology, we recommend the investigation of additional technologies that require electricity that will add value to the primary and secondary outputs from the agricultural technology. In particular, we recommend the evaluation of refrigeration technology to provide for cold storage of corn meal after processing.

This refrigeration has the potential to not only prevent pests but also to extend the length of time of crop storage which may have subsidiary benefits in allowing for more sustainable market access.

d) Create Market Access Linkages

In order to overcome the significant coordination challenges referenced in this report, the creation of market access linkages is recommended in order to catalyze the development of supply chains more organically. These market access linkages include: farmer co-operatives, farmers with transporters, transporters with wholesale animal feed purchasers, and animal feed wholesalers with poultry farmers. To the extent it is possible to encourage the development of these links, the benefits associated with market access are more likely to be self-sustaining. Furthermore, these links will help in overcoming the significant last-mile challenges faced in the rural villages that were analyzed.

e) Targeted Agricultural Extension Services

To help overcome information barriers identified during the evidence gathering process, it is recommended that targeted agricultural extension services be provided. These services should take into account the specific characteristics of the farmers, their environment and the villages they live in. Specifically, in designing these services it is recommended that the following two characteristics be considered. First, the type of information and extension service should be tailored to the beneficiaries, centralized programs that provide a standard approach have proven to be ineffective. There is an opportunity for these programs to offer more than just technology and inputs but to a more holistic offering that focuses on the development of farmers from a human capital perspective, and climate sustainability stewarding. Second, with women representing 70% of the agricultural workforce in Sierra Leone it is essential that any treatment plans take this gender dynamic and inequality into consideration since women are often times left out of extension programs.

5. Conclusion

In summary, this feasibility study aimed to test the three main components of a bundled agricultural intervention in the Sierra Leonean context: (i) *rural electrification*, (ii) *access to productive farming technology*, and (iii) *extension services and improved market access*.

The motivation behind such a feasibility study stems from the fact that this bundled intervention will be rigorously measured by a future randomized control trial to be implemented in hundreds of villages across Sierra Leone. Therefore, ensuring that the proposed bundle of services is suitable to rural Sierra Leone *before* such a scale-up is essential.

This feasibility study included three key activities:

1. A Smallholder Farmer Survey (section 3.1)

2. Semi-structured interviews with Key Value Chain Actors (section 3.2)
3. The fabrication and installation of a prototype of the electrified maize processing machine (a maize dryer) in two rural villages (section 3.3)

In addition to the above activities, Appendix 3 provides a detailed overview of the extension services that are to be included within the bundle.

First, the Smallholder Farmer Survey had three main findings: (i) the lack of farming machinery is a top challenge faced by smallholders, (ii) maize is a cash crop in Sierra Leone (unlike rice, which is a subsistence crop), and (iii) access to rural electricity and post-harvest processing technology is severely restricted among the surveyed smallholders (hindering their ability to produce higher value-added maize products).

Second, the semi-structured interviews with Key Value Chain Actors uncovered four main constraints smallholder maize farmers face: (i) the unavailability of key inputs, (ii) limited market access, (iii) a lack of adequate storage, and (iv) a lack of credit.

Third, the fabrication and installation of the maize dryer machine in two rural villages was necessary for three reasons: (i) to ensure the prototype designed by Stanford engineers was indeed functional in rural Sierra Leone, (ii) to uncover administrative procedures (some formal, and some informal) that must be followed during the scale-up, and (iii) to iterate and finalize the design as well as create a step-by-step installation guide for future installations (Appendix 2).

On the whole, this feasibility study largely validates the proposed bundled intervention. With the constraints around rural electrification, electrified farming technology, extension services, and market access relaxed (if not resolved), smallholders will be much better placed to move from subsistence towards commercialization. This transition is a necessary precondition for broader agricultural transformation.

References

African Center for Economic Transformation, 2017. *African Transformation Report 2017: Agriculture Powering Africa's Economic Transformation,* Accra, Ghana: ACET.

Aklin, M., Bayer, P., Harish, S. & Urpelainen, J., 2017. Does Basic Energy Access Generate Socioeconomic Benefits? A Field Experiment with Off-Grid Solar Power in India. *Science Advances,* 3(5).

Bandiera, O. et al., 2017. Labor Markets and Poverty in Village Economies. *Quarterly Journal of Economics,* 132(2), pp. 811-870.

Deutschmann, J. & Tjernstrom, E., 2018. *The Impact of One Acre Fund's Small Farm Program,* s.l.: Unpublished manuscript.

Kaplinsky, R., 2016. *Inclusive and Sustainable Growth: The SDG Value Chain Nexus,* Geneva: International Centre for Trade and Sustainable Development (ICTSD).

Kaplinsky, R. & Morris, M., 2001. *Handbook for Value Chain Research,* Ottawa: IDRC.

Lee, K. et al., 2016. Electrification for 'Under Grid' Households in Rural Kenya. *Development Engineering ,* Volume 1, pp. 26-35.

Lee, K., Miguel, E. & Wolfram, C., forthcoming. Experimental Evidence on the Economics of Rural Electrification. *Journal of Political Economy.*

Mellor, J., 2018. *Agricultural Development and Economic Transformation: Promoting Growth with Poverty Reduction.* s.l.:Palgrave Macmillan.

UN Comtrade, 2016. [Online]
Available at: https://www.indexmundi.com/facts/sierra-leone/indicator/TM.VAL.FOOD.ZS.UN
[Accessed 7 October 2019].

UN Comtrade, 2017. [Online]
Available at: https://oec.world/en/visualize/tree_map/hs92/import/sle/all/show/2017/
[Accessed 8 October 2019].

World Bank, 2008. *World Development Report 2008: Agriculture for Development,* Washington, DC: World Bank Group.

World Bank, 2016. *Who Are the Poor in the Developing World?,* Washington, DC: World Bank Group.

Appendix 1: Key value chain actors interviewed

Name	Organization and Position
Abdulrahman Dumbuya	Ministry of Agriculture, Forestry, and Food Security (MAFFS), Extension Officer (Irrigation/Engineering)
Ahmed Nanoh	Sierra Leone Chamber for Agribusiness Development, Executive Director
Alaska Bangura	Master Farmer (Malal Chiefdom)
Alexandre Serres	European Commission, Project Manager
Alex	ASA Microfinance, Managing Director
Andrew Kanu	ACTB, Credit Coordinator
Edwin Ighodaro	Lift Above Poverty (LAPO), Head of Corporate Services
Jane Kamara	MAF, District Agriculture Officer (DAO) of Western Area Rural District
Jeff Jusu Saffa	Madina Community Bank, General Manager
Joseph Amoatenj	Lambano SL Limited (poultry feed company), CEO
Mama Haja	Master Farmer (Mile 91)
Mama Yeabu	Master Farmer (Mile 91)
Melvin Fodeh Kamara	FINIC (farming machinery fabricator), Managing Director
Mohamed Bahsoon	Seed Tech International, Managing Director
Mohamed Sesay	MAF (Newton Agricultural Station), District Extension Officer of Western Area Rural District
Mohamed Sesay	Independent Maize Wholesaler
Molade Johnson	Grassroots Gender Empowerment Movement, Head of Finance
.	Union Trust Bank, Customer Service Representative
Note: The Warc Africa team also attended a Coordination Meeting at Newton Agricultural Station at the invitation of Jane Kamara (District Agriculture Officer of the Western Area Rural District). Around 30 value chain actors were present at this Coordination Meeting -- too many to list individually here.	

Appendix 2: Step-by-step maize dryer installation guide

PARTS LIST

Part #	Part	Part Description	Quantity
1	Wire Mesh Frame	Frame with 5 different parts	
1.1	Corner Leg	Connects 2 outside edges in a 90 degree angle	4
1.2	Outside Edge	The outer part of the frame	4
1.3	Side Part	Smaller pieces that go in the middle	2
1.4	Center Part	A longer piece that goes in the center	1
1.5	Support Part	Cross shape with a leg, connects to all of the other parts in the wire mesh frame	2
2	Wire Mesh	Wire mesh with handles	4
3	Heat Exchanger (HX)	HX in frame with legs	1
4	Air Tube	Connects HX to tube end	1
5	Tube End	Connects air tube to bed	1
6	Fan	Cooling fan from a car	1
7	Fan holder	Connects fan to the engine	
8	Engine	Honda GX200 gasoline engine	1
9	Key	Fitting into the keyway of the engine to connect the fan	1

10	Engine Stand	Stabilizes the engine	
11	Engine Stand Positioner	Embedded into the ground	4
12	Chimney	Connects to the top of the HX frame	1
13	Bin	Connects to tube end, made of cement bricks	1
14	Furnace	Under the HX, made of clay bricks	1
15	Furnace Grill	Placed inside the Furnace	1
16	Furnace Mesh	Placed on top of the Furnace Grill	1
17	Nuts & Bolts	Connections between parts	40

NUTS AND BOLTS CONNECTIONS

Part 1 (#)	PART 2 (#)	quantity
MESH FRAME		8
HX (3)	AIR TUBE (4)	12
Air Tube (4)	TUBE END (5)	7
FAN (6)	FAN HOLDER (7)	4
FAN HOLDER (7)	ENGINER (8)	1
ENGINE (8)	ENGINE STAND (10)	4

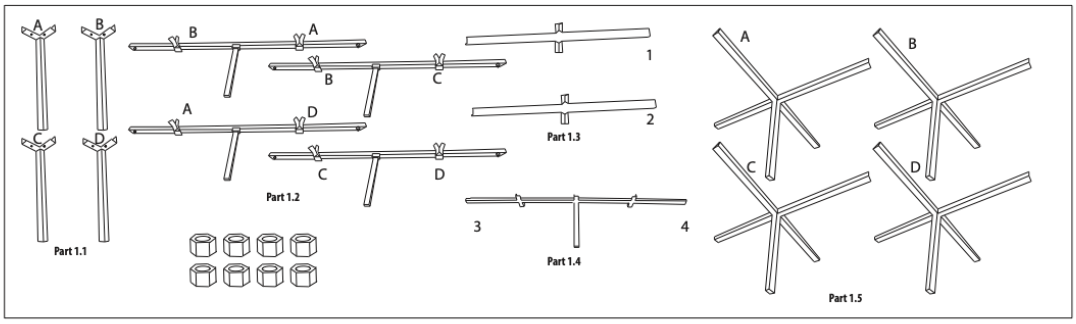
ENGINE STAND (10)	ENGINE STAND POSITIONER (11)	4

TOOLS LIST

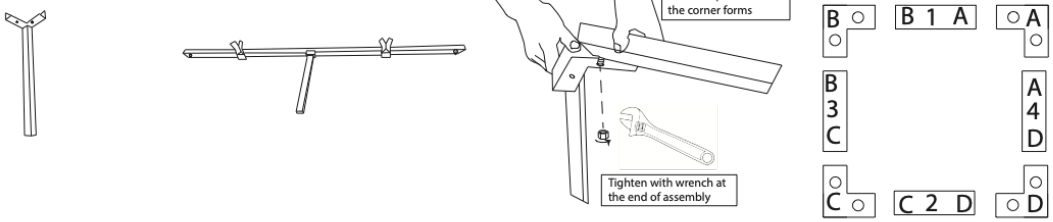
Bubble Level 	Adjustable Wrenches 	Trowel 	Rubbing Board 
Scythe 	Shovel 	Chisel 	Hammer 

Assembly of the Wire Mesh Frame (Parts # 1.1-1.5)

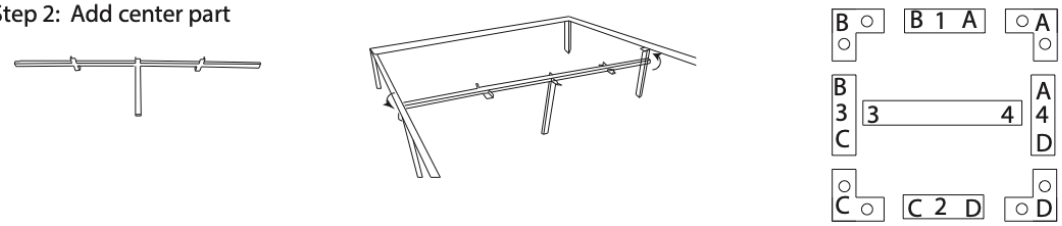
Parts for a.maize dryer frame Designed by FINIC



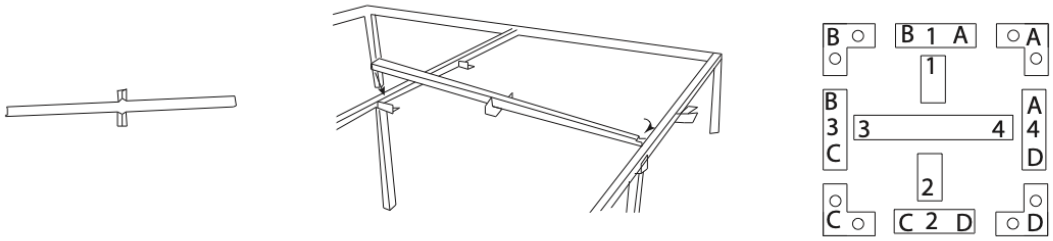
Step 1: Assemble corners



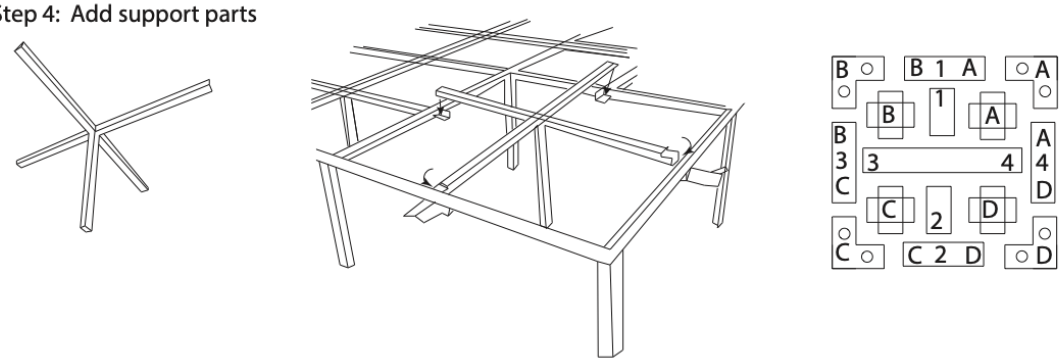
Step 2: Add center part



Step 3: Add side parts

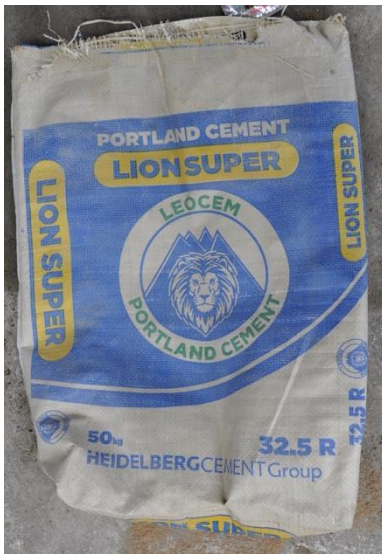


Step 4: Add support parts



Assembly of the HX, Air Tube, Tube End and Bin (Parts # 3-5, 13)

1. Make the cement mixture. The mixture ratio of cement to sand is 1 bag of 50 kg cement to 7 head pans of sand. Mix with water as needed.



2. Position the Wire Mesh Frame (Part # 1) on the ground. Make sure the frame is level using a bubble level. If it is not level, place some stones under the legs of the frame and secure it using the cement mixture.

3. Assemble the HX (Part # 3), Air Tube (Part # 4) and the Tube End (Part # 5) using nuts and bolts.


4. Position the Tube End at the center front of the Wire Mesh Frame.


5. Construct the Bin (Part # 13) with cement bricks. First lay out the first layer of bricks.

    a. Make sure that the bricks are level and straight using a bubble level and apply cement mix as necessary.


b. Make sure that the bricks are air tight and flush against the Wire Mesh Frame legs.

c. Bricks may need to be chiseled to fit around the frame. Adjust as needed.

6. Cement the bricks together.

7. Embed the prongs on the Wire Mesh Frame into the second layer of bricks. Bricks may need to be chiseled to accommodate the prongs. Adjust as needed.

8. Cement the bricks together.

    a. Make sure the sides of the Wire Mesh Frame are air tight and flush against the bricks. Fill any gaps with cement mix.

9. Layer and cement a third layer of bricks, still making sure that the bricks are level.

10. Plaster the inside up until the second layer of bricks with clay. Plaster the inside of the third layer and the outside of the Bin with cement mix.
    a. Make sure to knead the clay well before application. Mix the clay with water.






Assembly of the Fan, Fan Holder, Engine, Engine Stand and Engine Positioner (Parts # 6-11)

1. Attach the Fan (Part # 6) to the Fan Holder (Part # 7) using nuts and bolts.


2. Attach the Engine Stand Positioners (Part # 11) to the Engine Stand (Part # 10) using nuts and bolts.


3. Install the Engine (Part # 8) onto the Engine Stand. Align the holes on the stand and the engine, and use nuts and bolts to attach engine to the stand.

4. Install the Fan Holder onto the Engine by putting the Key (Part # 9) into the Engine's keyway and tightening the fan holder onto the engine with the bolt.

    a. Make sure that the Fan blades do not touch any part of the Engine.



5. Dig the ground where the Engine Stand is to be placed.


6. Position the Engine Stand assembly in the ground, making sure that:
    a. the fan is centered within the fan enclosure (IMPORTANT!!!)
        i. Spin the fan to make sure that the fan does not touch the enclosure
    b. the fan is level
    c. the Engine Stand Positioners are below ground up until the start of the Engine Stand
    d. Adjust with stones as necessary.

7. Fill the hole with cement mix.


8. Wait for the cement to set.

Assembly of the Furnace (Parts # 14-16)

1. Position the Furnace Grill (15) and Furnace Mesh (16) underneath the HX (3).

2. Position clay bricks around the HX legs.
    a. Chisel the bricks as needed.
    b. Make sure to leave a gap on all sides except for the one closet to the engine in the first layer of the bricks.

3. Position the Furnace Mesh on top of the bricks after the first layer.

4. Place a second layer of bricks on top of the mesh. Chisel as needed.




5. Place a third layer of bricks.
    a. Leave gaps on two sides for fuel addition.
    b. Make sure that there is enough brick to cover any space between the bricks and the HX.

6. Put the bricks together using clay. Fill gaps between the HX and bricks with clay.









7. Cut brick pieces to size so that they fit in the gaps on the two sides. Do not permanently clay these pieces to the Furnace.

8. Plaster the outside of the Furnace with cement mix.


Assembly of the Chimney (Part # 12)

1. Plaster the inside of the Chimney (Part # 12) with clay.

2. Attach the Chimney to the HX using nuts and bolts.

Appendix 3: Overview of Warc's extension services

A3.1 Overview

The effectiveness of Warc's extension methodology has been proven throughout Sierra Leone, and has positively impacted over 10,000 smallholder farmers. Warc extension services are based on building the foundation for peer-to-peer knowledge sharing. Over the course of 9 years of operation in Sierra Leone, our methodology has demonstrated that farmers learn best from other farmers.

A3.2 Philosophy of Warc's Extension Approach

Our approach centers on operationalizing a network of farmer groups who regularly meet together to learn from each other and support each other's development. To do this, Warc focuses on enabling an effective extension team (Farmer Connectors) to provide routine support to farmers directly on farms.

Building an effective agricultural extension network made up of high functioning groups of farmers requires considerable investment in developing localized knowledge of selected communities, creating a team of Farmer Connectors who are both technically sound and skilled facilitators, as well as investing in building trust, confidence, and teamwork amongst farmers. As such, creating an impactful network of farmers who learn from and support each other is more art than science.

In order for farmers to benefit from working together, especially over several seasons, they must be able to derive value from sharing knowledge and assets. This requires trust, cooperation, respect, and strong communication. In addition to coaching farmers on integrating good agricultural practices (GAP) in cereal production, Warc's agricultural extension services concentrate on developing these soft skills through farmers' interactions with Farmer Connectors.

Rather than a workshop-type training, Farmer Group meetings take place on the farmers' plots so that real life examples can be used. This is especially pertinent to farmers that are uneducated and did not have exposure to classroom-like learning methods. Farmers have trusted and learned from each other for millennia, and Warc's high-touch facilitation method leverages existing channels through which information in these areas has historically been conveyed.

A3.3 Warc Farmer Network

Warc's Farmer Network model reaches thousands of farmers through a team of Farmer Connectors. Farmer Connectors are facilitators who work with farmer groups on an ongoing basis over the course of one year to build groups' capacity to improve their productivity.

The Agricultural Extension **Network Coordinator** acts as the main Warc liaison for the team of Farmer Connectors. The Network Coordinator is responsible for investing in the team's skill development and coordinating all logistics that enable the team to reach farmers. At the end of each day, the Network Coordinator facilitates meetings with the Farmer Connectors to gather information about the challenges and successes and provides advice on how to improve.

Farmer Connectors are the direct contact point between Warc and farmers. Farmer Connectors primary role is to identify Lead Farmers in the communities they are working in and facilitate the meetings of the Farmer Groups. Early on in the process, the Farmer Connector will play a heavy role in supporting the Lead Farmers to create Farmer Groups and help these groups form a sense of identity. Because many farmers are used to an authoritative, top-down extension approach, rather than collaborative, farmer-to-farmer learning, the Farmer Connector must help guide the groups through a transition process in these early stages. The meetings are held weekly.

Lead Farmers form Farmer Groups by identifying farmers who would like to work together with them throughout the season. The Farmer Connector then facilitates ongoing weekly support to these Farmer Groups to strengthen and advise on skill development.

Additionally, there is an added benefit if Farmer Connectors have access to a model "Training Farm," from which expertise is generated and transferred to the Farmer Groups via demonstration. More information on the Training Farm model is in the section entitled "High-touch Extension Method" below.

The following outlines key characteristics and considerations of roles and activities within the Farmer Network model.

A3.3.1 Farmer Connectors

Desired Qualities of Farmer Connectors

A Farmer Connector is the direct interface between Warc and farmers. 'Soft' skills (inter- and intrapersonal skills) are more important than technical agronomic knowledge in determining whether an individual will be able to support the formation of functional Farmer Groups. While technical agronomic skills can be taught, skills like leadership, listening, taking pride in one's work, and trustworthiness are more difficult to instill through training. These skills are critical to becoming an effective facilitator. The following characteristics are sought when selecting an individual for the role of Farmer Connector:

1. Demonstrated interest in rural development
2. Motivation and abilities to successfully undertake rural community work
3. Relevant knowledge for geographic area of operation
4. Desirable interpersonal skills

After selection through both group interviews (to determine a potential Farmer Connector's interaction in a group) and personal interviews, Farmer Connectors are hired and trained in the facilitation methodology and gaps in any agronomic information are filled. While in service, Farmer Connectors are regularly tested on their skills and must maintain a level of expertise in the subject matter taught to Farmer Groups.

Warc places a special focus on gender balance when forming a team of Farmer Connectors. As Farmer Connectors, women take the opportunity to be leaders in the communities in which they work.

Farmer Connector Equipment

In addition to their invaluable notebooks which are used to capture daily information about their meetings and notes on Farmer Group progress, Farmer Connectors are assigned the following equipment which allows them to do their jobs:

Motorbike	Farmer Connectors are expected to facilitate 2-3 meetings a day in the fields of their Farmer Groups. This requires travel to remote areas and must take place during all seasons. Both men and women are trained and licensed to operate the motorcycles.
GPS Unit	Farmer Connectors use a GPS device to help measure and plot the farms of each member of their groups. The tool also assists them to measure the area of land cultivated so they can accurately measure yields.
Smartphone	The tool allows Farmer Connectors to communicate with Lead Farmers and have access to applications that assist with the job.
Survey Software	Open Data Kit survey software (i.e., SurveyCTO, CommCare) assist Farmer Connectors to do more formal data collection and Monitoring and Evaluation activities.

A3.3.2 Lead Farmers

Desired Qualities of Lead Farmers

A Lead Farmer acts as the primary liaison point between Warc's Farmer Connectors and other farmers in their community. Lead Farmers are individuals who demonstrate inherent leadership qualities and are motivated to support fellow farmers to work and learn together. Lead Farmers play a critical initial role in identifying and coordinating Farmer Groups. Farmer Connectors judge potential Lead Farmers by gauging the following characteristics:

1. 'Natural leader' characteristics
2. Evidence of better-than-average, market-oriented production processes
3. Demonstration of intentionality and innovation within production system
4. Willingness to work in team and support other farmers

As Lead Farmers serve as models to their groups, they must be generally successful in their field and have a good standing in the community. Lead Farmers help to form and coordinate groups, and thus must be respected by the group members.

A3.3.3 Farmer Groups

Desired Qualities of Farmer Groups

The ultimate goal of a Farmer Group is to provide farmers with more access to gainful agricultural opportunities than they would be able to access as individuals. While Farmer Groups come together for different purposes and to access different opportunities, the following tenet should hold true across all groups: group members perceive themselves as moving closer to accomplishing their goals (e.g., improved yield, improved income, enhanced resilience/reduced risk from production shocks like weather fluctuations) through their participation in the group (compared to if they were farming alone). Group members must hold a belief in the group's ability to deliver shared value in order to sustain working together. If farmers do not believe their participation in a group helps them meet their goals, or that group participation is taking their time from more valuable activities, the group will cease to function.

Selection Criteria for Farmer Groups

Following the Farmer Connectors' identification of Lead Farmers, the Lead Farmers are then tasked with convening a group of interested farmers to work together throughout the season. There should remain flexibility in the criteria around Farmer Group formation in any area which is in its first year of cultivation of a particular crop. During community entry, the Farmer Connectors take special care to learn about the local context.

Warc Farmer Connectors coach Lead Farmers on criteria that may enhance a group's effectiveness, allowing the Lead Farmer to coordinate a group of farmers within their community. The Farmer Connector stays heavily engaged and assesses the group's viability through interviews and on-farm work assessments.

Selection Criteria for Communities Engaged

The following criteria should guide the selection of which communities Warc Farmer Connectors focus their activities:

Presence of commercial farms	Ideally, there is a large commercial farm in the area that can serve as a model to farmers. However, Warc also establishes Training Farms, or smaller "Satellite Farms," to form the initial starting points for community identification, followed by entry into neighboring communities. The Satellite Farms serve as a place to experiment with agricultural and training methods, as well as serve as an aspirational model that farmers are invited to explore.
Population	Larger villages of at least 30 households or more are preferable.
Access to communities	Due to the high-touch nature of the work, communities must be accessible by road on a motorbike, even during the rainy season.

History of crop production	Communities where many farmers are currently engaged in the specific crop are preferred to communities which are more focused on other types of production.
Access to land	Farmers that have access to land and labor are preferred (e.g., mining or plantation activities have not undermined farmers' abilities to produce effectively).
Buy-in from leadership	Chiefs and community leaders must be cooperative, as demonstrated through their interest in working together and through low levels of conflict with other neighboring communities.

Guiding Factors for Group Formation

Group formation is inherently flexible and relies on aligning with the local context, but there are several factors that must hold firm in the optimal farmer network:

i) Independently Motivated Farmers

Groups should consist of serious, business-minded farmers who are ready to work together to improve their production practices. Farmers who join Warc-supported Farmer Groups must be ready and willing to contribute their resources (time, labor, and finance where applicable) to improving their farms. Clearly communicating that joining a group will not lead to free inputs is expressed by Farmer Connectors through messaging to Lead Farmers such as "a shop owner doesn't expect someone else to buy all their wares and foodstuffs for them before they start a business. Similarly, a serious farmer does not expect to receive free hand outs in order to engage in production."

ii) Access to Productive Assets

Group members should have access to land (though they do not have to be land owners) and/or other productive assets (e.g., an ability to contribute labor to the group's activities). No specific criteria needs to be set around land type (upland, boliland, swamp, etc.), though farmers are encouraged to form groups with others whose fields are in close proximity to theirs to improve logistics of sharing labor. All farmers in the groups should demonstrate previous experience cultivating the relevant crop(s).

iii) Optimal Size

Farmer Connectors advise that groups should be between 15 to 20 people. A smaller, more cohesive group is typically more effective than a large group, though it is ultimately farmers who must decide how they would like to organize together. If community members insist on suggesting many more individuals be part of the group (it is not uncommon to have 30+ individuals state they want to be part of the group), Warc would encourage asking these groups to self-organize into two smaller groups once the group begins working together and group dynamics become evident.

iv) Dedication to Inclusion

Women and young people should be actively encouraged to be included in groups, both as leaders and as members. Men and women have varied but equally active roles in agriculture, so this can be highlighted to encourage inclusivity during group formation. Discussing the roles that older vs. younger and male vs. female members can play within the group should be part of the group formation process. It is more traditionally acceptable for men to be seen as leaders, so women need more encouragement and support to be suggested as Lead Farmers, but it has been common within Warc's past extension networks.

v) Willingness to Work Together

Forming new Farmer Groups requires different types of support than working to improve existing Farmer Groups. Warc is continuously testing the efficiency of working with newly configured groups vs. working with existing groups. While most of the groups involved in Warc activities have been formed by the methodologies described above, groups that have previously worked together and have reconfigured based on members being interested in working with Warc have also been accepted to receive support.

With support and guidance from the Farmer Connector, the Farmer Groups are responsible for setting their own rules and schedules. The Farmer Connector suggests best practices for the farmers and allows them to fill in the details. This is an important aspect of the Farmer Group system as it generates a sense of ownership, self-determination, and pride surrounding the group.

A3.4 High-touch Extension Training Method

The extension is broken down into three main components: Group Building, Knowledge Transfer and Goal Setting, and Continued Knowledge Transfer:

Phase 1 – Group Building

The first step of the extension services is to form the Farmer Groups and begin building trust with the selected communities. This phase requires the most hands-on support from the Farmer Connector, as the facilitation-heavy methodology is the opposite of traditional "top-down" extension training. The group members need to "unlearn" the expectation that they will be told what to do.

The Farmer Connector will assist the farmers to form their groups rather than do so on their behalf. The Facilitator will also assist the farmers to develop rules for their groups, providing suggestions, but allowing the group to regulate itself. Meetings will occur weekly on the farmers' fields. During this phase, there is very little transfer of technical knowledge. Instead this phase sets the foundation from which cooperation, mutual support, and learning is built.

Phase 2 – Goal Setting and Knowledge Transfer

After the groups begin to trust each other and work cohesively together, the Farmer Connector will begin introducing more and more technical topics into the discussions. The Farmer Connector encourages the farmers to debate and answer each other's questions, but is also ready to supply them with the correct technical advice when necessary.

This is also the stage in which the Farmer Connector helps the Farmer Groups develop concrete goals. Throughout the process the farmers encourage each other to employ Good Agricultural Practices (GAP), but it is during this phase that the Farmer Connector formalizes their goals, and points the groups in the right direction to accomplish those goals.

Phase 3+ – Continued Knowledge Transfer

In addition to continued technical advice and encouragement, the Farmer Connector begins to include more information at this stage. Farmer Groups often ask the Farmer Connector for advice on various topics such as marketing or financial literacy, and sometimes the Farmer Connector will introduce it on his or her own. These lessons often move beyond strict agricultural training. They are also aimed at helping transition farmers' perceptions of their farms as places of subsistence towards viewing their farms as commercial enterprises. These additional skills help them to do so.

Eventually, as the Farmer Groups start meeting by themselves and begin to rely less on the Farmer Connector, the amount of facilitated meetings will decrease. The Farmer Connectors are able to begin working in a more high-touch manner with new groups while monitoring the more experienced groups.

Extension Complemented by a Training Farm

As mentioned above, farmers tend to trust and learn from other farmers. Extension in itself is a very important tool, but Warc has found that knowledge transfer is best done when a model farm is nearby the extension area.

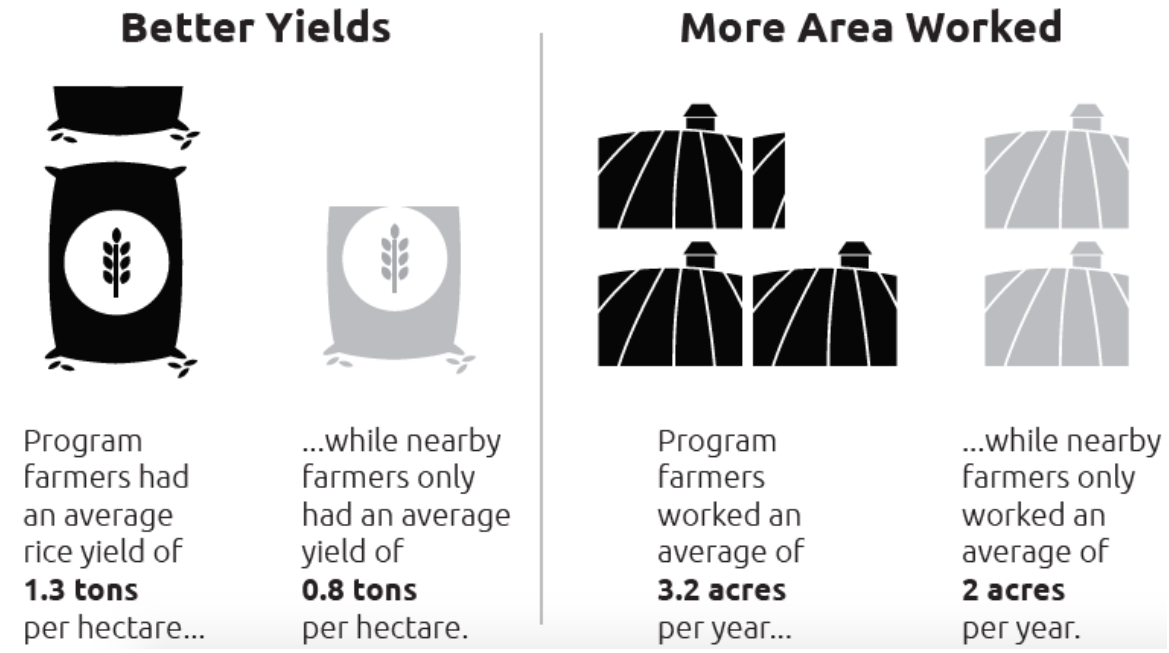
A3.5 Adaptability and Opportunities

Beyond pure agriculture education, this methodology can be adapted to teach other curriculums in addition to what Warc designs. Topics such as basic financial literacy or marketing skills can supplement traditional agriculture extension. The method of delivering the information is the same, but the information itself can change.

Warc can also implement this methodology to deploy educational programs designed by public entities, such as the Ministry of Agriculture, Forestry, and Food Security (MAFFS) or local governments. Government extension officers generally visit their communities sporadically, and have limited resources to engage in regular, high-touch agricultural extension. Warc has the know-how, management team, and technical knowledge to complement or replace government-led intervention strategies.

A3.6 Impact

Warc's extension methodology has proven successful across many projects over several years, covering over 10,000 smallholder farmers. The most recent group of 3,000 farmers saw yields increase by 60%, among a host of additional development impacts:



Appendix 4: Smallholder farmer survey questions

1. Basic Information	Answer Choices [where applicable]
What is your first name?	
What is your middle name?	
What is your last name/family name?	
What other name do you go by in the community?	
What is your gender?	● Male ● Female ● Prefer not to say
What is your birthday?	
What is the name of the village?	● Rochains ● Ropolonbana ● Torbu ● Mattru ● Rochains-Malal ● Gerehun ● Other
Are you the head of the household?	
How are you related to the head of the household? "I am the…"	● Wife/Husband ● Son/Daughter ● Brother/Sister ● Father/Mother ● Nephew/Niece ● Uncle/Aunt ● Grandparent ● Cousin ● Friend ● Other relation
Do you have a phone number where we can contact you?	
Whose phone number is this?	● Self ● Relative ● Community Leader ● Master Farmer ● Friend ● Other

What is the phone number?	
2. Business/Agricultural Production	**Answer Choices [where applicable]**
Do you farm by yourself or as part of a group?	● Self ● Group ● Refused to answer ● Don't know
How many groups are you part of?	
How many people are part of the ${group-pos-text} group?	
What is the name of the master farmer/leader of this ${group-pos-text} group?	
What is their phone number?	
What are the top 3 products you farm or produce?	● Maize ● Rice ● Cassava ● Palm oil ● Peppers ● Okra ● Groundnut ● Fish ● Cocoa ● Cattle ● Other
When did you start farming ${product-name}?	● In the past year ● In the past 5 years ● In the past 10 years ● More than 10 years ago ● Refused to answer ● Don't know
How many croppings of ${product-name} did you have last year?	
How much ${product-name} did you sell last season?	● All ● Almost all ● Half ● Some ● None
In what form did you sell your ${product-name} in?	● Unprocessed ● Processed (dried or milled) by hand ● Processed (dried or milled) by

	machine ● Other
Please specify what other form.	
At what price did you sell your unprocessed ${product-name}?	
At what price did you sell your manually processed ${product-name}?	
At what price did you sell your machine processed ${product-name}?	
Did you want to sell all the harvest?	
Did you manage to sell everything that you wanted to sell?	
Have you considered growing maize?	
Why have you not made the transition to maize yet?	● Cost ● No processing equipment ● Unavailability of input supplies ● Other ● Refused to answer ● Don't know
3. Challenges	**Answer Choices [where applicable]**
Select the top 3 challenges that you face when farming all of your crops.	● Fertilizer ● Seeds ● Storage ● Market access ● Land ● Credit ● Machinery ● Pests ● International competition ● Lack of labour ● Lack of farm inputs (tools) ● Other ● Refused to answer ● Don't know
Please rank the top 3 challenges (where 1 is the biggest challenge).	
4. Pests	**Answer Choices [where applicable]**

MAIZE	
What are up to three pre-harvest pests on your maize farm?	● Weeds ● Goats ● Army worm ● Leave disease (Exserohilum turcicum) ● Squirrels ● Grasshoppers ● Monkeys ● Thieves ● Other ● Refused to answer ● Don't know
What are up to three post-harvest pests on your maize farm?	● Rats ● Goats ● Army worm ● Squirrels ● Curculionidae insects (weevils/beetles) ● Grasshoppers ● Thieves ● Other ● Refused to answer ● Don't know
How do you combat pests for maize?	● Insecticide ● Peppers ● Ashes ● Indosine ● Manually ● Bagging ● Raising near heat ● Fencing ● Do nothing ● Other ● Refused to answer ● Don't know
How much of your maize harvest do you lose to pests?	● All ● Almost all ● Half ● Some ● None
RICE	
What are up to three pre-harvest pests on your rice farm?	● Weeds ● Birds ● Rice blast disease

	● Squirrels ● Grass cutter ● Thieves ● Other ● Refused to answer ● Don’t know
What are up to three post-harvest pests on your rice farm?	● Rats ● Goats ● Army worm ● Squirrels ● Curculionidae insects (weevils/beetles) ● Grasshoppers ● Thieves ● Other ● Refused to answer ● Don’t know
How do you combat pests for rice?	● Insecticide ● Peppers ● Ashes ● Indosine ● Manually ● Bagging ● Raising near heat ● Fencing ● Do nothing ● Other ● Refused to answer ● Don’t know
How much of your rice harvest do you lose to pests?	● All ● Almost all ● Half ● Some ● None
5. Non-Agricultural Employment	**Answer Choices [where applicable]**
Do you have secondary employment other than farming?	
Are you self-employed, or are you an employee?	● Self-employed ● Employee
What kind of business is this?	● Bike rider ● Taxi driver ● Street vendor (petty trading) ● Farm traders

	● Wholesaler ● Barbershop ● Agro-processing business ● Tailor ● Other ● Refused to answer ● Don't know
Does this business require electricity?	
What is the electricity source?	
What do you use electricity for in the business?	● Charging station ● Electric razor ● Fan ● Freezer ● Lighting ● Radio ● Refrigerator ● TV/DVD Player ● Welding ● Other ● Refused to answer ● Don't know
How much did you make in this business over the past month?	
How much did you spend in running costs over the past month?	
6. Fertilizer	**Answer Choices [where applicable]**
Where do you get your fertilizer from?	● Locally ● Ministry of Agriculture ● Group leader/Master Farmer ● I do not use fertilizer ● Other ● Refused to answer ● Don't know
What is the name of your fertilizer provider?	
What is the phone number of your fertilizer provider?	
How many 50 kg bags of fertilizer do you use per acre?	

7. Seeds (Rice)	Answer Choices [where applicable]
Seed used (rice)?	● Balanta ● Dijui ● M6 ● Pattay ● Nerica L19 ● Ngalawai ● Gbombia ● Rock 3 ● Rock 5 ● Rock 10 ● Mixed ● Other ● Refused to answer ● Don't know
Where do you get your rice seeds from?	● Locally ● Ministry of Agriculture ● Aggregator ● Market ● Saved/reused seed ● Other ● Refused to answer ● Don't know
What is the name of your rice seed provider?	
What is the phone number of your rice seed provider?	
Do you save some of your rice seeds for planting later?	
How many seasons do you use these seeds for?	
8. Seeds (Maize)	**Answer Choices [where applicable]**
Seed used (maize)?	● Pioneer 30Y87 ● Western Yellow ● Mali ● IDA ● Other ● Refused to answer ● Don't know
Where do you get your maize seeds from?	● Locally ● Ministry of Agriculture ● Aggregator

	● Market ● Saved/reused seed ● Other ● Refused to answer ● Don't know
What is the name of your maize seed provider?	
What is the phone number of your maize seed provider?	
Do you save some of your maize seeds for planting later?	
How many seasons do you use these seeds for?	
9. Storage	**Answer Choices [where applicable]**
Do you have access to bags to store your crops?	
Where do you store your crops?	● Market ● Home ● Separate storage area ● I don't have storage ● Other ● Refused to answer ● Don't know
Who owns the storage unit?	● Self ● Community ● Government agency ● Market storage site ● Friend/relative ● Other ● Refused to answer ● Don't know
What is the owner's name?	
What is the owner's phone number?	
How frequently do you have to pay rent?	● Daily ● Weekly ● Monthly ● Every 2 months ● Every 6 months

	● Once a year ● I don’t have to pay rent
How much do you pay in rent?	
10. Market Access	**Answer Choices [where applicable]**
Who do you mainly sell your crops to?	● Poultry farm ● Retailer ● Wholesaler ● Aggregator ● Locals ● Other ● Refused to answer ● Don’t know
What is the buyer's name?	
What is the buyer's phone number?	
Does this person come to your farm to pick up your crops?	
What means of transportation do you use to deliver your crops?	● Public transportation ● Walking ● Tractor ● Owns truck/car ● Other ● Refused to answer ● Don’t know
What is the monthly cost of transporting your crops?	
11. Land	**Answer Choices [where applicable]**
Who owns the land that you farmed/worked last season?	● Self ● Community owned ● Local Landholding Family ● Other ● Refused to answer ● Don’t know
What is the landowner's name for the land that you don't own?	
What is the landowner's phone number?	
How many acres of land did you farm/work last	

season?	
Do you have to pay rent for this land?	
How frequently do you have to pay rent?	● Daily ● Weekly ● Monthly ● Every 2 months ● Every 6 months ● Once a year ● I don't have to pay rent
How much do you pay in rent each time?	
12. Credit	**Answer Choices [where applicable]**
Do you ever take out loans to help you with your farming business?	
What was this loan amount?	
Where did you get this loan from? [select all that apply]	● Community bank ● Clubs/Sou sou groups ● Family/friends ● Community member ● Microfinance institution ● Other ● Refused to answer ● Don't know
How much money did you borrow from ${credit-name}?	
13. Machinery	**Answer Choices [where applicable]**
Do you have access to mechanized post-harvest processing machines?	
What kind of machinery?	● Hammer mill ● Mixer ● Dryer ● Other ● Refused to answer ● Don't know
Who owns these machines?	● Self ● Community ● Private owner ● Ministry of Agriculture ● Other

	● Refused to answer ● Don't know
What is the name of the machine owner?	
What is their phone number?	
14. Energy Use	**Answer Choices [where applicable]**
Do you have any access to electricity in your house?	
What are the main sources of electricity in your household?	● Generator ● Stand-alone solar panel ● Public utility grid (EDSA, NPA, Bo-Kenema Power Service) ● Other ● Refused to answer ● Don't know
15. Generator	**Answer Choices [where applicable]**
GENERATOR	
Who owns the generator?	● Self ● Community ● Government agency ● Private owner ● Other ● Refused to answer ● Don't know
What is the name of the owner of the generator?	
What is their phone number?	
What do you use the generator for?	● Household appliances ● Business appliances ● Other ● Refused to answer ● Don't know
Do you have to pay anything to use this generator? How much?	
In a typical week, how many hours do you run the generator?	

In a typical week, how much do you spend on fuel to run the generator?	
16. Stand-alone Solar Panel	**Answer Choices [where applicable]**
SOLAR PANEL	
Who owns the solar system?	● Self ● Community ● Government agency ● Private owner ● Other ● Refused to answer ● Don’t know
What is the name of the solar system owner?	
What is their phone number?	
How much did you spend to purchase the solar panel you own?	
Do you have a regular usage fee that you must pay to use the solar panel? How much?	

The International Growth Centre (IGC) aims to promote sustainable growth in developing countries by providing demand-led policy advice based on frontier research.

Find out more about
our work on our website
www.theigc.org

For media or communications
enquiries, please contact
mail@theigc.org

Subscribe to our newsletter and
topic updates
www.theigc.org/newsletter -signup

Follow us on Twitter
@the_igc

Contact us
International Growth Centre,
London School of Economic
and Political Science, Houghton
Street, London WC2A 2AE

IGC
International
Growth Centre

DIRECTED BY
LSE
UNIVERSITY OF OXFORD

FUNDED BY
UKaid
from the British people

Designed by soapbox.co.uk