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Beyond Blanket Solutions: Examining the Potential of Community Seed Banks to Improve Maize Seed Security in Northern Malawi

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Abstract:

In Malawi, maize seeds are a sociopolitical currency and the government's primary tool for addressing severe and chronic food and seed insecurity. The large-scale government and donor-sponsored seed subsidy program (FISP) favors the distribution of commercial hybrid/OPV seed in order to augment yields; yet policy analysis suggests that exclusively addressing seed security through the formal seed sector risks undermining local systems of seed exchange. These informal systems have been documented repositories of locally-adapted crop varieties that possess a variety of desirable production and organoleptic qualities. Recently, community seed banks (CSBs) have emerged as an alternative, NGO-led development initiative aimed at improving seed access by providing a plethora of social and economic services beyond germplasm storage. To understand the role CSBs in maize seed systems, 60 semi-structured interviews were conducted with smallholders in two districts of Northern Malawi as part of a cross-sectional case study. Quantitative and qualitative data were collected pertaining to maize seed access opportunities, farmer preferences, and patterns of seed adoption; findings were used to compare CSB members with non-members. Despite widespread interest in adopting commercial seed to obtain higher yields, farmers' maize variety evaluations indicate higher levels of satisfaction for local varieties when considering both production and post-production characteristics. CSB members show lower levels of satisfaction for commercial maize than other farmers. These findings indicate that CSBs can expand farmers' frame of reference by providing members with a variety of seeds that meet a diverse set of preferences and by serving as a platform for exchange and experimentation. CSBs can therefore be viable complements to formal seed systems by encouraging farmers to grow a multitude of cultivars while also providing access to local varieties, which often possess desirable organoleptic qualities that commercial seeds generally lack. This study invites future research surrounding CSB viability, as its findings have wider implications for the potential of bottom-up, locally-based development interventions to improve smallholder farmer seed security in Sub-Saharan Africa.

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Yewo ocho mene!

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List of Abbreviations

SSA	Sub-Saharan Africa
CSB	Community Seed Bank
BCI	Biodiversity Conservation International
SFHC	Soils, Food, and Healthy Communities (NGO)
FISP	Farm Input Subsidy Program
ADMARC	Agricultural Development Marketing and Research Corporation

1. Introduction

In Sub-Saharan Africa (SSA), seeds are deeply embedded in the economic, political, and cultural fabric of rural livelihoods. Adoption of crop varieties in this region is influenced by seed access channels, both formal (commercial, government, relief) and informal (own supply, local markets, community exchanges). Maize in particular is the most important food crop in SSA, accounting for 30%-70% of total caloric consumption across the region (Langyintuo et al., 2010). In southern African states, average consumption is over 100 kg/capita/year (Smale et al., 2011). In Malawi, maize is the most dominant food crop grown by almost every farmer, accounting for about 50% of all planted land area (Khunga, 2019). Maize occupies a fundamental role in both Malawi's agricultural policies and the everyday lives of its citizens, as symbolized by the local proverb *Chimanga ndi moyo,* "maize is life" (Smale, 1995). Maize seeds are therefore a key component of cultural traditions, economic sustainability and farm-system resilience for many Malawian smallholders.

Although maize has been cultivated in Malawi since the era of the slave trade (c. early 16th century), the crop gained prominence as cultivation of local grains, such as finger millet and sorghum, were discouraged by European settlers in the early 20th century (Bezner Kerr, 2014; Vaughan, 1982). After achieving independence from British colonial rule in 1964, the Malawian government pursued an interventionist agriculture development strategy through investment in modern maize breeding programs, extension services, and promotion of fertilizer use (Chirwa, 2005). However, commercial maize research and development suffered several periods of stagnation due to shifting policy priorities and a greater emphasis on estate-based economic development, which marginalized smallholder farmers (Kydd, 1989; Kydd and Christiansen, 1982; Smale et al., 2011). This narrow political focus created a highly export-centric commercial agriculture sector vulnerable to exogenous shocks (Harrigan, 2003). In 1980, a civil war in neighboring Mozambique, severe drought, and a growing trade deficit plunged the government into debt and ushered in a period of structural adjustment programs that saw the privatization of the seed sector (Chinsinga, 2011; Peters, 2006). In the mid-1990s, a food crisis motivated the Malawian government to break with donor-backed neoliberalist policies by re-introducing a "smart subsidy" program for agricultural inputs (including improved maize varieties) that has since remained the country's predominant paradigm for rural development. In this post-independence era political landscape, maize has been used as the primary vehicle for addressing severe and chronic food insecurity. Therefore agricultural policies have consistently promoted the adoption of modern maize seeds and non-organic inputs as integral to improving production and alleviating hunger (Chirwa, 2005; Lunduka et al., 2012; Smale, 1995) (for further historical background, see Appendix I).

Despite the increased marketing of modern maize varieties, there remains widespread cultivation of local varieties governed through informal seed systems. This trend is seen across Africa, with more than 80% of the seed planted by farmers obtained through informal mechanisms (de Boef et al., 2010; Louwaars et al., 2013). Studies analyzing the use of hybrid maize seed in SSA often reference structural issues within the formal seed system as the reason behind low adoption rates, such as: farmer misconceptions about modern varieties, lack of access to information and technology, seed and input prices, difficult environments for formal research systems, deficient road infrastructure, weak extension services, and overall poor value chain function (Chirwa, 2005; Fisher et al., 2015; Langyintuo et al., 2010; Louwaars et al., 2013; Waldman et al., 2017). While such literature highlights valid areas of improvement for the commercial seed sector, such suggestions are typically based on the underlying assumption that farmers prefer the characteristics of the improved seed over what they can access through informal mechanisms. Other studies that more explicitly analyze the relationship between farmer preferences and maize seed adoption encourage the development of improved varieties with more appealing organoleptic traits. In essence, these papers propose greater investment in multi-objective breeding programs as a way of improving seed security (Fisher and Snapp, 2014; Fisher et al., 2015; Lunduka et al.,

2012). Though these suggestions could result in higher levels of commercial maize adoption, research and development programs that focus exclusively on marketing desirable seeds within a commercial framework risk maintaining the same access constraints currently faced by farmers seeking modern varieties. A study conducted by Westengen et al. (2019) highlights this issue, concluding that wealthier and more food secure households benefit first from policies that strengthen the formal seed sector. In this context, it is quite common to conflate seed quality (as defined by the FAO: germination ability, physical/varietal purity, seed health) with genetic quality (most often measured in through production parameters). Research in SSA that directly links low hybrid adoption rates with low maize production underwrites policies that fortify the commercial sector, often through increased regulations addressing genetic resource access, intellectual property rights, seed standardization and certification. This logic persists in institutional responses to situations of acute or prolonged stress in southern African countries, in which aid will often manifest as direct distribution of commercial maize seed to vulnerable populations (Sperling et al., 2008). However these measures, championed by states and donors that favor private sector agricultural development, often ignore the prominence of informal seed systems and thus risk becoming counterproductive in addressing issues of seed security[1] (de Boef et al., 2010; Sperling et al., 2008).

In fact, farmer seed networks can provide locally adapted, quality seeds with a variety of characteristics desirable to farmers that extend beyond yield and drought tolerance (Coomes et al., 2015). For example, research suggests that through local markets, community exchanges, and *in-situ* seed conservation, farmers breed and circulate maize seeds that satisfy a wide range of desired agronomic and organoleptic qualities, including: maturation rates, storability, high flour-to-grain ratios, taste, poundability, etc. (Almekinders et al., 1994; Cleveland et al., 1994; Kydd, 1989; Lunduka et al., 2012). Preference for maize landraces also stems from their adaptability to local conditions; seeds have been selected by farmers for generations to achieve high levels of productivity within a narrow set of ecological conditions (Gibson, 2009). Climate adaptability has gained saliency as a valuable varietal trait in recent decades with the increase of transitory but frequent acute climate stresses in Malawi (Nordhagen and Pascual, 2013). In some cases, the diverse genetic portfolio provided by local varieties has proved to better withstand stresses in different agro-climates than hybrid maize (Bezner Kerr, 2013; McGuire and Sperling, 2016). This is because hybrids within the formal seed system must be genetically homogenous to comply with commercial standards, and are therefore generally less resilient to irregular events, such as droughts and floods. Given the increasing prevalence of climatic events in this region of the world, it is necessary to examine how seeds factor into farmers' adaptation strategies. Some recent research supports the adoption of modern "climate smart varieties" (such as drought tolerant [DT] hybrid seeds) as the most effective for smallholders to adapt to climate change (Atlin et al., 2017; Fisher et al., 2015; Holden and Fisher, 2015). However, other research on adaptation strategies recommend more systemic approaches, such as: implementing wide-reaching and flexible seed distribution systems that link formal and informal seed systems, addressing market and non-market transactions, and supporting locally-adapted interventions that benefit producers and consumers (Coomes et al., 2015; Nordhagen and Pascual, 2013; Thornton et al., 2018).[2]

[1] Seed security is defined by the FAO as when "men and women within the household have sufficient access to quantities of available good quality seed and planting materials of preferred crop varieties at all times in both good and bad cropping seasons" (FAO, 2015). The original conceptual framework for seed security, established in 1998, was based on three pillars: seed access, seed availability, and seed quality. However, in recent years this framework has been expanded to include two additional key elements to seed security: varietal suitability (adapted crop varieties farmers prefer and need) and resilience in the context of shocks and stresses (FAO, 2015). These additions more directly address the individual preferences of farmers and the cultural value of different seed varieties.

[2] Unfortunately, it is not within the scope of this study to analyze how different climatic events have affected seed access for communities, but climate change will be recognized as a prevalent threat in the region and a motivator for increasing smallholder resilience.

Since the 1980s, community seed banks (hereafter CSBs) have gained prominence in the Global South as one of such interventions for improving food and seed security while building smallholder resilience to climate change (Andersen et al., 2018). While CSBs can vary in terms of governance and organization, they primarily function as a repository of genetic material to help preserve the agrobiodiversity inherent in local varieties and provide farmers with means of diversifying their on-farm production. Within the framework of climate-smart agriculture, international NGOs have increasingly supported CSBs as a measure of disaster-relief and climate change adaptation (Nyantakyi-Frimpong, 2019; Thornton et al., 2018). While germplasm conservation and climate risk mitigation continue to be the dominant narratives surrounding CSBs, recent case studies also reveal their potential to integrate formal and informal seed systems through offering a broad range of auxiliary social and economic services (Vernooy et al., 2015; Westengen et al., 2018). In part due to its inherent versatility, the CSB model has shaped the development of local institutions that can provide: centers of education and knowledge transfer regarding agricultural biodiversity, documentation of traditional knowledge and cultivation techniques, the collection, production, and exchange of seeds, and *ex-situ* conservation of genetic resources (Vernooy et al., 2016). In Malawi, several NGOs that are backed by international donors have recently helped establish CSBs as a locally-based counterpart to the top-down, subsidy-oriented policies driving national agricultural development. As community-managed centers of seed production, storage, and distribution, CSBs pose a viable complement to commercial seed systems that are potentially better suited to providing farmers with locally-adapted seeds that meet a variety of preferences. Through auxiliary services such as workshops and seed fairs, CSBs can also encourage farmers to cultivate a portfolio of seeds that have desired attributes, thereby increasing resiliency against adverse climatic conditions.

Despite a policy environment that favors the commercialization and homogenization of seed supplies, local seed systems persist in times of increasing climatic stress, pointing towards the need to use collaboration between formal and informal systems as a metric for seed security and agricultural development rather than simply the adoption of modern commercial seed. Past studies of local variety cultivation have called for greater linkages between local seed systems and the formal sector through an integrated approach that favors farmer participation in variety development and seed supply (Almekinders et al., 1994; Cleveland et al., 1994). Since there are few recent investigations that a) address farmer seed preferences in the framework of improving formal and informal sector complementarity and b) examine how CSBs can play a role in these types of interventions, it is of interest to continue this line of research by examining if and how CSBs can improve seed security.

Instead of focusing on how farmer preferences can be addressed through only the formal system, this project pursues a more holistic analysis of factors underlying seed security in Northern Malawi with an empirical emphasis on how community seed banks shape farmer access opportunities, preferences, and patterns of seed adoption. This research is guided by the principal question: What role can CSBs play in increasing formal and informal seed system complementarity in Northern Malawi? (For the full list of research questions that guided the methodology, see Appendix II). Using original data collected over 5 weeks of fieldwork in Rumphi and Mzimba districts of Northern Malawi, this case study examines 1) the availability of different maize seeds in the current socioecological and cultural context of local agricultural systems 2) drivers and barriers underlying access to maize seeds, including different seed attributes farmers value and 3) how CSBs indirectly and directly help farmers obtain seeds of preferred varieties. It is concluded that farmers in Northern Malawi usually grow a portfolio of maize varieties obtained from multiple sources. As seeds have become increasingly incorporated into the monetary economy, especially through the marketing of hybrid/OPV varieties, principle barriers to access are predominantly financial; farmers often face prohibitive seed prices and transportation costs. However social factors, such as trust and processes of information exchange, can also condition access to local and commercial seeds within informal systems. Despite widespread interest in adopting commercial seed to obtain higher yields, farmers' maize variety evaluations indicate higher levels of satisfaction for local varieties

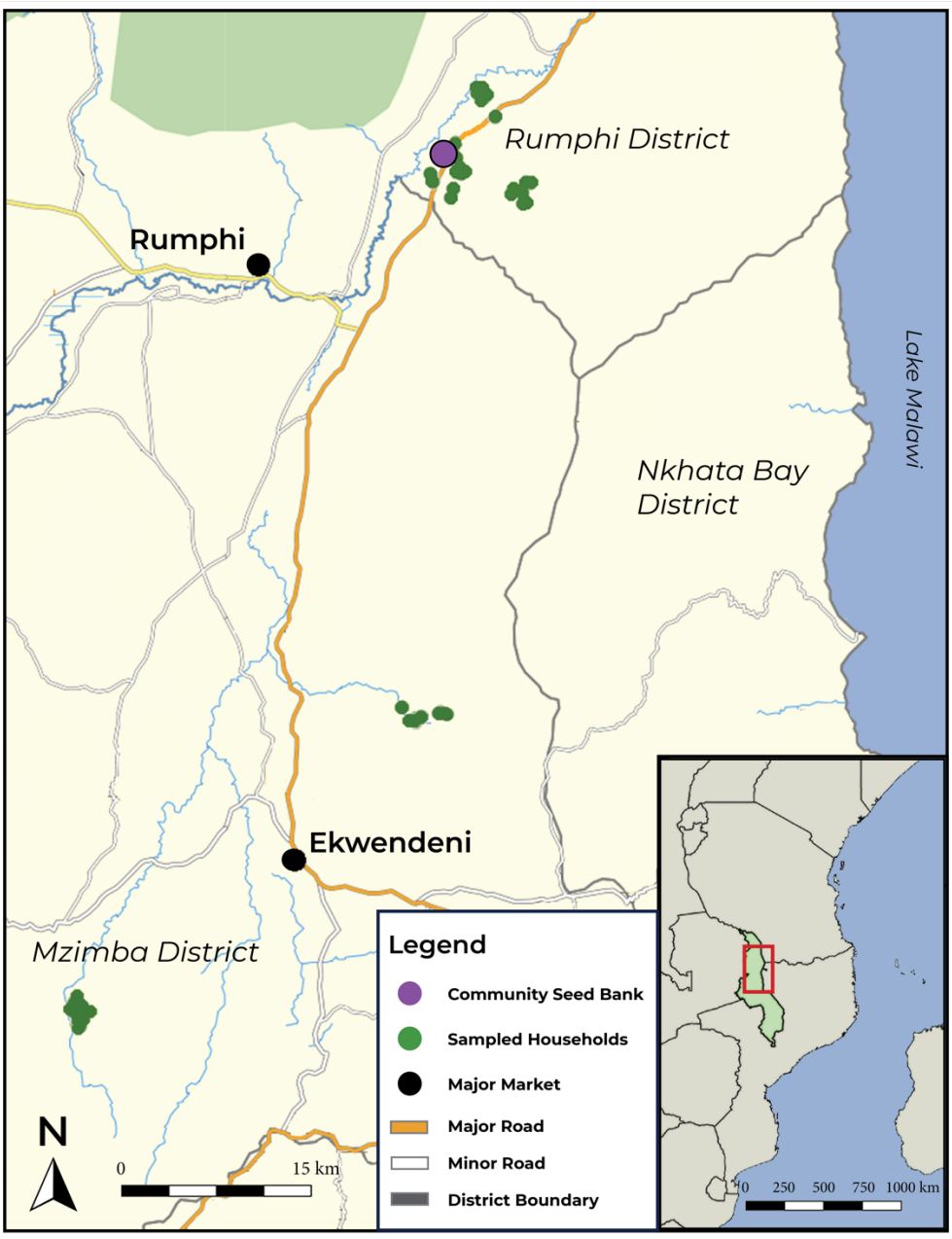
when considering production and post-production characteristics. Participation in Mkombezi CSB seems to be linked to farmer seed preferences, with CSB members showing lower levels of satisfaction for commercial maize than other farmers. These findings indicate that CSBs can expand farmers' frame of reference by providing members with both a variety of seeds that meet a diverse set of preferences and serving a platform for exchange and experimentation. Therefore, this case study suggests that CSBs can be viable, locally-based complements to formal seed systems by encouraging farmers to grow a variety of cultivars and providing access to local varieties that possess desirable organoleptic qualities that commercial seeds generally lack. Through investigating the role of a CSB in a particular socio-economic context, this study and its findings highlight the potential of community-based institutions to strengthen informal seed systems, thereby working to improve smallholder seed security in SSA.

2. Methods

2.1 Study Area

Fieldwork was conducted in 22 different village areas within Mzimba and Rumphi districts of Northern Malawi, where on average smallholder farming households cultivate 1-2 hectares of land. This zone is mid-altitude (1000-1200 m asl) sub-tropical region with unimodal rainfall between December and April (600-1100 mm/yr) and an average growing season of 195 days (Bezner Kerr, 2014; HarvestChoice, 2015; Snapp et al., 2019). Though the general study area is within one agro-ecological zone, micro-climatic variations impacted agricultural systems across relatively short distances. For example, in the Mkombezi area of Rumphi district, a local drought following the rainy season left fields yellow and wilted. Just 50 km south near Ekwendeni, the landscape remained lush with regular rain. It is important to recognize the potential impact of these small yet severe variations in climatic stress on farmer interview responses, particularly those attributing value to drought tolerant seeds.

This study evaluates operations at the Mkombezi Community Seed Bank, one of five regional CSBs in Rumphi district managed by the national NGO Biodiversity Conservation International (BCI). The seed bank was built in 2010 and since has attracted 82 members, the majority of which live in villages within a 5km radius. The seed bank has a room for group meetings, a library, and two seed storage rooms in which seeds were stored in cool, dark conditions. One of such rooms is dedicated to local germplasm storage, featuring small labeled jars of seed arranged on timber shelves. The other storage area contains large bags of seed resting on timber platforms; this bulk storage area contains repaid seed loans from the last growing season. Behind the building, a live seed bank contains small plots of land where seeds are grown for multiplication and demonstrative purposes. The seed bank is funded by the Development Fund of Norway as part of a larger Community Based Agrobiodiversity Management project, within which BCI implements its activities.



Base map: OSM Generic Routable, 2019

Figure 1. Study Area (Northern Malawi)

Figure 1. Map depicting clustered locations of households selected for semi-structured interviews based on GPS data, the Mkombezi CSB, and major features (markets, roads, districts).

According to the classifications used by Vernooy et al. (2014) to describe the core functions of community seed banks (see Section 4.3), the Mkombezi CSB can be categorized as an institution principally occupied with conservation of local agrobiodiversity, but also engaged in activities to expand seed access and availability and increase food sovereignty through providing auxiliary services such as: multiplying farmer preferred varieties in a live seed bank, acting as a platform for farmer education and experimentation, using hired expertise to promote ecological farming practices to build resilience, fostering inter-CSB exchanges of knowledge and germplasm, and hosting workshops on climate change, gender, and teamwork. Due to outside management and shared funding, there exists a high level of exchange and networking between all of the CSBs in Rumphi.

While BCI fieldworkers help coordinate events and workshops, day-to-day operations at each CSB are overseen by a local volunteer chairperson and an executive committee. The Mkombezi seed bank was specifically chosen for this study as it was the first CSB implemented by BCI and thus has the most well-established operations and member base, providing a useful historical perspective on how the CSB has evolved its operations over the last 9 years.

Photo: Mkombezi Seed Bank, Rumphi District

Photo: Live Seed Bank, Rumphi District

2.2 Data Collection

Fieldwork was conducted in collaboration with two national NGOs: Soils, Food and Healthy Communities (SFHC), involved in participatory action research with local communities in Northern Malawi and Biodiversity Conservation International (BCI), which manages five seed banks in Rumphi district. Both organizations provided contacts and logistical support; their collaboration was integral to accessing remote areas and gaining permission from local leaders to visit households in their respective villages. Over the course of 3 weeks, 60 semi-structured interviews were conducted with farmers ranging in ages 20 – 81 from 60 different households in two northern districts of Malawi. In the Rumphi district, 30 households were selected from between 1-5 km of the Mkombezi Community Seed Bank, located about 25 km from Rumphi, the closest major market. In Mzimba district, 30 households were selected from two different village areas, each about 25 km from Ekwendeni, the closest major market (see Figure 1). In both districts, households were purposefully sampled in order to gather perspectives from a pool of farmers with diverse gender, age, and family profiles (see Table 1). In Rumphi district, households were also sampled at variable distances from the seed bank, along with a mix of member and non-member respondents (21 members, 9 non-members). Longer, in-depth interviews were also conducted with the Mkombezi CSB chairperson and a village elder from the Mzimba district. These discussions provided more detailed accounts of seed bank operations and a historical perspective on seed sharing practices, respectively.

All interviews were completed with the help of a translator, as most of the farmers speak only the local language, Tumbuka. Farmers were required to give informed consent prior to participation, agreeing to allow photos and their GPS location to be anonymously recorded. A semi-structured interview format was chosen in order to gather sufficient quantitative information using standardized questions pertaining to the respondent's livelihood strategies and maize cultivation practices, as well as to obtain qualitative information regarding the respondent's perspective on certain issues. The predetermined interview questions were developed and revised in collaboration with leaders from SFHC, BCI, and the Mkombezi CSB. Incorporating feedback from local residents in the question drafting process was essential in producing a guide well adapted to the linguistic nature of the interview interaction and the subject matter. Inquiries designed to yield qualitative data often

included follow-up questions, probing questions, and specifying questions (as defined by Kvale and Brinkmann (2008)) that were improvised to extend the respondent's answers on subjects that they seemed keen to discuss. All answers were transcribed on a printed interview guide to enable coding and digitalization of results at a later stage (see Appendix II). During the interview, farmers were often asked to elaborate via follow-up questions to open-ended inquiries. In many cases, questions that probed into personal preferences and perspectives resulted in informal discussions. Salient quotes were transcribed, and paraphrased responses were later dissected using qualitative coding.

Within the interview, farmers were asked to evaluate the maize varieties they were growing during the 2018/2019 season across 8 characteristic categories using a scoring system: 0 = poor, 1 = average, 2 = good. Though respondents had to score within a 3-number range, they could give each criterion in question any value within that range. Using this system, respondents could give independent evaluations for each variety trait (Abeyasekera, 2009).[3] In total, farmers were asked to rank each of their current maize varieties for seed quality, maturation period, drought tolerance, yield, storability (how well the maize can be stored for long periods of time), poundability (how well the maize grains can be pounded or milled into flour), taste, and color. These characteristic categories were chosen as important evaluation criteria based on prior variety preference studies in Malawi (Abeyasekera et al., 2002; Lunduka et al., 2012) and input from SFHC and BCI staff members that have longstanding projects with farmers in the region.

Observational data was also collected from informal discussions and participation in two farmer field days. The first farmer field day was organized by the Mzimba district Ministry of Agriculture and consisted of 10 short field visits, where farmers and NGO representatives presented on a range of subjects concerning seed choice and crop management. This event occurred during the first week of fieldwork and provided key information pertaining to the different types of agriculture systems within the region and the principal crops grown by small-scale farmers. The second farmer field day was hosted by the Mkombezi Community Seed Bank and attended by members from three other seed banks in the region, traditional leaders, and field workers from BCI. CSB members hosted visitors at various nearby field sites, explaining how different local varieties of common food crops function under drought conditions. Afterwards, BCI facilitated a group discussion on climate change mitigation and building resilience through agricultural practices. This event provided a key window into the diverse array of seed bank operations, serving as an opportunity to observe farmer-to-farmer knowledge exchange and group learning.

2.3 Data Analysis

The data analysis was carried out with 3 primary foci 1) generating an overview of household demographics and farming systems across districts to assess population uniformity; 2) cataloging different maize seed types and sources as basis for evaluating access and availability parameters between CSB and non-CSB households; 3) comparing maize variety evaluations by maize type and CSB participation as a basis for assessing influences on farmer seed preferences. Though both quantitative and qualitative data were coded to generate descriptive statistics, only quantitative data was subjected to statistical analysis.

Interview data were entered into Microsoft Excel, comprising a large dataset of quantitative and qualitative information on farmer profiles, crop and seed related practices, and personal preferences/perspectives. Qualitative responses were coded and categorized to determine recurrent themes. These themes were used to generate frequency tables that compared farmer responses to open-ended questions. Descriptive statistics were

[3] Maxwell and Bart (1995) characterize this method as "open scoring," a more flexible alternative to the common PRA method of "restricted scoring," which requires a fixed number of points to be assigned across a set of criteria.

generated to analyze socio-demographic consistencies between the areas in which interviews were conducted. This household data included information on gender, age, cultivated land, household size, dependency ratio, and income activities (Table 1). The dependency ratio, a method based on Snapp et al. (2019), was calculated by dividing the number of dependents in the household (children age 0 – 17 and elderly age 65+) by the number of adults. The result provides a general approximation of the household's economic status and labor availability: ratios < 1 indicate low dependency, rations between 1-2 indicate medium dependency, and ratios > 2 indicate high dependency.

Frequency tables were also created to identify general trends in several areas of the interview concerning crops grown this season (maize and complementary crops), sources and methods of obtaining seeds, and seed access. Within the latter section, responses concerning barriers to seed access were subject to qualitative coding to determine trends; often, a single response corresponded to several categories. For each response category, frequencies are derived from the total number of farmers who responded to the question. For evaluating different responses to most important maize characteristics, proportions of CSB and non-CSB farmers are compared across several response categories. To evaluate the difference between proportions, a Fisher's exact test of independence was used; this test was selected as it is more appropriate given the small sample size of each sub-group ($n < 50$) than a more common chi-square test. However, it should be noted that given the small sample size, indications of statistical significance, denoting differences in proportions, have limited power. Fisher's exact test results (as shown in Tables 3 & 7) should therefore be interpreted within the context of this study, though they might also signal places of interest for a larger study to conduct a more representative questionnaire.

Farmers' scores were used as a general parameter to assess their experiences with certain maize varieties across different categories, as well as an indication of their overall satisfaction with the maize seeds they obtained that year. To discern potential differences in satisfaction with local and hybrid/OPV maize, the scores given by farmers were grouped by maize type. To balance out the contributions from each household (equalizing households that grow 6 varieties of maize with those that only grow 1 variety), the average score for each category was calculated by maize type for each household. These scores serve as the household's overall evaluation of hybrid/OPV or local maize. Evaluations for all maize, local maize and hybrid/OPV maize were grouped by household type: CSB members, non-CSB members, All Farmers (aggregate group).

Given the relatively small sample size for each grouping and limited range of possible scores (0 – 2), it is not appropriate to use standard assumptions of variance or normal distribution as an approach to statistical analysis (Franzel and Coe, 2002). Therefore, to analyze differences between mean scores across household groupings, the Mann-Whitney U-Test was used as an equivalent of the t-test for independent (non-paired) samples for non-parametric data. Significant differences between groups in average scores for characteristic categories are identified in the tables and are denoted as the following: * = $p < .10$, ** = $p < .05$.

After evaluating their maize varieties across 8 different criteria, farmers were asked to select three (non-ranked) criteria from the list as the most important to them. The disadvantage to this method is providing farmers with a limited range of responses. However, when the question, "what three maize seed characteristics are most important to you?" was posed in an interview trial, the respondent struggled to differentiate between a maize characteristic and a maize variety. Posing the question "out of all of the criteria we just talked about (*list 8 categories)*, which three are the most important to you?" (or alternatively: Which three characteristics are the most valuable to you in a maize plant? Which three characteristics do you prioritize when choosing a maize seed?) elicited a greater level of comprehension and a more confident response. Frequencies were generated based on how often each criterium was listed as a response, and a Fisher's exact test of independence was used to calculate differences in responses based on gender and CSB membership.

2.4 Research Approach and Limitations

Research was conducted within the larger framework of ACCESS, a project assessing seed security in Malawi, Tanzania and Ethiopia. The goal of the project is to gather information on farmers' needs, challenges, and preferences with regard to the seeds they use in order to inform policies aimed at improving seed security in all three countries (Westengen, 2018). This case study uses this aim as a point of departure and employs to explore seed systems in a specific social, ecological, and political context, using maize as the primary focus. By drawing upon aspects of participatory action-research (PAR) and agroecological research, this study seeks to "amplify those voices that have been traditionally excluded from the research process" (Méndez et al., 2016) and integrate these perspectives in a larger framework of social and political analysis.

In the book *Agroecology: A Transdisciplinary, Participatory, and Action-Oriented Approach* (2016), authors Mendez et al. defend using traditional knowledge and farmer perspectives as the backbone of participatory agroecological research against criticism of romanization and inherently placing positive value placed on the word "traditional." The authors argue that rather than using a technology-focused, agronomic approach to classify and investigate problems faced my smallholder farmers, an agroecological research agenda should be developed from the scientific exchanges that naturally occur in smallholder communities. Therefore, this seed systems study focuses on farmer perspectives as the primary source of qualitative and quantitative information, acknowledging the farmer's deep location-specific knowledge of local climate conditions, farming systems, social customs, and political practices. A seed security assessment with an empirical emphasis on farmer preferences and perspectives deviates from more common top-down approaches that measures modern technology adoption (in the form of improved varieties and chemical inputs) as a metric for production and thus more food secure households. This is not to insinuate that traditional, local/indigenous practices are inherently superior to modern technological approaches in the context of improving seed security. Rather, this approach seeks to integrate academia with experiential and farmer-derived knowledge in a transdisciplinary fashion to better understand drivers and barriers underlying seed access. This is done in part by acknowledging the important role of traditional (informal) seed systems and smallholders as the principle actors (rather than simply consumers) within these systems. Given the narrow-scope and limited human resources employed, it was not feasible in this case study to engage multiple actors in the seed system in iterative processes of observation, reflection and analysis to facilitate action at multiple scales. However, the conclusions from this research can contribute to larger, long-term movements that incorporate a greater number of actors in regional seed systems, as well as guide future research evaluating CSBs around the world.

However, serious limitations must be recognized when relying on farmer testimonies for qualitative and quantitative data. Interviews invite self-reporting, which can cause skewed results when farmers are asked to quantify certain figures (like land area cultivated) or recall the names of varieties grown. A study on improved cassava variety adoption in Colombia highlights potential disparities in actual vs. reported variety adoption data by coupling interviews with field DNA tests. It was found that mis-guided farmer identification of varieties led to errors in determining factors underlying adoption (Floro et al., 2018). In this study, farmers also occasionally struggled to recall what types of maize they were currently growing and sometimes could only distinguish between commercial and local varieties. These types of responses could also be convoluted due to the need for translation. This led to a less-precise evaluation of farmer preferences, resulting in comparisons between aggregate groups based on maize type rather than specific varieties.

In this study, patterns of maize adoption are examined using both a quantitative (recording maize varieties grown) and qualitative approach (asking why farmers chose to adopt certain types of maize). As mentioned, the "self-reporting" aspect has its drawbacks, but so does using drivers of adoption as a simplified method of

understanding intricate processes that underlie shifts in technology (Glover et al., 2019). For example, asking farmers the reasons behind their adoption of certain maize varieties and categorizing responses by trends can disregard differing levels of experience and experimentation with hybrid/OPV maize seeds. In this case, "variety adoption" is considered equal to cultivating the variety for at least one growing season (see Section 4.3). However, this definition does not encapsulate the dynamic processes of exposure to commercial seeds (which certainly varies across respondents) and is not necessarily congruent to other definitions of adoption employed in other seed systems studies.

Finally, a key component of the methodology is the use of maize variety evaluations to measure satisfaction. Naturally, satisfaction is a subjective concept and therefore difficult to quantify on a scale (in this case, 0 – 2). Satisfaction is also relative; farmers that have been exposed to many varieties of maize have a greater frame of reference in which to make evaluations than those who know only what they are currently growing. A second disadvantage with this method is the difficulty in calculating and interpreting "overall satisfaction" from taking the average of all scores for a variety, as it automatically gives equal weight to each criterion. Since the list of variety criteria were predetermined, it cannot be assumed that all farmers actively considered each category when they choose their maize seeds. For example, a couple of farmers mentioned susceptibility or resistance to field pests when describing their current varieties, even if these criteria was not officially evaluated in the interview (including susceptibility to storage pests but not field pests was an oversight in the design of the scoring exercise). Future research in this area should adopt more complex methodologies to measure farmer preferences, perhaps prompting farmers to name their own criteria for evaluation, devising a system to assign weight to these criteria, and/or using a larger numerical scale to assess satisfaction.

3. Results

The findings from the fieldwork are organized into three main topics that explore key aspects of maize seed systems and show comparisons between CSB and non-CSB households. The first section provides an overview of local agricultural systems, including the cultivation of non-maize crops and the prevalence of different maize types within these systems. The second section shows how maize seeds are sourced and obtained, as well as what drivers and barriers determine access to different varieties. The third section explores farmer maize seed preferences and patterns of seed adoption.

3.1 Overview of study population

The socio-economic profiles of interviewed households remained relatively consistent across village areas and districts (see Table 1). More women were available for interviews than men, often due to men being absent for daily off-farm activities or migratory labor. However, as Tumbuka culture is patrilineal (land is inherited through male kinship lines) (Bezner Kerr, 2014), a majority of the households have male heads (HH) in both Mzimba and Rumphi districts. Almost all households rely on agriculture-based income, whether it is selling cash crops, marketing produce or livestock, or informal piecework labor on others' fields (known locally as *ganyu)*. Households that reported earning money through self-employment usually referred to the sale of agricultural products at an independent market stall. Remittances were generally received from family members engaged in migratory labor on estates or through sharecropping on smallholder farms. Despite the central role of agriculture in the livelihoods of rural households, farmers did not possess the monetary or labor capital to produce on more than 3-4 acres (1-2 hectares) of land.

Table 1. Profile of Interviewed Households by District

	Rumphi District	Mzimba District	Total Study Area
Total Respondents [n]	30	30	60
Male	12	14	26
Female	18	16	34
Female HH	4	7	11
Male HH	26	23	49
CSB members	21	0	21
Distance from CSB (km)	3.23 (1.85)	N/A	N/A
Age	44.17 (13.70)	45.27 (15.48)	44.70 (14.50)
Males	46.67 (17.21)	44.29 (11.91)	45.38 (14.34)
Females	42.50 (11.00)	46.13 (18.41)	44.20 (14.83)
Cultivated Land Size [acres]	3.59 (1.77)	3.48 (1.84)	3.53 (1.79)
Household Size [no. people]	5.10 (1.99)	4.70 (2.77)	4.90 (2.40)
Dependency Ratio	1.34 (0.97)	1.06 (0.70)	1.20 (0.85)
No. of Income Activities	3.30 (1.15)	3.40 (1.03)	3.35 (1.09)
Income Activities [% (n)]			
Cash Crops	86.67 (26)	86.67 (26)	87 (52)
Ag. Wage Labor	53.33 (16)	56.67 (17)	55 (33)
Non-Ag. Wage Labor	6.67 (2)	23.33 (7)	15 (9)
Sale of Livestock	60 (18)	60.00 (18)	60 (36)
Regular Salary	20 (6)	10.00 (3)	15 (9)
Remittances	30 (9)	33.33 (10)	32 (19)
Self-Employed	73.33 (22)	70.00 (21)	72 (43)

Table 1. Dependency ratio is calculated by comparing the number of adults (age 18 -65) in each household to the number of children (age 0 – 17) and elderly (age 65+). The ratio is calculated as: (number of dependents / number of adults. Ratios < 1 indicate low dependency, rations between 1-2 indicate medium dependency, and ratios > 2 indicate high dependency. Note: values are presented as the mean value with the standard deviation in parentheses unless otherwise noted.

Though maize is the staple crop of the northern region, farmers usually grow a variety of crops for both subsistence and income. Rural smallholders in Malawi typically cultivate using mixed-cropping systems to maximize food production (Snapp et al., 2019), with 95% of interviewed farmers intercropping maize, usually with a mix of pumpkins, sweet potato, and legumes (groundnut, soy, or beans). Such crops are produced primarily for home-consumption, and the excess is either sold at the market, to regional distributors, to vendors, or through informal community networks. In the northern region, tobacco is the primary cash crop; however, the competitive auction-based market, high demand for labor, land and inputs (fertilizers and pesticides), and on-farm processing infrastructure requires significant start-up capital. As 100% of the interviewed households grow maize (primarily for home-consumption, excess was sold), a general indication of how a household

diversified their agriculture-based livelihood was discerned through asking farmers to list 1-3 important *non-maize* crops that they are currently cultivating. As maize is grown as a dietary staple, farmers usually attributed value to non-maize crops that provide substantial income. In Table 2, responses are divided by the households within Mzimba district, households within Rumphi district, and an aggregate group of all respondents.

The cultivation and attribution of value to non-maize crops are relatively similar across districts, reflecting uniform farming systems across the northern region where interviews took place. There are notable regional differences in legume production, with Mzimba households prioritizing soy and Rumphi households prioritizing Bambara nuts (*Vigna subterranea*). During the Mzimba field day, farmers demonstrated different maintenance techniques for soil fertility management, including mulching maize plots with pigeon pea and groundnut as well as using mixed legume-maize cropping systems. Other demonstration fields consisted of side-by-side hybrid maize monocultures for easy variety comparison; at these events farmers mentioned being encouraged by government extension workers to plant improved varieties in monocrops in order to increase production.

Table 2. Important Non-Maize Crops by District

% (n)	Mzimba	Rumphi	All Farmers
Groundnut	70 (21)	80 (24)	75 (45)
Soy	73 (22)	10 (3)	42 (25)
Tobacco	37 (11)	40 (12)	38 (23)
Beans	43 (13)	33 (10)	38 (23)
Bambara Nut	3 (1)	30 (9)	17 (10)
Sweet Potato	20 (6)	13 (4)	17 (10)
Tomatoes	7 (2)	13 (4)	10 (6)
Cassava	13 (4)	7 (2)	10 (6)
Greens	0 (0)	10 (3)	5 (3)
Irish Potato	3 (1)	3 (1)	3 (2)
Pumpkin	7 (2)	0 (0)	3 (2)
Millet	3 (1)	0 (0)	2 (1)
Onions	0 (0)	3 (1)	2 (1)

Table 2. Farmers were asked to list non-maize crops that they had grown in the 2018/2019 season that they saw as important to them (maximum 3). The results are recorded as the proportion of all farmers interviewed in each district (n = 30), and an aggregate group of all respondents (n = 60).

These seemingly contradictory methods reflect changing farmer attitudes towards intercropping; in interviews, some farmers viewed monocropping as an advanced and more profitable practice and regretted not having the labor or inputs to do it themselves. Yet at the Mkombezi CSB field day in Rumphi district, intercropping was emphasized by both farmers and BCI fieldworkers as a viable method for climate change mitigation, as well as for improving household food security. For example, one potential reason Bambara nuts were prioritized in Rumphi district is because they were promoted by the CSB as an early-maturing, drought-tolerant crop that

can also improve soil fertility when intercropped. Although it was not within the scope of this study to record and analyze crop diversification at the farm level, these observations suggest that the impact of CSBs on farm-level agrobiodiversity (as well as livelihood and dietary diversity) merit future investigation.

On average, the interviewed households reported devoting 58% of their land to maize production, which is in accordance (if not slightly higher) than other published findings on the subject (Kawaye and Hutchinson, 2018; Snapp et al., 2019). Figure 2 illustrates the types of maize grown by interviewed households, loosely categorizing maize varieties as either local or hybrid/OPV. For a list of specific varieties reported as grown by interviewed farmers, refer to Appendix IV. Each farmer was asked to self-report the acreage of land they allotted for maize production in the 2018/19 growing year, including both the total land area and the acreage for each maize type. Of the farmers that grow both local and hybrid/OPV maize, on average 52% of their land is allocated for local varieties and 48% for hybrid/OPV varieties, providing no indication of land prioritization based on maize type. When questioned about maize field management, 80% of farmers that grow both hybrid/OPV and local maize applied the same amounts of fertilizer, regardless of maize variety. The only differentiation was found in the usage of storage pesticides, where 40% of farmers who applied such products reported delayed or lesser application on local varieties compared to hybrids/OPVs due to superior storage quality of local maize.

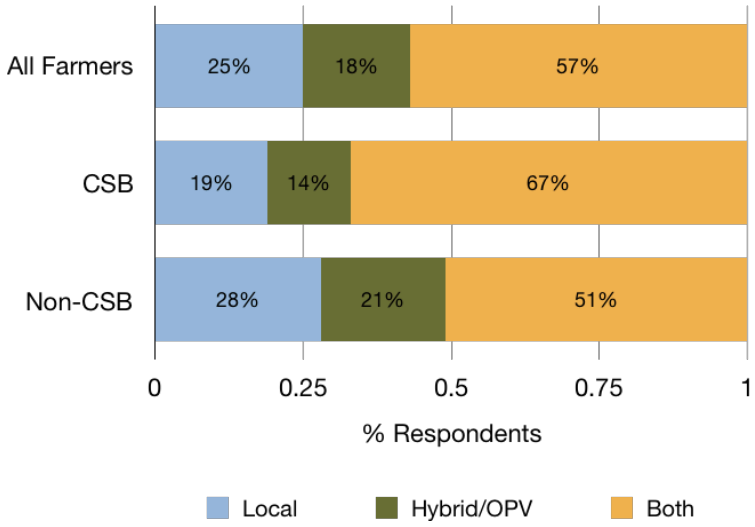


Figure 2. Types of Maize Grown by Interviewed Households

Figure 2. Proportions of farmers that grow exclusively local maize, exclusively commercial (hybrid/OPV) maize, and a mix of both are presented for CSB households (n = 21), Non-CSB households (n = 39), and an aggregate group of all farmers interviewed (n = 60).

Without easy access to chemical inputs to provide optimum growing conditions, it is typical for small-scale farmers in Malawi to grow a portfolio of maize varieties to achieve adequate levels of production (Gibson, 2009). For example, farmers might grow short-stalked, early maturing maize for consumption during the typical hungry period (following the rainy season) and large-cob maize with hard grains for long-term storage (Lunduka et al., 2012). In other instances, based on their respective storage and production capacities, smallholders grow local varieties for household consumption throughout the year and hybrid seed to sell at the market. In both cases, the traits of the maize seed factor into how the maize is used and if/when it is consumed. Types of maize grown by CSB and non-CSB households reveal slight differences between groups, as shown in Figure 2. While it appears more CSB households grow both types of maize, and less grow exclusively hybrid/OPV maize, a Fisher's exact test of independence found no significant differences between frequencies.

Table 3. Source and Variety Counts for Maize: CSB vs. Non-CSB Households

		CSB (n = 21)	Non-CSB (n = 39)	All Farmers (n = 60)
	Avg. Total	**2.19** (.68)**	**1.63** (.94)**	**1.90 (.88)**
No. Varieties	**1**	3 (14%)**	17 (44%)**	20 (33%)
	2	11 (52%)	18 (46%)	29 (48%)
	3	7 (33%)**	4 (10%)**	11 (18%)
	Avg. Total	**2.38* (.93)**	**1.95* (.79)**	**2.10 (.88)**
No. Sources	**1**	4 (19%)	13 (33%)	17 (28%)
	2	8 (38%)	15 (38%)	23 (38%)
	3	6 (29%)	11 (29%)	17 (28%)
	4	3 (14%)**	0 (0%)**	3 (6%)

Table 3. Results are divided into CSB farmers, Non-CSB farmers, and an aggregate of group of all farmers. Average number of maize varieties grown and average number of sources for maize varieties obtained are written as the mean with the standard deviation in parentheses. Other values are described as (n) followed by frequencies, detailing the percentage of respondents that grew 1, 2, or 3 different varieties of maize and respondents that source maize from 1, 2, 3, or 4 sources respectively. To critically compare values between CSB and Non-CSB households, a Mann-Whitney U-test was conducted to assess the difference in means for both variety and source counts. Fisher's exact test of independence was used to compare proportions of respondents between groups for each category. Significant differences are denoted as: * = $p < .10$, ** = $p < .05$

Overall, source and variety count reveal that the majority of farmers grow more than one variety of maize, and usually obtain their maize seed from multiple sources. These findings are consistent with other studies in SSA documenting smallholder seed sources that report multiple access channels for one crop (Bezner Kerr, 2013; McGuire, 2008; Sperling et al., 2008). However, comparisons between CSB and non-CSB households indicate that the former grow a greater number of varieties of maize from a greater number of sources. Overall, about 86% of CSB members grow more than one type of maize, compared to 56% of non-CSB households (see Table 3). Discussions with the BCI director highlighted this emphasis on diversification: "[at the CSB] we want to be informative rather than instructive, we focus on giving farmers options instead of telling them what to grow or what not to grow" (CSB field day). These observations suggest that by providing access to a multitude of local maize varieties with differing characteristics, the CSB gives farmers a means for on-farm diversification. Interestingly, this emphasis on variation included the adoption of commercial maize. While the CSB did not loan hybrid/OPV seed to farmers, they also did not discourage farmers from growing hybrid/OPV maize along with local varieties.

3.2 Maize seed access

To better understand the complex mechanisms of seed acquisition through formal/informal means, it is important to distinguish between where and how seeds are obtained. This distinction extends into

differentiating between access and availability of seeds: availability is primarily a question of geographical location in a specific space and time period, whereas access is conditioned by the farmer's assets, both monetary and social (Sperling et al., 2008). Therefore, while a certain type of seed might be available through any number of sources, farmers might not be able to obtain it due to access constraints. For example, in Malawi, hybrid/OPV varieties are commercially distributed and are available at agro-input stores for purchase with cash and/or a coupon obtained through the Farm Input Subsidy Program (FISP) (see Appendix I). Depending on the price of the hybrid variety and the relative demand, the coupon may only cover part of the cost of maize seed. In some cases, representatives from the agro-input stores will travel to rural areas with a limited selection of seed to exchange for coupons, as many villagers cannot afford the transportation to travel to commercial areas. These types of arrangements pose financial constraints that limit the farmers' ability to choose the type of hybrid/OPV seed they desire. It was observed that geographic isolation coupled with seed costs also motivate farmers to recycle their hybrid seeds, which can degrade seed vigor and thus expected production output (Nordhagen and Pascual, 2013; Smale and Jayne, 2003). In this way, hybrid/OPV seeds become incorporated into informal seed exchange networks. Yet unlike local seeds, farmers reported that family and community members will generally expect compensation for sharing hybrid/OPV seed stocks (only 8% of hybrid seeds were gifted, compared to about 27% of local seeds). As one village elder noted, "*hybrids are too expensive. Now, you can't share the seeds you bought because you only buy enough for your land. Your neighbors will send you to the shop if you beg them for more than a cupful of seed*" (KI Interview). This quote suggests that the pathways in which hybrid/OPV varieties circulate through informal networks of seed exchange are perhaps less fluid than those of local varieties, as their monetary value is transferred from the commercial sphere.

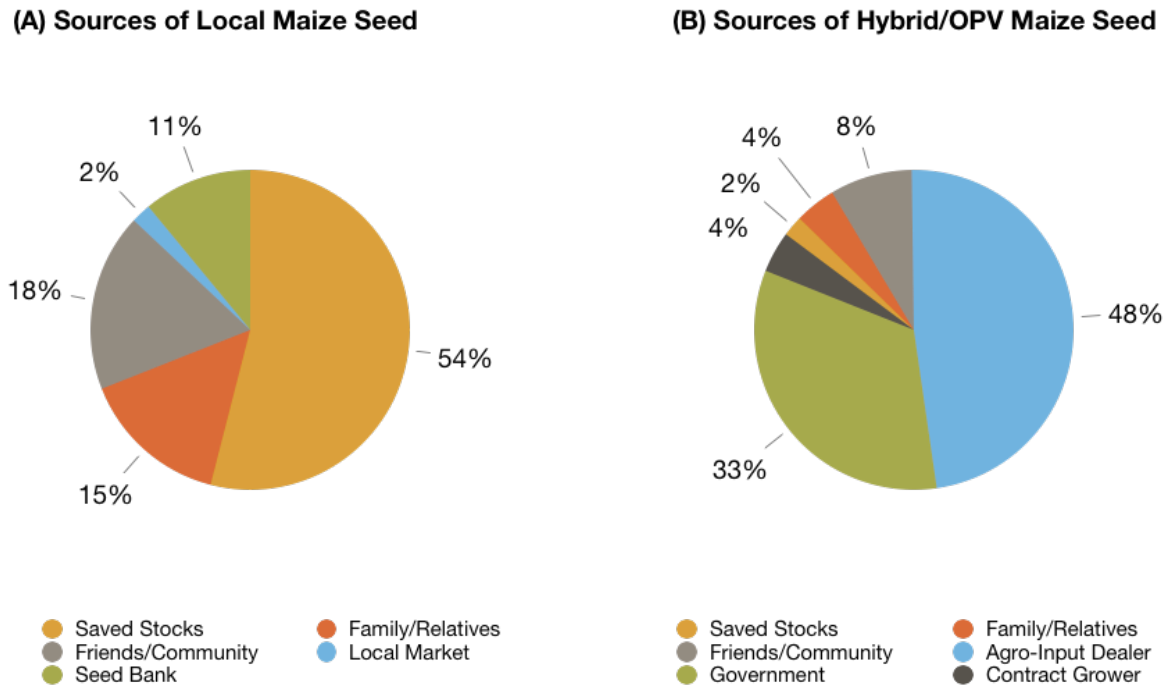


Figure 3. Sources of Maize Seed

Figure 3. Sources indicated by farmers for local and hybrid/OPV maize varieties that were planted during the 2018/2019 growing season.

Saving seeds from the previous harvest is a common practice in farmer-seed systems across most of SSA. Farmers have direct control over the selection of seeds of known quality; these interacting processes of human and natural selection produce cultivars uniquely suited to local environments (Almekinders et al., 1994;

Nordhagen and Pascual, 2013). Households interviewed in Northern Malawi confirmed the persistence of this tradition, with the large majority of local seed having been sourced from home-saved stocks or gifted from family or community members (Figure 3). Though official data was not recorded for each household, many farmers who reported cultivating home-saved maize have been recycling the same seed for decades. While less than 2% of farmers' local maize was sourced from the local market, almost 6% was purchased, which suggests that in some (though seemingly uncommon) instances, villagers purchase local seeds from other community members (Figure 4).

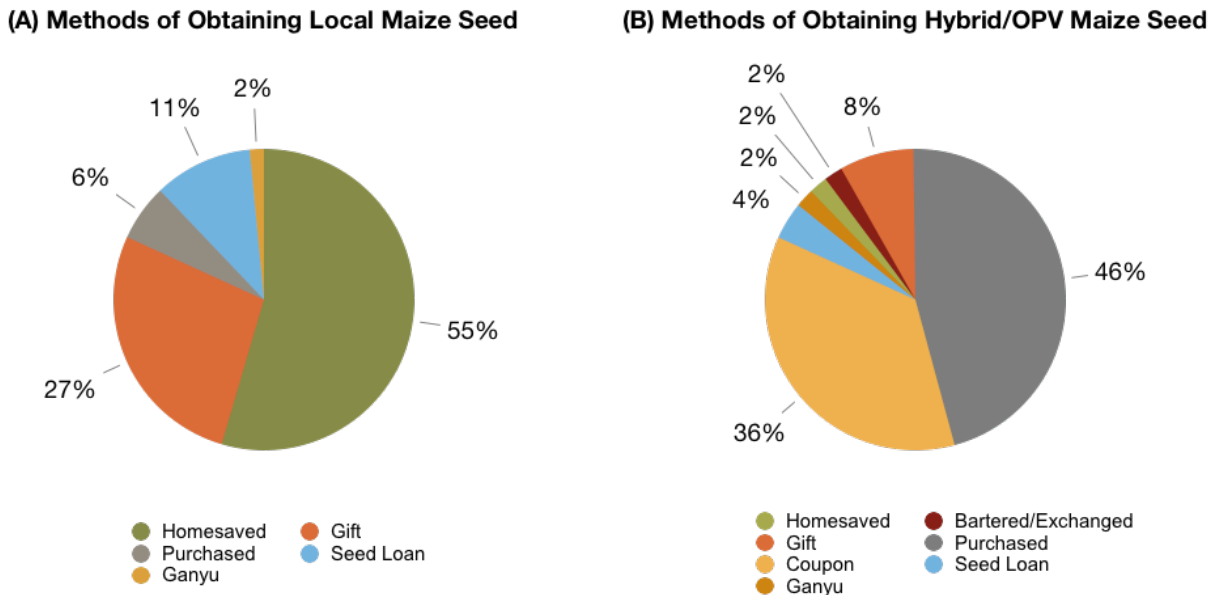


Figure 4. Methods of Obtaining Maize Seed

Figure 4. Methods indicated by farmers for obtaining local and hybrid/OPV maize varieties that were planted during the 2018/2019 growing season.

Of the 60 farmers that were interviewed in Rumphi and Mzimba, 54 (90%) reported desiring a seed variety they cannot access. These farmers were then asked about the varieties they desired, where they could normally find such varieties, and what makes these seeds difficult to obtain. To identify trends and potential discrepancies between CSB and non-CSB farmers, Figure 5 presents both aggregate response data and a comparison between household groups. 91% of farmers reported at least one type of hybrid seed as desired but inaccessible (no OPV varieties were mentioned in response to this question). The constraints for accessing these varieties is relatively uniform across household groupings, as the Mkombezi CSB does not store hybrid/OPV seed. Farmers often view commercial maize (commonly referred to as *boma* "government" maize) as agronomically superior and consider shops as the only reliable source for quality seed. As one farmer explained, "*Your yield will be low if you plant shared [commercial] seed"* (Semi-structured interview). These adverse attitudes towards sharing hybrid/OPV help regulate the seeds to the commercial sphere. The principle barriers faced by all interviewed households are therefore primarily financial and logistic; prohibitive seed prices and transportation costs (both monetary and physical) for long-distance travel prevent farmers from purchasing hybrid/OPV seed.

Coupons from the FISP are intended to help farmers reduce these constraints to accessing commercial seed. Yet while 36% of farmers reported using a coupon to purchase hybrid/OPV seed for the current growing season, 33% of respondents had never even received a coupon in the last 5 years. It was observed that in a couple of the visited villages, distinguished community members receive a voucher every year while others

have never been a beneficiary. In some of these cases, the village chief has enacted a system where voucher benefits must be divided between households or transferred to new members of the community. It was also observed that within polygamous households, coupons are either shared by all families or given by the husband to his preferred wife. Though the coupon system is exclusively for commercial seeds, the use of the coupons themselves has been integrated into unofficial power structures and seed exchange systems traditionally associated with local seed (see Section 4.1)

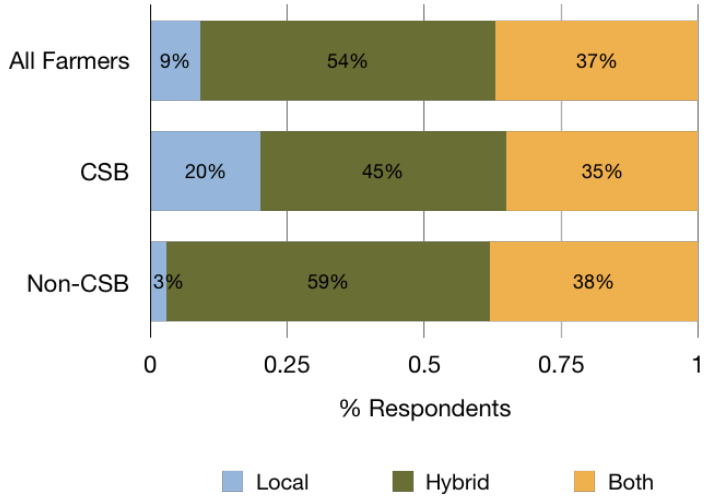


Figure 5. Types of Desired Maize Seed Reported as Inaccessible: CSB vs. Non-CSB Households

Figure 5. Types of desired maize seed reported as inaccessible by interviewed farmers. Specific seed varieties farmers mentioned were categorized by maize type, with "both" indicating that the farmer desired local and hybrid/OPV maize varieties. Results are only available for farmers that indicated having access issues with a certain seed they desired (n = 54). Proportions of responses are presented for CSB households (n = 20), Non-CSB households (n = 34), and an aggregate group of all farmers interviewed (n = 54).

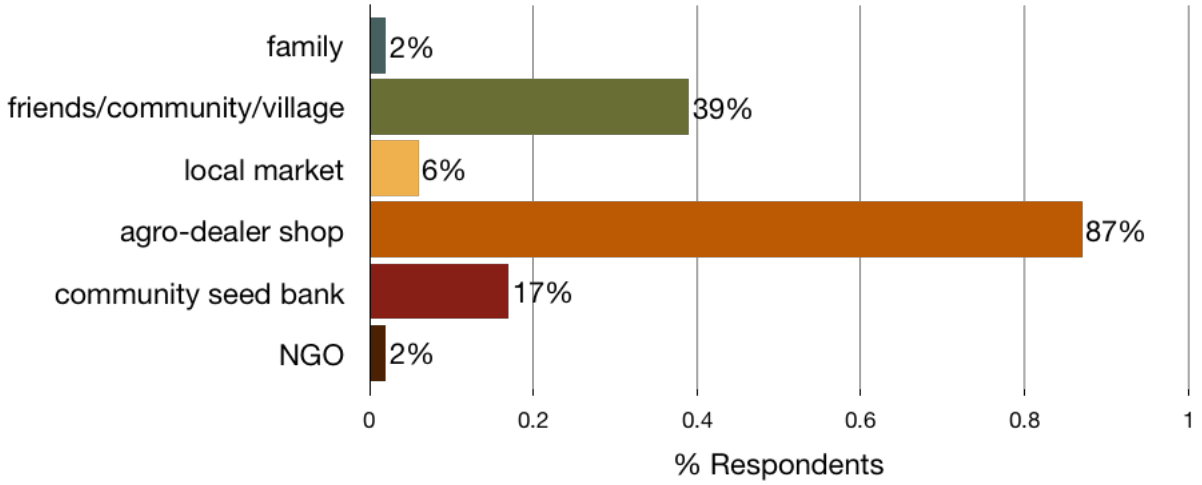


Figure 6. Sources of Desired Maize Seed Reported as Inaccessible

Figure 6. Sources of desired maize seed reported as inaccessible. Note: some farmers listed multiple varieties in response to this question, citing multiple sources for some varieties.

As local seeds are traditionally transferred through informal mechanisms, access issues tend to be more nuanced. Both household groups that expressed desire for local varieties cited friends, the community, and the local market as places where they could find but not access such seeds (Figure 6). When asked what prevented them from acquiring their desired local variety, some farmers cited social barriers such as shyness or not knowing who to ask for seed (Figure 7). In some cases, farmers that struggled to find the desired seed in the village were often geographically situated near other interviewed households that cultivated the sought variety. These instances suggest that limited communication and seed exchanges among community members can hinder farmers' access to preferred varieties. As only 6% of interviewed farmers reported purchasing their local seeds (from family/friends or the local market), it can be assumed that issues arising from social relations pose a greater influence on local seed circulation than financial constraints.

It must be noted that although fewer farmers (44%) mentioned at least one local variety as inaccessible, the majority of these responses (55%) came from CSB members. Some households participating in the CSB cited barriers such as high demand for certain varieties at the bank, or their own late planning in taking out a seed loan (Figure 7). While CSBs can perhaps generate demand for local varieties by exposing members to new types of maize, internal organization issues can prevent sufficient seed multiplication or accurate assessment of demand, barring members from easy access to varieties that are normally available to participants (see Section 4.2).

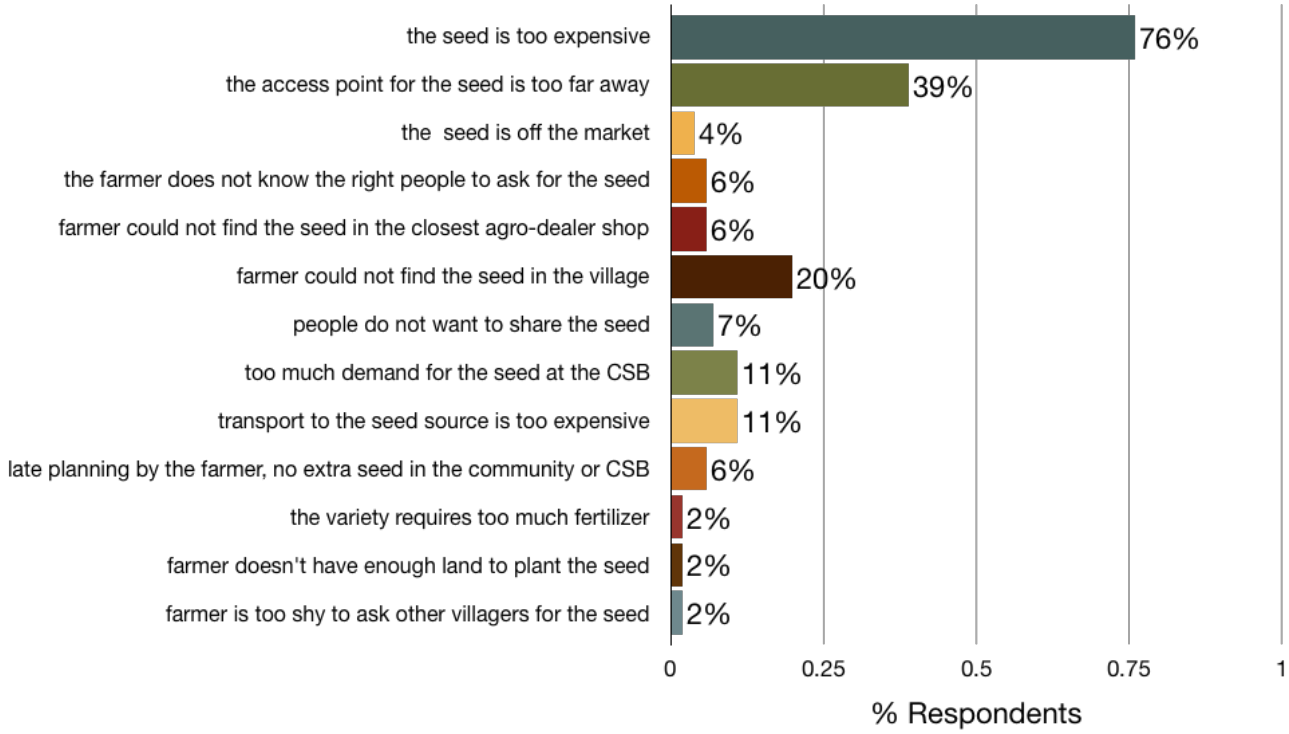


Figure 7. Reasons Given by Farmers for Seed Inaccessibility

Figure 7. Reasons given by farmers for seed inaccessibility (including both hybrid/OPV and local varieties). Principle reasons given by farmers to explain barriers to access were noted and categorized by general trends using qualitative coding. Proportions are derived from the total number of farmers that indicated they wanted a specific maize variety they could not access (n = 54).

The social reasons cited in Figure 7 also point towards a larger cultural shift in behaviors surrounding seed transactions. In Malawi, a general decline in seed sharing between friends and kin has been observed due to an increased reliance on commercial seed production and monetary income to cover costs of living (Bezner Kerr, 2013). Indeed, both CSB and non-CSB farmers expressed reluctance when asked if they felt comfortable asking family or community members for maize seed. Though this discomfort was not shared by all respondents, positive and negative responses were generally clustered by village, indicating that norms surrounding seed sharing are dependent on social relations within specific communities. In the course of discussions about seed acquisition, some farmers lamented what they saw as a loss of seed sharing culture among family members and communities. When asked about the root of this change, one elderly woman remarked:

> *"People can't just give away seed. People know money. If you ask your neighbor for seed, they ask how much money you carried with you. A long time ago, people could love one another, they could share without demanding money. Now, money is essential."* (Semi-structured interview).

She was not the only farmer to mention the cultural changes accompanying the shift to a monetary economy, a transition that slowly permeated rural areas following Malawian independence. Older respondents recalled "*a time when people shared with each other without demanding money*" (Semi-structured interview). Conversely, younger respondents usually described purchasing seeds from neighbors as a longstanding practice. For example, one young woman remarked, "*Here, we have always had to buy seed. But we help one another – if I grow enough maize I can sell to my neighbor so they don't have to pay for transport or walk to the town, which is far*" (Semi-structured interview). In this case, selling seed was not perceived as an unfriendly gesture, but rather a way to help other community members. Monetizing seed transactions also seems linked with degrees of inter-community trust. As one man summarized, "*Before it was easier to share seeds with each other, but now you can't rely on your friends to give you quality maize, just shops*" (Semi-structured interview). Coomes et al. (2015) echoes these observations by stating that "seed exchanges are transacted bearing in mind the potential social costs and benefits of sharing material and information, as well as the trustworthiness of the parties involved." Such calculations are arguably extended into decisions surrounding what types of seeds farmers seek from their communities. For example, when asked why she grows local maize, a woman simply replied, "*Local maize stays in the family"* (Semi-structured interview). Home-saving and family exchanges, two practices linked with local maize, are interactions that can strengthen inter-generational ties and reaffirm notions of cultural heritage. However, it seems that as seed transactions continue to be incorporated in local economies, smallholders are placing greater confidence in commercial seed providers than other farmers outside of their family sphere. Therefore, while not all respondents believed seed sharing to be a bygone custom, these observations show how shifts in social relations, the degree to which a community member can love and trust one another, are inextricably tied to behaviors surrounding seed access.

3.3 Patterns of Seed Adoption

To understand why farmers desire certain types of seeds over others, interviewed households were asked to score the varieties they had planted in the 2018/2019 growing season for eight agronomic and organoleptic traits. The scores for each variety provide an indication of the farmer's satisfaction with their planted maize varieties across different characteristic categories. To examine how CSB participation influenced farmer evaluations of their maize varieties, two analyses were conducted based on aggregate scores for local and hybrid/OPV varieties. Although the specific varieties grown by each household were recorded (see Appendix IV), scores were grouped by maize type for simplified comparison and to minimize errors in self-reporting (see Section 2.3). Aggregate groups also eliminate possible errors in specific maize variety recollection, as

some farmers were unable to recall the commercial or local name of the maize crops they cultivated. Recycled hybrids, though only reported in a few cases, are grouped with hybrids as farmers generally perceived them to be of the same quality as purchased hybrid seed.

Table 4. CSB and Non-CSB Farmer Evaluations for Hybrid and Local Varieties

		Seed Quality	Maturation Period	Yield	Drought Tolerance	Storability	Poundability	Taste	Color	Overall
CSB	Local	1.95	1.79*	1.45	1.39**	1.84**	1.97**	1.97**	1.97**	1.79**
	Hybrid/OPV	1.66	1.50*	1.47	0.84**	1.00**	1.30**	1.23**	1.56**	1.32**
Non-CSB	Local	1.88	1.92	1.72	1.62	2.00**	2.00**	2.00**	1.95	1.89
	Hybrid/OPV	1.79	1.70	1.79	1.58	1.91**	1.82**	1.82**	1.99	1.78
All Farmers	Local	1.91	1.87**	1.62	1.53	1.94**	1.99**	1.99**	1.96**	1.85**
	Hybrid/OPV	1.74	1.63**	1.67	1.31	1.57**	1.63**	1.60**	1.84**	1.61**

Table 4. Evaluations of local and hybrid/OPV maize varieties for CSB farmers, Non-CSB farmers, and all farmers surveyed. For each group of respondents, average local and hybrid/OPV scores for maize are compared across characteristic categories. All farmers were asked to rate their local or hybrid/OPV maize varieties in each characteristic category on a scale of 0 = poor, 1 = average, and 2 = good. Significant differences between hybrid/OPV and local maize scores for each household group/maize characteristic were calculated using a non-parametric Mann-Whitney U test are noted as follows: * = $p < .10$, ** = $p < .05$ Note: The "overall" score for each category is derived by calculating the average of all scores across all characteristic categories as a general indication of satisfaction for each variety (local and hybrid/OPV) for each household surveyed. The average of these overall scores is calculated for each variety grouping for all survey participants and the sub-groups of CSB and Non-CSB households. In some cases, scores for categories such as Storability, Poundability, or Taste had slightly less responses and thus less available data, as farmers had not harvested the maize and could not report on post-production qualities.

Table 4 examines how farmers evaluated their local and commercial maize for eight different traits, with significant differences between scores for hybrid/OPV and local maize marked for each household group and all farmers. Overall, farmers gave local maize higher scores than hybrid/OPV maize for all post-production characteristics, including: storability, poundability, taste, and color. Local maize was also rated higher for maturation period, signifying that farmers were generally more satisfied with the expected growth rate for their local varieties. These findings are consistent with other studies evaluating farmer preferences for different aspects of local landraces and hybrid/OPV maize in Malawi (Bezner Kerr, 2013; Lunduka et al., 2012; Snapp et al., 2019) in which the former are generally found to have superior post-production qualities than commercial maize. Interestingly, in the areas where hybrids are generally marketed by the government and seed companies to be superior, such as seed quality, yield, and drought tolerance, there exist no significant differences in farmer evaluations. Such trends suggest that while farmers might seek commercial seed to increase production, they do not always find hybrids/OPV as satisfactory in practice.

Evaluations of local vs. hybrid/OPV maize remained relatively consistent across household groupings, with only a few key differences, in part due to slight climatic variations between study areas. During the weeks in which fieldwork was conducted in Rumphi district, a long drought had severely affected agricultural production. Interviewed farmers in this area therefore made critical evaluations based on how their maize was performing under these extreme climatic conditions. As the majority of Rumphi district interviews were conducted with CSB members, the CSB household grouping indicates a notable difference between hybrid and local maize scores for drought tolerance and maturation period, with landraces scored more favorably. Indeed, scores from CSB households show greater overall satisfaction with local maize than commercial. These results are particularly notable given the drought conditions, suggesting that CSB households grew local maize that was perceived as agronomically superior in times of climatic stress.

Table 5. Comments by Maize Variety Grouping

Variety/Grouping	# farmers growing	Type	Positive	# comments	Negative	# comments
Lokolo	31	Local	it takes less flour to make *nsima* than hybrids; you get less bran and more pure flour when you pound the grains by hand or at the mill	25	easily affected by drought	9
			it does not need storage chemicals; late application of storage chemicals is okay; the grains are not attacked by pests in storage	24	low yield, especially with poor rains	4
			very sweet; makes very good *nsima*	9	late maturing	2
Kafula	13	Local	early maturing, short stalks	11	small cobs	3
			good poundability - produces a lot of flour ("you go to the mill with a tin of grain and you return with a tin of flour")	3	grains too small	1
			very sweet; very tasty when roasted	2		
Bingo	5	Local	you can pound the grains by hand; uses less flour to make *nsima* than hybrids; you get less bran and more pure flour when pounding grains	5	late maturing	2
			stores well, does not need immediate storage chemical application	4	not drought tolerant	2
			good yield, big cobs	2		
Seed Co. Hybrids	16	Hybrid	good yield	7	too much bran at the mill, less pure flour (grains are too soft)	6
			drought tolerant	2	easily attacked by pests in storage	4
			big cobs with a small core and big grains	3	poor taste ("tasteless")	2
Dekalb Hybrids	14	Hybrid	good yield	6	needs storage chemicals	7
			big cobs	5	not drought tolerant	3
			early maturing	3	attacked by field pests	2

Pannar Hybrids	9	Hybrid	good yield	4	attacked by pests in storage - needs immediate chemical application	5
			early maturing	2	poor taste	3
			drought tolerant	2		

Table 5. Farmer comments pertaining to different maize varieties they grew in the 2018/2019 growing season. Comments were transcribed and categorized by trend using qualitative coding. Trends were organized by variety grouping and divided into generally positive or negative comments for each type of maize.

Such trends are also evident in the comments farmers gave pertaining to what they liked/disliked about their maize crops. Table 5 illustrates how farmers generally praised local varieties for their post-production qualities but cited struggles with drought or low yields. Commonly grown hybrids were noted for their high yield but criticized for their pest-susceptibility while in storage. This is largely due to the degrees of grain hardness present in dent hybrids compared to local Malawian maize, which typically are flint varieties. Dent grains have higher soft starch ratios than their flint counterparts, and are thus more susceptible to pest attacks in storage and are more difficult to pound manually (Kydd, 1989). Although the grain hardness of specific commercial varieties was not asked from interview respondents, it can be assumed from the comments that farmers were generally less satisfied with the poundability or storability of their hybrid/OPV maize than that of their local varieties, two characteristics linked to grain hardness.

Table 6. CSB and Non-CSB Farmer Evaluations for Hybrid and Local Varieties

		Seed Quality	Maturation Period	Yield	Drought Tolerance	Storability	Poundability	Taste	Color	Overall
Local	CSB	1.95	1.79	1.45*	1.39	1.84**	1.97	1.97	1.97	1.79*
	Non-CSB	1.88	1.92	1.72*	1.62	2.00**	2.00	2.00	1.95	1.89*
	All	1.91	1.87	1.62	1.53	1.94	1.99	1.99	1.96	1.85
Hybrid/OPV	CSB	1.66	1.5	1.47**	0.84**	1.00**	1.30**	1.23**	1.56**	1.32**
	Non-CSB	1.79	1.7	1.79**	1.58**	1.91**	1.99**	1.82**	1.99**	1.78**
	All	1.74	1.63	1.67	1.31	1.57	1.63	1.60	1.84	1.61

Table 6. For each type of maize, CSB and Non-CSB household evaluations are compared across characteristic categories. All farmers were asked to rate their local or hybrid/OPV maize varieties in each characteristic category on a scale of 0 = poor, 1 = average, and 2 = good. Significant differences between CSB and Non-CSB maize scores for each maize type/maize characteristic were calculated using a non-parametric Mann-Whitney U test and are noted as follows: * = $p < .10$, ** = $p < .05$ Note: The "overall" score for each category is derived by calculating the average of all scores across all characteristic categories as a general indication of satisfaction for each variety (local and hybrid/OPV) for each household surveyed. The average of these overall scores is calculated for each variety grouping for all survey participants and the

sub-groups of CSB and Non-CSB households. In some cases, scores for categories such as Storability, Poundability, or Taste had slightly less responses and thus available data, as farmers had not harvested the maize and could not report on post-production qualities.

To illustrate differences in how CSB and non-CSB households evaluated hybrid and local maize varieties, Table 6 compares average scores by each household grouping for both local and hybrid/OPV maize respectively. For local maize, few significant differences are evident in evaluations based on CSB participation outside of yield and storability. However, hybrid/OPV maize was scored much more favorably by non-CSB participants than CSB participants across almost all characteristic categories, except for seed quality and maturation period. These results indicate that CSB members are more critical of commercial varieties and are generally less satisfied with their hybrid/OPV maize performance in the field and after harvest. Given that both household groups faced similar barriers and opportunities to access hybrid maize (as both study areas were the same distance from major markets and agro-dealer shops), such results point to the influence of CSB participation on farmers' perceptions of maize performance. One reason for this could be that the CSB experimental plots allow farmers, regardless of whether they grow the variety themselves, to critically compare the performances of a large range of maize varieties. CSB members therefore might have an expanded frame of reference; though learning about the varying potentials of many local varieties, respondents are perhaps better equipped to make critical evaluations of commercial maize.

Discussions with members about why they participate in a CSB yielded several strong response trends, one of which is "knowledge exchange." Many farmers mentioned discovering new seed varieties (both maize and other crops) at the CSB and using the live seed bank as a place to compare how certain maize seeds perform under different conditions. Other farmers provided anecdotes about finding unfamiliar maize varieties on exchange visits or practicing new storage techniques for certain types of maize that they now use at home. At the field day in Mkombezi, a BCI fieldworker toured demonstration plots with participating farmers, describing the distinctive traits of certain local maize varieties and field management strategies. Farmers were then encouraged to have a group discussion about what they had learned. For many members, these events provided invaluable opportunities for farmers to learn from both field experts and each other. As one man explained, "*Here we learn how to live in a community. We learn a lot about the qualities of different maize types and share our field methods for taking care of different crops."* In general, member testimonies cited "learning about new varieties," "new farming and seed storage techniques," and "exchange visits" as primary reasons why they joined the CSB. These response trends indicate that farmers are eager to participate in the social services offered at the CSB. Therefore, by creating a space that facilitates farmer-to-farmer exchange, the CSB can give smallholders the tools they need to make informed decisions on which seeds to obtain and cultivate.

When asked why they grow maize, farmer responses followed several prominent themes: "for food security/to avoid hunger," "to make *nsima* (porridge made from maize flour)," and "it's a source of income if you have excess" (see Appendix V). These primary justifications were confirmed when farmers were asked to list their top three most important maize traits. Here, the most popular answers were poundability, yield, and taste (Table 7). Overall, these responses indicate high value placed on productivity, which can lead to and larger stores of maize and potentially increased income, and post-production appeal, the facility of pounding and preparing enjoyable meals with the maize harvest. When results are separated by CSB and non-CSB households, responses differ slightly by household group. CSB members notably prioritize storability and poundability more than non-CSB members. These slight differences reveal how CSB participation can alter how farmers perceive and value their maize varieties. Perhaps by having greater exposure to a multitude of local varieties that exhibit more desirable storability and poundability characteristics, CSB participants are more likely to

attribute greater value to post-production traits. Heightened preferences are also likely due to the central role that storage plays in seed bank operations.

Table 7. Most Important Maize Characteristics: CSB vs. Non-CSB Members

(A)

All Farmers (n = 60)	
Maize Variety Characteristic	Frequency of Responses
Poundability	**37 (62%)**
Yield	**34 (57%)**
Taste	**30 (50%)**
Seed Quality	25 (42%)
Drought Tolerance	23 (38%)
Storability	19 (32%)
Maturation Period	12 (20%)
Color	0 (0%)
Total Responses: 180	

(B)

CSB Members (n = 21)	
Maize Variety Characteristic	Frequency of Responses
Poundability**	**17 (81%)**
Storability*	**10 (48%)**
Yield	**10 (48%)**
Taste	9 (43%)
Seed Quality	6 (29%)
Drought Tolerance	6 (29%)
Maturation Period	5 (24%)
Color	0 (0%)
Total Responses: 63	

(C)

Non-CSB Members (n = 39)	
Maize Variety Characteristic	Frequency of Responses
Yield	**24 (62%)**
Taste	**21 (54%)**
Poundability**	**20 (51%)**
Seed Quality	19 (49%)
Drought Tolerance	17 (44%)
Storability*	9 (23%)
Maturation Period	7 (18%)
Color	0 (0%)
Total Responses: 117	

Table 7. These tables compare responses from farmers when asked about which three maize characteristics were the most important to them when selecting a maize variety to grow. As a response, farmers were asked to select three characteristics they had used in evaluating their maize varieties. The results indicate how many times each characteristic was selected as important for interview participants. To evaluate the differences between proportions across CSB (B) and Non-CSB (C) respondents, a Fisher's exact test of independence was conducted to compare proportions for each characteristic. Significant differences between groups are marked as follows: * = $p < .10$, ** = $p < .05$

Table 8. Drivers for Adoption and Discontinuation of Maize Varieties

Reasons for Adoption	Frequency [% (n)]			Reasons for Discontinuation	Frequency [% (n)]		
	All	CSB	Non-CSB		All	CSB	Non-CSB
variety has high yield	50 (24)	29 (5)	61 (19)	yield was disappointing	38 (13)	54 (7)	29 (6)
farmer had coupon	33 (16)	35 (6)	32 (10)	grain was attacked by pests in storage	32 (11)	23 (3)	38 (8)
farmer wanted to experiment with hybrid seed	29 (14)	18 (3)	35 (11)	poor poundability	24 (8)	38 (5)	14 (3)
seed was gifted	25 (12)	24 (4)	26 (8)	farmer could not afford to buy new hybrid seeds	21 (7)	8 (1)	29 (6)
saw the variety in a friend's field	23 (11)	18 (3)	26 (8)	variety was affected by drought	18 (6)	23 (3)	14 (3)
variety is early maturing	21 (10)	24 (4)	26 (8)	variety was late maturing	15 (5)	8 (1)	19 (4)

variety is drought tolerant	19 (9)	24 (4)	16 (5)	farmers ate seed intended for home-saving	12 (4)	15 (2)	10 (2)
it was the only seed available	13 (6)	12 (2)	13 (4)	cobs and/or grains were too small	8 (3)	8 (1)	10 (2)
farmer saw/heard advertising for the seed (signs, radio)	8 (4)	0 (0)	13 (4)	taste was poor	6 (2)	8 (1)	5 (1)

Table 8. Results are presented as frequencies followed by the number of farmers who gave that specific response. Frequencies are derived from the total number of farmers that adopted a new seed within the last 5 years for each category and the number of farmers who discontinued a seed within the last 5 years. For adoption: all farmers (n = 48), CSB (n = 17), Non-CSB (n = 31). For discontinuation: all farmers (n = 34), CSB (n= 13), Non-CSB (n=21). Note: Farmers often mentioned multiple reasons for adoption and continuation, and thus responses were recorded across several thematic categories.

Why farmers choose to adopt and discontinue maize varieties also reflects their tendency to prioritize certain maize variety traits. According to farmer interviews, one of the principal reasons for seed adoption and discontinuity is perceived and realized yield (Table 8). Preference for traits linked with production, such as early maturation and drought tolerance, were also mentioned. It is important to note that most cultivators of landraces had home-saved their seeds over many seasons, and thus the majority of adopted seeds reported were hybrid/OPVs. As most rural households do not have easy access to a platform to compare commercial varieties (outside of the occasional government-sponsored field day), these perceptions are largely the result of informal exchanges among community members. In interviews, most respondents that adopted new commercial seed attributed their decision to friends or family who already grew the variety in question, saying "*I heard this variety has high yield*" or "*I saw this variety in a friend's field and I admired the big cobs*" (Semi-structured interviews). Yet as hybrid seed must be purchased every year, it is commonly regarded as the "rich person's,", "modern," and/or "business" maize. Due to these positive associations, some farmers expressed feeling pressure to adopt and cultivate commercial seed. As one woman remarked, "*I am satisfied with my local maize yield, but I have seen my friends use hybrid maize for business and I felt like I had to try it myself, but I was not satisfied"* (Semi-structured interview). Such anecdotes point towards the potential for social pressure to distort the benefits of certain maize varieties, resulting in disparities between expected and actual results during cultivation.

Farmers that chose to discontinue certain varieties also did so due to production concerns: disappointing yields and poor drought tolerance (Table 8). While organoleptic traits did not factor into reasons for seed adoption, prominent reasons for variety discontinuation also include poor storage, poundability and taste. Overall, these reasons highlight how values concerning both productivity and edibility dominate in decisions concerning adoption and discontinuation of maize varieties. When comparing this same data between CSB and non-CSB households, similar priorities prevail. Yet it seems that while fewer CSB members were adopting varieties based on projected yield than non-CSB farmers, they were more likely to discontinue varieties based on disappointing yield. CSB members seem also more likely to discontinue varieties based on poor poundability and drought tolerance when compared to non-CSB members. For non-CSB members, the price of hybrid seeds factored larger as a reason for discontinuation, having been mentioned as frequently as disappointing yields. These results suggest that while generally all farmers share similar motivations for seed adoption, CSB members seem more likely to discontinue varieties based on dissatisfaction with qualities that they value (such as yield and poundability), rather than financial limitations.

4. Discussion

The above findings, though rooted in a specific time and place, illustrate the complex interactions between formal and informal maize seed systems; these results also show how access to a CSB can influence how farmers participate in these systems. The following section will examine these results within the enabling social and political environment of Northern Malawi. In this framework, CSBs will be evaluated as a tool for increasing formal and informal seed system complementarity.

4.1 Maize Seed Systems: Malawi's Enabling Social and Political Environment

In Malawi, maize seeds are a sociopolitical currency, an instrument and symbol of power. For the farmers interviewed in this study, the role of maize seems to transcend sustenance. As one woman summarized, "*Maize solves life's problems. If you have maize, you are a boss"*(Semi-structured interview). For these households, the exchange and propagation of maize seed is intricately woven into the fabric of social relations, where a tin of maize seed is a cherished gift to newly married couples, sick loved ones or visitors. These gifts strengthen social bonds among and between generations and are often accompanied with knowledge on seed-selection and variety propagation. However, not everyone is included in these networks of seed transfer. Wealth and connections, often determined by customary village power structures, condition access to seed. Those on the fringes of a community, such as tenant farmers, orphans or those with socially stigmatized health problems (such as HIV) usually cannot benefit from these types of seed exchanges (Bezner Kerr, 2013). In Northern Malawi, interviewed village chiefs in both Mzimba and Rumphi districts cultivated more varieties of maize over a larger expanse of land than other farmers. A study mapping social seed networks in Ghana found similar seed access disparities based on kinship ties, with migrant families being excluded from traditional farmer-to-farmer seed exchange (Ricciardi, 2015). Discussions with farmers also provided insight on how household structure impacts processes of seed transfer and exclusion. It was observed that polygamy, a persistent practice in the rural villages of both Rumphi and Mzimba districts, can determine different levels of seed access for women depending on their wife status, leading to seed access inequalities within households[4].

The local power dynamics and social norms that underpin how farmers access seed are far from static; agricultural policy, environmental degradation, conflict, and economic globalization (among other exogenous factors) affect how community behaviors surrounding seed. For example, in Northern Malawi, over recent decades commercial maize has been integrated into traditional seed exchange networks through the distribution of government-subsidized maize seed vouchers. The most recent and far-reaching voucher distribution program (FISP) is orchestrated by the Ministry of Agriculture in collaboration with local village chiefs and Village Development Committees based on several beneficiary criteria targeting "the productive poor" (Lunduka et al., 2013). However, studies evaluating the impact of FISP have found that households in districts that had higher levels of popular support for the ruling political party received more subsidized seed and fertilizer than other households (Lunduka et al., 2013). These loose regulations and minimal oversight also result in subsidy politicization at the local level. Often, the distribution of vouchers within villages follows the same partial pathways as traditional seed circulation practices. Chibwana et al. (2010) support this notion with their FISP impact study, finding that poor households were less likely to receive vouchers than non-poor households; they postulate that households with higher levels of education and longer residency in the village have greater bargaining power with local leaders. As discussed, villages visited within this study exhibited

[4] Data on polygamous households was not collected during the fieldwork. Though gendered access to seeds was not a principal focus within this project, other studies have more detailed findings on how gender determines farmer participation in formal/informal seed systems, addressing disparities in land and input access, agrobiodiversity knowledge, and seed decision-making (Bezner Kerr, 2013; Fisher and Kandiwa, 2014; Ricciardi, 2015).

methods of voucher distribution that retrace the same partial pathways as traditional seed circulation practices (see Section 3.1). While the management of the vouchers was almost always in the hands of local leadership, village chiefs sometimes enacted sharing systems to ensure all coupons received within the village were split among the residents. These cases, though exceptional, are notably contrary to policy analysis that questions the validity of the FISP's "targeted" distribution program through highlighting abuses of local authority (Ricker-Gilbert et al., 2011). Therefore, depending on local power structures, the integration of commercial seed vouchers into traditional seed transfer practices can either exacerbate or ease existing exclusionary processes in community seed exchange.

As evidenced by farmer testimonies, social relations and power dynamics also play into decisions surrounding maize seed adoption. As discussed in Section 2.4, the analysis of adoption employed in this context is inherently limited due to the cross-sectional nature of the study. Though degrees of exposure or familiarity with the adopted technology could not be measured, farmers were asked to discuss seeds they had grown in the last 5 years to provide a more in-depth temporal perspective of their cultivation history. A large majority of the varieties adopted by interviewed households in the last 5 years are hybrid/OPV, as most farmers growing local varieties home-save their seed. As observed, farmers often choose to adopt maize seeds based on perceived production potential and base their decisions on what they hear from friends or see growing in their community (see Section 3.3). Though variety evaluations showed that farmers were generally less content with the post-production qualities of commercial seeds, farmers still seem to appreciate their monetary value and association with modernity. On the contrary, local seeds were more generally associated with tradition, and in some cases, poverty. By linking the cultivation of hybrid/OPV maize with a higher social status, farmers can more easily fall victim to social pressure. This is not to infer that the decision to adopt commercial varieties is uncalculated or purely a product of influence, or that the result is inevitably negative. In fact, high levels of inter-community communication and social cohesion can help farmers learn which commercial varieties grow best in their specific agro-climate. In some interviews, farmers even mentioned splitting the cost of commercial seed with a friend after they had seen others growing it in their village: an adapted version of seed sharing and exchange. Though research on social relations and seed supply primarily focuses on local seeds (Coomes et al., 2015; McGuire, 2008; Ricciardi, 2015), it can be assumed that the networks governing the spread of information on commercial seed performance are subject to similar exclusionary processes affecting traditional practices of seed and knowledge transfer.

Relying on community members for hybrid/OPV seed recommendations can also result in the spread of misinformation regarding seed quality and performance. While farmer-to-farmer exchanges might influence maize adoption patterns and, as observed in this study, encourage the adoption of hybrid/OPV maize, it was also noted that the perceived benefits of a maize variety can outweigh the results in practice. Interestingly, the majority of the interviewed farmers had recently adopted new commercial seed, yet preference evaluations for maize types show greater satisfaction with local seed across both production and post-production parameters. Dissatisfaction with both production and post-production qualities also factored into reasons for variety discontinuation. Such findings suggest that for some farmers, their commercial seeds did not perform as expected. A study on seed choice in Zambia finds similar discrepancies between advertised and realized variety potential concerning hybrid/OPV seeds, and attributes these adoption patterns to the availability of information on seed performance as well as the cultivation of homogenous seeds in heterogenous agro-environments (Waldman et al., 2017). It should also be noted that seed companies play an active role in advertising hybrid/OPV seeds, promoting their products through collaboration with government extension agencies. Bombarding farmers with information through billboards, radio ads, field days, packaging, among other outlets can also lead to confusion regarding the plethora of varieties and their various traits (Waldman et al., 2017). These findings point towards a need for more accurate and inclusive information dissemination on commercial

seed. Measures to integrate formal and informal seed systems therefore must consider the influence of seed companies, social relations and local power dynamics regarding practices of seed adoption.

4.2 The Role of Community Seed Banks

The above discussion uses the study findings to give an overall assessment of maize seed systems in Northern Malawi, addressing how the formal seed system has been integrated into aspects of traditional (informal) seed exchange within the local socio-political context. The following two sections will explore the role of the Mkombezi CSB within this framework and assess its potential as a sustainable and scalable institution to improve seed security through formal/informal sector complementarity.

Access and availability of maize seeds was not notably impacted by seed bank membership as households typically obtain maize seeds from a variety of sources. While the bank's seed loan and multiplication scheme increased the availability of local varieties, high demand for some of these varieties limited access for households that were late to procure a loan. At the time of the interviews, it was unclear whether these limited supplies were due to miscalculation of local demand or technical issues experienced during seed multiplication/storage. However, it is noted that for most community seed banks, acquiring the necessary land, water, and human capital for adequate seed management, processing, and storage poses a challenge for bulk seed production and quality assurance (Vernooy et al., 2015). No technical guidelines exist yet for determining the resources necessary for producing specific quantities of seed for different crop varieties; greater member outreach and location-specific seed multiplication guides and could be a way to help CSBs better calculate and respond to demand for certain popular varieties, both maize and other crops. Overall, it seems that these organizational issues did not prevent the "late" farmers from obtaining local maize seed altogether, as households often participated in networks of seed sharing and/or home-saved their stocks. The cultivation of local varieties is intertwined with traditional practices of seed exchange, sharing and home-saving. This is perhaps why a large part of the interviewed seed bank members (58%) did not source maize from the CSB. Furthermore, all of the farmers that did source maize from the CSB also grew varieties acquired from other sources such as friends/family, or home-saving, indicating that members did not exclusively rely on the CSB for their maize seed supply.

The specific functions of the CSBs all over the world are largely determined by the social and political contexts from which they emerge. While most CSBs fall under the general definition of "community-based storage of seeds and grains that are distributed to farmers as a loan and payback system," (Nyantakyi-Frimpong, 2019), they usually offer a range of auxiliary services that extend beyond seed preservation. For example, in addition to seed storage rooms, the Mkombezi CSB has both a conference space and a small library. Members collaborate with BCI to host events such as farmer field days, community gatherings, exchange visits, and workshops on climate-change, gender, and teamwork. The CSB chairperson also coordinates with vendors to provide a market outlet for smallholder producers, encouraging members to form cooperatives in order to meet production quotas and receive fair market prices. While it is easier to quantify CSB impact on maize seed access through tracking loan and payback exchanges, participation in these events and use of these services also seems to influence patterns of maize seed adoption, notably what types of maize farmers grow and what characteristics they prefer. As discussed in Section 3.3, members are generally eager to participate in these social events at the CSB facility. Such opportunities capacitate smallholders to make educated decisions through exposure to distinct local varieties and their respective field and storage management techniques. As noted by Waldman et al. 2017, patterns of seed adoption are affected by the availability of information on seed performance and the facility of smallholders to access this information. In this case, it was found that CSB members favored local maize over commercial, showing lower levels of satisfaction for hybrid/OPV maize than other farmers. These findings indicate access to a CSB expanded the farmers' frame of reference by

providing members with (a) a variety of seeds that meet a diverse set of preferences, (b) a platform for education and experimentation and, (c) a means to exchange with other farmers' outside their normal sphere of interaction and communication.

The latter benefit has become increasingly salient in an era of changing norms around seed sharing and exchange. As observed through interviews, attitudes towards giving away seeds can shift depending on village customs. Levels of trust among friends and community members seemed to inform where and how farmers obtained their seeds. According to Coomes et al. (2015), "communities with weak social networks have been shown to be vulnerable to adverse conditions because of constrained access to locally adapted seed, compared to those with strong social networks." As observed in Mkombezi, CSBs can strengthen local social relations by encouraging farmers to gather and exchange ideas, practices, and genetic material. Such events have the potential to increase community cohesion through shared learning that serves to increase mutual trust among members; farmers can directly observe seed production at the CSB and in their fellow farmers' fields and can therefore take part in quality assurance. This is particularly important given the observed severity of droughts in the Rumphi region, which were reported to have increased in longevity and intensity due to climate change. The pressure of extreme climatic conditions seems to have pushed members to make critical evaluations of their maize variety performance, reinforcing the necessity for farmers to be able to access seeds with greater drought tolerance and desirable maturation period. Although farmers might not singularly rely on the seed bank to access these types of seeds, CSBs can indirectly improve seed access by acting as a social nexus in communities, breaking down the social barriers that can inhibit seed exchange. Increasingly these types of institutional approaches to addressing climate shocks are becoming favored over traditional processes of seed aid, which can risk undermining seed system resiliency through providing new or mal-adapted varieties in inappropriate agro-environments, compete with local seed enterprises, or increasing farmer dependency on outside interventions (McGuire and Sperling, 2013). By encouraging informal seed exchange while serving as a repository for local germplasm, CSBs can provide a type of seed aid that extends beyond provision of materials by encompassing and ultimately strengthening existing socio-ecological systems.

However, as member-based institutions that are partially funded by participation fees, CSBs are inherently exclusive. Their potential to strengthen social ties extends only as far as their accessibility to all members of the community. As bottom-up institutions, CSBs are not divorced from local social relations and power dynamics. In Mkombezi, a majority of the CSB's 82 members live within 2-4 kilometers of the seed bank within the valley, save for a group of members from a mountain village located 5-6 kilometers away. These farmers participate from a distance, making less frequent trips to the storage facility and attending only obligatory meetings. To compensate, these members had established a small experimental plot in the mountains to test CSB-sourced varieties in their local agro-climate. Members made up a sizable portion of the village population. Yet when non-CSB farmers in the area were asked about barriers to participation, they described an exclusive process of existing members choosing new members. To them, CSB membership is conditioned by having relatives down in the valley. For example, one farmer described how the chief of their village had a son in Mkombezi. After becoming a member, he proceeded to choose families in his village that were permitted to participate in the CSB. The farmers excluded from this process were interested in learning more about the CSB but limited by distance and lack of affiliation with village leadership. This particular example evidences how CSBs, like other village-level institutions, are embedded in local political hierarchies. Farmer anecdotes on this subject speak to the importance of evaluating the efficacy of an institution in its specific socio-political context. Nyantakyi-Frimpong (2019) touches upon this imperative in her evaluation of seed banks in Northern Ghana, finding the micro-politics of resource access and control to be crucial to the success or failure of CSBs. Reisman (2017) also cautions against romanticizing the idea of community-based institutions as inherently more "trusted, equitable, and efficient" than larger-scale operations. In this case, the potential of the Mkombezi CSB to deliver socially equitable benefits is limited by the partiality exercised by local leadership. Measures

to expand access in the surrounding area must address these disparities by facilitating information dissemination through impartial networks and promoting a culture of acceptance among participants to reach a more diverse membership.

4.3 Community Seed Banks as a Tool for Rural Development

As a relatively recent phenomenon in decentralized development, CSBs are commonly characterized in scholarly literature as centers for *ex-situ* agrobiodiversity conservation, established with the goal of protecting and regenerating lost crop diversity for disaster relief (Feyissa, 2000; Thornton et al., 2018; Wajih, 2008; Wiggins and Cromwell, 1995). Yet when evaluated for their efficacy as an intervention, CSBs are usually critiqued for their limited scalability and financial dependence on external agencies (Lewis and Mulvany, 1996; Thornton et al., 2018; Westengen et al., 2018; Wiggins and Cromwell, 1995). Recent case studies on different CSBs around the world challenge this narrative by providing examples of institutions that both (a) facilitate a wide range of auxiliary activities, building institutional legitimacy through community engagement and (b) collaborate with other seed banks and larger institutions to reach a greater population (Vernooy et al., 2015). Economic sustainability remains the biggest challenge for many CSBs, especially those without an enabling policy environment. However, both this case study and others from around the globe suggest that using local human and social capital to create networks and foster economic empowerment can help CSBs gain legitimacy and remain effective in the long term.

Vernooy et al. (2014) classifies CSBs based on the following primary functions: (1) Conservation of genetic resources, (2) Enhancing access and availability of diverse local crops, (3) Ensuring seed and food sovereignty. The potential of a CSB to expand its role beyond that of a local *ex-situ* seed storage facility (classification 1) is largely a question of the legal and policy environment in which it operates. As most CSBs are concerned with the development and dissemination of local seed, there is often conflict with national seed policies that prohibit the distribution of unregistered varieties in non-emergency contexts (Westengen et al., 2018). However, in some countries, current policies and laws support farmer-led efforts to safeguard local agrobiodiversity and protect traditional seed production and exchange. For example, in Brazil, three states (Paraiba, Alagoas an Minas Gerais) have created supporting legal frameworks for the implementation of CSBs maintained by smallholder farmer associations, supported by NGOs and local governments (Santilli, 2015). In Burundi, CSBs in the Kirundo province are recognized as registered associations and are supported through the provincial investment plan for the agriculture sector (Ngendabanka et al., 2015). In Nepal, the government is beginning to adopt policies more favorable for CSBs; the recent Seed Vision 2025 and Agrobiodiversity policies give credit to CSBs through facilitating greater community-based seed production and capacity-building among farmer groups for the conservation and sustainable use of agriculture genetic resources (Chaudhary et al., 2015). These policies exemplify how CSBs can be incorporated and recognized by legal frameworks. Yet in many of these types of cases, challenges remain concerning proper support and implementation, especially in countries with high levels of government turn-over that convolutes bureaucratic processes.

Regardless of whether the CSB is directly engaged in food sovereignty activities, official recognition and legislative provisions that support farmers' rights over seed are essential for the long-term survival of CSBs in any country. In Malawi, the recently released National Seed Policy stops short of declaring farm-saved seed illegal but does not provide any support to informal seed systems or the organizations that work within them. This poses a challenge to the longevity of CSBs in the Rumphi region; while interviewing the chairperson of the Mkombezi CSB, he cited maintaining institutional credibility as the biggest issue in the absence of external funding. Without the backing of an NGO (in this case, BCI with the Development Fund of Norway), he feared members would not feel obligated to pay back their loans. While his seed bank is internally managed by a

committee of local members, authority ultimately rests with the external source of funding and expertise. At this moment, member fees are the only source of revenue. Meanwhile, BCI provides agronomic training and contributes pesticides/fertilizers for the experimental plots, while also helping with the funding and organization of thematic workshops (KI interview). According to the Mkombezi chairperson, their presence encourages good teamwork between the members. These concerns point towards the need for increased human and social capital. Shrestha et al. (2015) asserts that "the process of farmers working together and participating in activities strengthens their capacity for collective action and…shared responsibility for resources, risks, and benefits." In this case, BCI has laid the groundwork for an institution deeply embedded in traditional practices of seed sharing and exchange, while also introducing new concepts of gender equality and teamwork to strengthen internal cohesivity. Leadership roles and decision-making are managed by internal committees, and through BCI field days and workshops, technical expertise is being transferred to the membership. As discussed, the Mkombezi seed bank is a social node for farmer exchange within the community. As BCI continues to capacitate the members through programs aimed at conservation, access and availability, and food sovereignty, the CSB might gain greater legitimacy in the eyes of the community.

In the absence of a supportive political environment, institutional collaboration and regional networking can also increase the breadth of CSB operations and expand impact. For example, eight CSBs in the north of Mali have formed a formal network that frequently partners with CSB networks in southern Mali to support the conservation and exchange of local varieties through seed fairs, visits and exchange workshops. These networks are also allow for the cultivation of varieties in multiple agro-climates, preserving seeds that might have otherwise disappeared in area-specific climatic events, such as a drought or flood (Goïta et al., 2015). Partnerships with national gene banks also contribute to more robust institutions. Once unique to the formal seed system, collaboration agreements between CSBs and gene banks has increased due to new emphasis on decentralized, participatory development practices to conserve and augment agrobiodiversity (Westengen et al., 2018). In Uganda, for example, a team working with Biodiversity International sourced bean seeds with good climate adaptation potential from national and international gene banks to use in participatory field trials with farmers at the seed bank. The resulting varieties were evaluated by farmers for their climate resilience as well as other important characteristics and later incorporated into the CSB's collection of germplasm (Vernooy et al., 2016). Extending the network of a CSB through these types of strategic partnerships can provide new opportunities for supplementing the *in-situ* genetic diversity within the surrounding village farms with new, preferred crop varieties. Institutional collaboration is also a way for CSBs to scale up impact through networks of knowledge and germplasm exchange.

In Northern Malawi, BCI currently manages five seed banks in Rumphi district that frequently cooperate for exchange visits and workshops. In discussions with CSB members, many emphasized the benefit of using the CSB as a platform for networking, increasing their knowledge about the diversity of crops and different farming techniques. While none of BCI's CSBs have any formal connections to national or international gene banks, there are informal agreements with public extension services and traditional leadership. Seeking greater support from public institutions could be a strategy for strengthening BCI's CSB network and expanding its impact over a larger area. Closer collaboration with government divisions and research organizations in seed bank operations could also give the CSBs greater institutional legitimacy in the eyes of its members. Indeed, a previous study on participatory governance in Malawi shows that those involved in extension platforms generally support farmer-led, bottom-up institutions as a way to involve citizens in democratic processes and to provide services adapted to local conditions (Álvarez-Mingote and McNamara, 2018). However, participatory institutions (such as CSBs) require high levels of collaboration between trained public officials and motivated citizens to increase participant welfare. Establishing partnerships with extension services could also help the CSB expand its crop profile to include OPVs bred through public breeding programs, thereby improving complementarity between informal and formal seed systems. Lastly, coupling these efforts with

strategies to increase economic returns (through seed sales to non-members, group marketing schemes, etc.) would improve the financial independence of the seed banks and permit an eventual transition to autonomy. Overall, observations from this fieldwork indicate that the scalability and sustainability of CSBs are not bound by the physical size of the facility. While the Mkombezi CSB cannot yet become independent from external funding, its embedded position within the local seed system and socio-political framework shows great promise for long-term institutional sustainability.

5. Conclusions

In Northern Malawi, the circulation and cultivation of maize seeds are the lifeblood of the local culture, politics, and economy. Farmers obtain maize seeds through a multitude of social and economic channels, with a single farmer usually cultivating multiple varieties from distinct sources. Despite the extensive use of maize seed and fertilizer vouchers under the FISP, access and availability of commercial maize seeds is restricted by financial and geographic circumstances. Local varieties are usually home-saved by the family or obtained through informal mechanisms of seed exchange. Hybrid/OPV seeds enter these informal community networks but are often traded at a price. In these cases, both local and commercial seed access and availability are largely conditioned by social capital, including levels of community inter-communication, trust, and seed exchange.

Maize variety evaluations indicate that smallholder farmers distinguish between local and commercial maize; respondents generally preferred local varieties that they can access through informal systems when scoring production and organoleptic characteristics. However, these distinctions did not extend into the realm of field management. Despite growing multiple maize varieties for different purposes, most interviewed farmers did not prioritize field pesticide or fertilizer application based on maize type. One of the main factors influencing maize variety adoption is perceived and realized yield, while variety discontinuation is usually due to dissatisfaction with both production and organoleptic qualities of the maize in question. Overall, despite widespread interest in commercial seed, informal mechanisms of exchange and local varieties dominate maize seed systems in Northern Malawi. While participation in both formal and informal seed systems is conditioned by local politics and social norms, access to commercial seeds is especially influenced by exclusionary processes determining wealth and social status within the community. This is in part due to the politicization of FISP voucher distribution.

Following the FAO's expanded definition of seed security, seed system interventions must consider farmer preferences and needs when attempting to improve availability and access to quality seed. The CSB in Mkombezi was selected as a focus of study to assess its potential to strengthen informal and formal seed system complementarity by providing farmers with varieties that contain qualities generally lacking in commercial seeds. It was found that the CSB increases the availability of several prominent and diverse local varieties, even if farmers did not exclusively rely on the CSB as a source for maize. Issues with internal organization occasionally limited access of certain seeds in cases of high demand. Farmers that participate in the CSB showed lower levels of satisfaction than non-CSB farmers for commercial seed, and greater preference for maize with good post-production quality. This indicates that access to a CSB can perhaps expand a farmers' frame of reference and influence patterns of seed adoption. Overall, member testimonies on CSB participation were overwhelmingly positive, farmers especially appreciated the benefits of the seed bank's auxiliary services: marketing to vendors, center for workshops, and a platform for knowledge exchange through field days and exchange visits.

These findings illustrate how the Mkombezi CSB bolsters the local informal seed system through increasing the availability of desired local varieties while acting as a social nexus for the exchange of knowledge and

germplasm. By reinforcing the social ties that underlie informal seed systems and encouraging the cultivation of a diverse array of desirable maize varieties, the Mkombezi CSB improves seed security for participating farmers. Indeed, involvement in the CSB could be augmented with greater impartial outreach to surrounding villages. Increased collaboration with government and public research institutions could further help the CSB improve formal/informal system complementarity, although this also requires actors within the commercial system to recognize and validate traditional means of seed production and exchange. Overall, given its realized and potential benefits for smallholder farmers as one of several seed banks in the region, the Mkombezi CSB is on a positive trajectory to accrue the necessary social, human, and financial capital to expand its impact and become a self-sustaining institution. This case study is intended to encourage future research directed at evaluating the potential of CSBs as viable agriculture development interventions; as CSBs continue to emerge around the globe, their impact could be assessed through the lens of nutritional security, on-farm biodiversity, or livelihood diversification, among other relevant foci. Most importantly, greater validation of CSB projects through such research and development initiatives can also promote the use of informal and formal seed system complementarity as a metric for assessing seed security.

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7. Appendix

I. Historical Background: Maize in Malawi

Since the arrival of European settlers and missionaries in the late 19th century, maize has played a central role in Malawi's narrative of agricultural development. The crop gained prominence as a consequence of colonial-era agrarian restructuring; plantations were established around the production of tobacco, cotton, coffee and tea, while a peasant subsistence economy persisted with limited production of cash crops on marginal land (Vaughan, 1982). Large-scale agricultural enterprises soon monopolized arable land and available labor. In the North, men were often required to migrate to Southern Rhodesia or South Africa to work on European estates, which forced them to simplify their own on-farm production (Bezner Kerr, 2013). As a result, farmers began prioritizing maize; compared to other staple grain crops, maize had higher returns to land in most agro-ecological conditions, greater potential for genetic variability, and was favored for export by the British starch market (Smale et al., 2011; Vaughan, 1982). Even with the increased emphasis on maize production, the British settlers actively discouraged the production of local maize varieties, which they saw as of inferior genetic quality to imported hybrids from the U.S., Zimbabwe (at the time Northern Rhodesia), and South Africa (Smale and Jayne, 2003). After World War II, the British promoted the cultivation of these improved varieties as part of a campaign to modernize African agriculture, introducing extension programs, seeds, credit and subsidized inputs (Bezner Kerr, 2013). In Malawi (as in other southern African states) these trends commodified maize as a central food crop in the country's political economy, setting the stage for post-colonial agricultural policies that fostered the later privatization and monopolization of the maize seed industry.

Government-sponsored maize research began in the 1940s/50s using genetic material from Malawi, Mexico and Zimbabwe to produce hybrids of white maize. Originally, the public breeding program had several key requirements for the hybrids, "(i) that the maize should be flint (or as near as possible)[5], (ii) cobs should be low-carried to reduce lodging in often termite ridden soils, (iii) rust resistance was important for the hot, low altitude areas, (iv) husks should cover cobs to protect against birds and insects, bearing in mind that farmers preferred to dry the grain in the field" (Kydd, 1989). This multi-objective program aimed to produce maize appropriate for Malawian agro-climates and farming practices, while providing a higher-yielding alternative to local varieties. However, the development of such varieties was ultimately limited due to a tumultuous political climate following Malawi's independence in 1964; the maize research program suffered from staffing changes, inconsistent funding, and internal discord.

Agricultural policies in this period were centered around estate development, causing breeding programs to neglect smallholder preferences and prioritize export-oriented production (Harrigan, 2003). While estate owners promoted publicly funded maize research, their interests lay in producing maize as a secondary commercial crop or to feed field laborers (Smale, 1995). The importation and development of high-yielding maize hybrids for the estate-sector therefore became the priority for the post-colonial government, which implemented the parastatal ADMARC (Agricultural Development Marketing and Research Corporation) marketing boards to manage seed and fertilizer distribution and purchase smallholder crops (including tobacco, groundnuts, and beans along with maize) at rural depots (Bezner Kerr, 2013). Research has found that the monopolistic extension support, credit, and marketing services provided by ADMARC were ultimately more beneficial for commercial agriculture, with surpluses financing further estate development (Harrigan, 2003).

[5] During this period, the majority of modern maize bred by international seed companies were dents or semi-dents due to their ease of processing with modern roller mills (Kydd, 1989). Dent grains have higher soft starch ratios than their flint counterparts, and lower flour to grain extraction when making the refined flour for the staple porridge dish *nsima*. (Kydd, 1989; Smale and Jayne 2003).

Furthermore, this national marketing monopoly kept prices artificially low for smallholder farmers selling their maize and tobacco crops, while estate-owners could negotiate directly with international buyers (Kydd and Christiansen, 1982). Overall, government promotion of commercial agriculture at the expense of smallholders effectively set up a 'dual' economic structure resting on the efficacy of state-run agricultural, financial and marketing institutions (Peters, 2006).

In the late 1970s, growing interest from donors in improving smallholder maize yields encouraged greater investment and international collaboration in maize research. While estate interests had previously shifted the national research program's focus to dent production for easier large-scale processing, at this time new emphasis was given to the production of semi-flint OPVs, which breeders saw as more appropriate for smallholder consumption (Kydd, 1989). However, research and development initiatives were again stunted by a fiscal crisis stemming from the government's estate-centric export strategy. After a wave of exogenous shocks exposed the vulnerability of the country's dualist economy, the Malawian government turned to the IMF and World Bank for Stabilization and Structural Adjustment Loans (Harrigan, 2003; Peters, 2006). Such measures mandated cuts to public expenditures, such as the national breeding program, rural ADMARC facilities, and fertilizer subsidies (Peters, 2006). During this period, maize price liberalization had also caused the public maize marketing system to collapse; all of these factors contributed to a food crisis in 1987 (Peters, 2006). This succession of economic and institutional failures eventually pushed the government to break with the IMF and World Bank, reinstating an interventionist approach to improving food security through focusing agricultural spending on input-support programs (Bezner Kerr, 2013; Harrigan, 2003).

The first of such initiatives, called the Starter-Pack Program (SPP), was opposed by USAID and the World Bank, and even seen by some donors as welfare and/or a short-term move for political gain (Peters, 2006). The subsidy, which provided smallholder recipients with a small package of fertilizer, hybrid maize seed and legumes, saw an increase in maize production shortly after implementation. This initial success led to the subsequent development of the SPP into the donor-backed Targeted Inputs Programme (TIP), which was seen as less of a welfare program due to its limitation on beneficiaries (Smale et al., 2011). These programs were initiated while the Malawian government transitioned from an autocracy to a multiparty democracy in the mid-1990s, the ripple effects of which generated greater political instability and market liberalization. During this regime the World Bank and the IMF had also pressured the government to sell off their grain reserves in favour of financial reserves, using foreign exchange earnings instead of food storage to improve food security (Peters, 2006). All of these factors saw Malawi shift from self-sufficiency in maize production to becoming import-dependent. The subsequent food crisis, compounded by extreme climatic events and corruption within the government, led to successive food crises between 2000-2005 (Chinsinga and Poulton, 2014).

The relative inefficacy of TIP during this period, in concurrence with a change in government leadership, instigated the launch of the most recent subsidy initiative called the Farm Institute Subsidy Program (FISP). This large-scale program provides coupons for subsidized fertiliser and improved hybrid maize seed (and at some points OPVs) to about 2 million of Malawi's 2.7 million smallholder farming households (Lunduka et al., 2013). Recipients are chosen in a lottery and can theoretically choose between OPV and hybrid maize varieties, although the number of hybrid seeds available under the subsidy (compared to OPVs) rose from 60% to 90% within the first 5 years of implementation (Arndt et al., 2016). This is partially because several influential donors disapproved of the use of OPVs, citing lower production rates than hybrids. Chinsinga (2011) also posits that the government favours hybrid seed over OPV subsidies as a more powerful political vehicle, a quick way to address food security through the provision of modern, high-yielding varieties. Overall, the dissolution of the public-sector breeding programs during this period of market liberalization created a nationwide dependency on multinational seed companies for the majority of hybrid seed supply; currently, Monsanto, Seed Co., Pannar Seed, and Pioneer own 90% of the seed market. Therefore, the onset of input

subsidy programs instigated a new level of public-private collaboration, with multinational seed companies reaping the benefits of a guaranteed market (Chinsinga, 2011).

A wealth of recent literature examines the efficacy of the FISP in supporting levels of commercial maize adoption and production over the last 15 years with mixed findings. In terms of production, the program was initially hailed as an overwhelming success; within the first year of the program, Malawi was producing surplus maize and said to be leading the way to a new Green Revolution for Africa (Chinsinga, 2011; Sachs, 2012). The program gained widespread donor support as a "smart subsidy" program, fostering development of the commercial sector by increasing demand for products at a discounted price (Ricker-Gilbert et al., 2011). The FISP was intended to promote modern maize and fertilizer adoption by allowing smallholder farmers to experiment with small quantities of seed. Indeed, studies show that participants in the program increased adoption of hybrids, such as drought tolerant maize, and overall allocated more land area to improved maize cultivation (Chibwana et al., 2012; Holden and Fisher, 2015). Substantial impacts were also seen with female-led households, in which adoption of improved maize varieties reportedly increased 222% through the subsidy program (Fisher and Kandiwa, 2014).

However, discrepancies exist between government reports on maize production rates and household-level data, indicating that the impact of the program on production, while positive, is perhaps less than what official statistics show (Lunduka et al., 2013). In fact, recent analyses show that official reports overestimated true post-FISP yield gains and that any increases in production can largely be attributed to population growth (Messina et al., 2017). These conflicting results extend to reports on how the FISP impacted adoption rates of hybrid/OPV maize and chemical inputs; lower overall levels of adoption of hybrid maize has been reported in Malawi, even in comparison to other countries in SSA (Lunduka et al., 2012). Some authors that acknowledge these lower-than-expected production and adoption statistics identify operational problems within the FISP as the principle cause. Such issues include: biased input distribution based on political motives and social customs, insufficient amounts of fertilizer given relative to seed, and diversion and leakage issues (Chibwana et al., 2010; Lunduka et al., 2013; Ricker-Gilbert et al., 2011). While these studies also call for a more comprehensive assessment of the program's effectiveness, they do not call for more comprehensive solutions to addressing stunted commercial seed adoption rates, or question why these rates are stunted in the first place. These investigations tend to assume that the improved varieties provided by the FISP are preferred by farmers without considering external factors associated with levels of commercial maize adoption and production. In essence, they tend to overlook the persistence of local maize cultivation and informal seed systems.

The recent update of the National Seed Policy reflects a similar disregard for the informal seed systems currently utilized by a majority of smallholders. According to the policy, the regulations put in place focus on the formal seed system "in order to catalyze productivity improvement by increasing production, access to and the use of improved varieties and high-quality seed" (Government of Malawi, 2018). Local seed is only recognized to the extent that it complies with the same uniformity and stability standards as commercial seed, which is rare as landraces are usually genetically heterogeneous. This "blind spot" for informal systems is recognized by major international organizations and NGOs working in Malawi, such as the FAO and NASFAM (National Smallholder Farmers' Association of Malawi), which are actively engaged in projects to promote alternative mechanisms of seed access (Westengen, 2016).

Overall, the policy environment described here is increasingly supporting top-down commercialization of seed access channels, leaving little room for seed system interventions that foster a bottom-up approach to ensuring seed security for smallholders. CSBs in particular have emerged as an adaptable model for preservation of agrobiodiversity and regional food supplies. As summarized by Vernooy et al. (2015), "beyond this core conservation function, community seed banks have a broad range of additional purposes and vary significantly

in scope, size, governance and management models, infrastructure and technical aspects, e.g. seed collection, seed storage and conservation, documentation and administration." Such versatility renders CSB institutions largely unsuitable for broad analysis, and the majority of literature on their establishment, evolution and sustainability takes the form of case studies. While CSBs have been criticized for their lack of scalability, their global prominence and multifunctionality shows promise for improving farmer seed access in a variety of local contexts. In the case of Malawi, the enabling policy environment favors private-sector driven agricultural development. However, given the prominence of traditional farmer seed-exchange systems, it is of interest to evaluate the potential of CSBs to complement, rather than compete with, formal seed sector growth by validating and reinforcing informal mechanisms of seed access.

II. Research Questions

Principle Research Question: What determines access and availability of quality maize seed (as well as patterns of adoption for seeds with desired traits) for smallholder farmers in Northern Malawi, and how are these factors impacted by participation in a community seed bank?

Maize Seed Access and Seed Networks

1.1 How and from where do farmers source their maize seeds?

1.2 What determines access and availability of maize seeds (hybrids, OPVs, local varieties)? What are the principle barriers?

1.3 Why do farmers prefer local vs. hybrid vs. OPV varieties?

1.3.1 How do farmers evaluate and compare agronomic/post-production qualities between hybrid maize seeds, OPVs, and local cultivars?

Seed Preferences

2.1 Is there a difference between what seeds farmers use and what seeds they prefer?

2.1.1 If so, to what extent is this affected by different aspects of access such as affordability, access to social networks, information, socioeconomic status, and gender?

2.1.2 To what extent is farmer satisfaction with their seeds impacted by access to a CSB?

2.2 What varietal attributes are most important to maize farmers (what traits do they prioritize)?

2.2.1 To what extent are these varietal attributes found in hybrid seeds vs. OPVS vs. local cultivars?

2.2.2 Where can farmers find seeds with these desired attributes?

Community Seed Banks

3.1 Why do farmers use/not use community seed banks (CSBs)?

3.1.1. What are the various functions of CSBs?

3.2 How does CSB participation impact how farmers evaluate different types of maize seeds?

3.2.1 How do CSBs impact farmer access to a portfolio of seed characteristics (i.e. multiple varieties or multi-purpose varieties)?

3.3 Do CSBs increase the access/availability of preferred maize varieties for participating farmers?

III. Semi-Structured Interview Guide

MAIZE SEED SYSTEMS INTERVIEW GUIDE

MARCH/APRIL 2019

Informed Consent? YES / NO
(interview, pictures, GPS)

*Interviewer:*_____ *Date:*_____ *Interview #* _____
*Translator*_____

Household Head: yes / no: _____*(relation)* *circle if HH :* *MHH* *FHH* *CHH* *Age:* _____

Sex: M F (circle) *HH size:* *people* *Area cultivated in 2018/2019:* *acres*

*Village*_____ *District :* *Mzimba* *Rumphi* *(circle)*

I. RESPONDENT PROFILE

1. How many adults (age 18 – 65) are in your household? _____
2. Do you live with any elders over 65, or children younger than 17? How many? Elders _____ Children_____
3. Have the following income activities contributed to your household's overall income in the past year **(2018/2019)**? [0 = No, 1 = Yes]

3.1 Production/sale of cash crops		3.5 Regular salary labor	
3.2 Agricultural wage labor (ganyu)		3.6 Remittances	
3.3 Non-Agricultural wage labor (ganyu)		3.7 Self-employed/ small-scale business (private driver, selling products, etc.)	
3.4 Sale of livestock/animal products		3.8 Other: _____	

II. NON-MAIZE CROPS GROWN THIS CURRENT SEASON : (November 2018 - May 2019)

4. For this year's growing season, what are your **three most important non-maize crops** for which you used seed or planting material?

5. Can you tell me about how you accessed the seed of these crops? What about the quality of the seed?

Non-maize crops	**Main sources of non-maize seed:** (WHERE) **list ALL sources** **See codes 1-10**	**How it is acquired** (HOW) **see codes A-K**	**General Seed /Variety Quality? G=good A=average P= Poor (record additional details if given)**

Sources of seed: CODES		**How acquired: CODES**	
1= home-saved/own stocks	6= community seed bank (CSB)	A= save/own stocks	G= seed loan
2= family (kin, parents, in-laws)	7= government	B=exchange/barter	H= food aid
3= friends/neighbors/ community members	8= NGO /FAO	C= gift	I= money credit
4= local market	9= contract growers	D= purchase/buy	J= seed for labor (ganyu)
5= agro-input dealer	10= other (specify)	E= vouchers/coupons (FISP)	K= other (specify)
		F=direct seed distribution	

III. MAIZE

6. On how much of your land do you plant maize (all varieties)? _____acres
7. How many varieties of maize do you grow? _____
8. Who decides what varieties of maize to plant?

9. Who is responsible for managing the maize crop?

10. Do you grow hybrid maize? _____ [0 = No, 1 = Yes]
11. On how much of your land do you plant hybrid maize? _____acres
12. Do you grow local maize? _____ [0 = No, 1 = Yes]
13. On how much of your land do you plant local maize? _____acres
14. Do you intercrop maize with other crops? _____[0 = No, 1 = Yes]
15. What other crops?
16. Can you tell me all of the ways you get your maize seed, and from where? (For the **2018/2019 season)** Fill out table:

Sources of seed planted **list ALL sources** **See codes 1-10**	**How acquired** **see codes A-k**	**Type of Maize (hybrid, OPV, local)**	**Quantity local units**		**Qty (kgs)**
			#	**Unit**	
	Total maize planted:				

17. This season, did you plant more or less maize than usual? Why?

IV. MAIZE VARIETY SUITABILITY

18. Could you tell me each variety of maize you grow, and then rank it for each characteristic?
    0 = poor 1 = average 2= good

Variety Name	Type of Maize (hybrid, OPV, local)	Seed Quality (germination rate)	Maturation Period	Yield	Drought tolerance	Post-harvest storage	Poundability	Taste	Color	Other

Note: What is "good" color to them? what is a "good" maturation period for that variety? Are they satisfied?

19. In general, what characteristics of maize are most important to you? Why?

Characteristic	Why it's important:

20. Are there maize varieties that you wish you could get but cannot? _____ [0 = No, 1 = Yes]
21. If yes, what types of maize? Why those varieties?

22. Why? What makes this seed difficult to access?

23. Where is this seed normally obtained?

24. Do you feel like you can ask your friends/neighbors/community to give you maize seed if you ever need it? _____ [0 = No, 1 = Yes]

25. Why or why not?

V. ACCESS TO NEW MAIZE VARIETIES

26. In the last 5 years, have you ever received /obtained a new maize variety? _____ [0 = No, 1 = Yes]
27. If yes, how and why? (Include source, variety name, and if you are still sowing the variety)

28. In the last 5 years, have you stopped planting certain maize varieties? _____ [0 = No, 1 = Yes]
29. If yes, what are your main reasons for discontinuing these varieties?

VI. MAIZE AND INPUT USE

30. Do you put inorganic or organic fertilizer on your maize? _____[0 = No, 1 = Yes] *(if yes, circle which one)*
31. If so, do you only apply it to certain maize varieties? Or do you apply more to some varieties than others?

32. Do you use field pesticides (chemical, botanical) on your maize? _____[0 = No, 1 = Yes] *(if yes, circle which one)*

    If so, do you only apply it to certain maize varieties? Or do you apply more to some varieties than others?

33. Do you use storage pesticides on your maize? _____[0 = No, 1 = Yes]

    If so, do you only apply it to certain maize varieties? Or do you apply more to some varieties than others?

34. Did you have any post-harvest losses last season? What was the cause? Which varieties?

VII. FARMER INPUT SUBSIDY PROGRAM

35. In the last 5 years, have you received vouchers from the government subsidy program to help purchase seed/fertilizer?_____ [0 = No, 1 = Yes]
36. If yes, how many times have you received a voucher? _____ times
37. What type of hybrid or OPV maize do you receive?

38. In general, how would you describe the quality of the seed you can get through the vouchers? Are you satisfied?

VIII. COMMUNITY SEED BANKS *(if applicable – if not, skip to last question)*

39. Do you know if there is a community seed bank in or near your village? _____ [0 = No, 1 = Yes]
40. If yes, how far away is it? _____km
41. If yes, are you a member of the community seed bank? _____ [0 = No, 1 = Yes]

If yes: (if no, skip to 50)

42. Do you source any of your **maize** seeds from your community seed bank? _____ [0 = No, 1 = Yes]
43. If yes, what types of maize seeds?

44. How many years have you been a member of your community seed bank? _____ years
45. Do you participate in seed storage, production, or distribution activities at the seed bank? _____ [0 = No, 1 = Yes]
46. How do you participate? *(Ask for details)*

47. What are your primary reasons for using your community seed bank? Why did you join?

If no:

48. What are your primary reasons for not using community seed bank? Is there anything that would make joining the seed bank more appealing to your family?

IX. FINAL COMMENTS

49. Why do you grow maize? *(ask for details) Probe: Why is maize important to you? Why do you prefer maize over other crops?*

If possible, ask if we can take pictures of the different maize varieties being grown and record all names of varieties.

IV. Maize Varieties Grown by Interviewed Households

Table 9. Maize Varieties Grown by Interviewed Households

Local	# farmers	Hybrid/OPV	# farmers	Recycled Hybrid	# farmers
Lokolo	31	DK8033 “Mapasa”	9	"Dekalb"	5
Kafula	13	PAN53	9	SC719 “Njovu”	2
Bingo	5	SC403 “Kanyani”	8	SC627 “Mkango”	1
Lokolo/Kamapalapati mix	4	DK8053 “Mkangala”	5		
Lokolo/Kamapalapati/Bingo mix	3	SC719 “Njovu”	4		
Local Orange	3	SC627 “Mkango”	3		
Kamtepatepa	1	“Pioneer”	2		
Bera	1	“Demeter OPV”	2		
		MH18	1		
		MH33	1		
		MH26	1		
		SC537 “Mbizi”	1		

Table 9. Maize varieties reported as planted in the 2018/2019 growing season by interviewed households. Note: names within quotation marks signify common local names for commercial varieties or, in some cases, when the respondent could only name the seed company of their hybrid seed but not the specific variety.

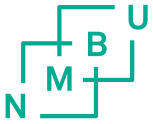
V. Reasons Given by Farmers for Growing Maize

Table 10. Reasons Given by Farmers for Growing Maize

Reasons for Growing Maize	Frequency [% (n)]
source of income, you can always sell the excess	82 (49)
food security (“to be saved from hunger”)	67 (40)
to make *nsima*	50 (30)
it is a tradition	42 (25)
easy access to markets, lots of demand	33 (20)
it is the staple food in Malawi	27 (16)
it gives you energy and makes you full	22 (13)

you can eat maize in many forms, easy to consume at any time	13 (8)
the land is suitable for maize	12 (7)
maize stores better than other crops	8 (5)
it is easy to exchange with neighbors, like a currency	7 (4)

Table 10. Top reasons for growing maize as reported by interviewed households. Answers were often given by the principal respondent with help from family members if they were in the area. Frequencies are derived from the total number of farmers interviewed (n= 60).



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