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Exchange and experimentation: community seed banks strengthen farmers' seed systems in Northern Malawi

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ABSTRACT

In Sub-Saharan Africa, the cultivation of local crop varieties persists despite a political environment that favours commercial seed system development to address seed and food insecurity. Community seed banks (CSBs) are emergent alternative/complementary development initiatives, yet there remains limited empirical research on their role in farmers' seed systems. In Malawi, where maize is a sociopolitical currency, we use maize seeds as a means to examine how CSBs may support farmers' seed systems. Through 60 semi-structured interviews with both CSB members and non-members, we collected quantitative and qualitative data on maize seed access opportunities, farmer preferences, and patterns of seed adoption/discontinuation. Interviews show that while CSBs play a negligible role in farmers' maize seed supply, they can strengthen seed sharing networks through auxiliary social and economic services. CSB members report higher levels of satisfaction with local maize over commercial maize, suggesting CSBs can expand farmers' frame of reference through events that encourage exchange and experimentation. Local power dynamics can affect CSB accessibility; initiatives to expand CSB operations must therefore address the inherent exclusivity of CSBs as membership-based institutions. These findings invite future research on CSB viability and the potential of decentralized development interventions to improve farmers' seed security in Sub-Saharan Africa.

KEYWORDS

Community seed bank; seed systems; sustainable development; seed security; variety characteristics; Malawi

1. Introduction

Seeds are fundamental to food production and seed systems are therefore a central tenet of agricultural development in low – and middle-income countries. The bulk of the support to seed system development from governments and donors is directed at the formal seed sector – the institutions involved in breeding and dissemination of certified seeds of improved varieties (Almekinders et al., 1994; Louwaars & de Boef, 2012; McGuire & Sperling, 2016). In Sub-Saharan Africa, a neoliberal agenda born from structural adjustment measures in the 1980s has shaped the last decades' policies and investments in

agricultural development. Seed system development in particular has favoured market-based solutions (Hambloch et al., 2021; Scoones & Thompson, 2011; Westengen et al., 2019).

Despite the political and financial support for increased marketing of commercial seed (henceforth referring to hybrid or open-pollinated variety [OPV] certified seed from formal breeding programmes and marketed by seed companies), there remains widespread cultivation of local varieties managed in farmers' seed systems. Across Africa, it is estimated that more than 80% of the seeds planted by farmers are obtained from local sources, such as farmers'

saved seed, social networks and local markets (de Boef et al., 2010; Louwaars et al., 2013). With increasing evidence and awareness of the important role of farmers' seed systems in smallholders' seed supply comes heightened interest from international and national actors in exploring alternative avenues of seed system development and seed security¹ interventions (Coomes et al., 2015; Global Alliance for the Future of Food, 2016; McEwan et al., 2021; McGuire & Sperling, 2016; Sievers-Glotzbach & Christinck, 2021; Sperling et al., 2008).

Community seed banks (CSBs) have emerged as a type of local intervention for supporting farmers' seed systems. While CSBs can vary in terms of governance and organization, they primarily serve as a repository of genetic material, including local varieties, and provide farmers with means of diversifying their on-farm production (Andersen et al., 2018; Sthapit, 2013; Vernooy et al., 2015). CSBs often have one or more of three core functions: 1) to conserve local agrobiodiversity, 2) to enhance seed access and availability, and 3) to ensure seed and food sovereignty (Vernooy et al., 2014). With regard to the first two functions, international NGOs have traditionally characterized CSBs as a disaster-relief and/or climate-smart agriculture intervention (Mbow et al., 2019; Nyantakyi-Frimpong, 2019; Thornton et al., 2018). CSBs are however also gaining recognition for their potential to improve seed and food sovereignty through serving as centres of education and knowledge transfer, bases for seed collection, production and exchange, and/or market hubs (Porcuna-ferrer et al., 2020; Vernooy et al., 2014; Westengen et al., 2018). Such versatility renders it difficult to undertake comparative and critical analysis of CSBs. As a result, CSBs are commonly characterized as inherently trusted and effective institutions (Reisman, 2017). The usefulness or relevance of CSBs, which can vary depending on the complexities of the local social and political context, is not often questioned in the discourse around rural development (Reisman, 2017). Though the global adaptability of the CSB model has been well highlighted (Vernooy et al., 2015), there is limited empirical research on CSBs and their impact on seed systems. Given their presumed versatility as locally embedded institutions, it is important to investigate to what extent CSBs can strengthen farmers' seed systems and seed security.

To explore the role of CSBs in a specific context, we conducted a mixed methods case study with smallholder farming communities in Northern Malawi. We

focus on the primary staple, maize (*Zea mays*), using maize seeds as a lens through which to examine how farmers engage in seed systems. Maize is prominent 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 a cultural and political currency; national agricultural policies have consistently promoted the adoption of modern maize seeds and synthetic inputs as integral to improving production and alleviating hunger (Chirwa, 2005; Lunduka et al., 2012; Smale, 1995). The large-scale, government and donor-sponsored Farm Input Subsidy Programme (FISP – revised in 2020 to the Affordable Inputs Programme) favours the distribution of commercial hybrid seed to augment yields, with farmers' seed systems largely absent from official policies and regulations (Chinsinga, 2011; Government of Malawi, 2018; Government of Malawi, 2021).

By comparing CSB members and non-members, we evaluate the potential of CSBs to enhance farmers' seed systems through influencing maize seed access, availability, preferences, and patterns of adoption/discontinuation for both local and commercial varieties. Through conducting 60 semi-structured interviews with individuals within smallholder farming households, we gathered qualitative and quantitative data on 1) the availability of different maize seeds, including the social and financial determinants of seed access; 2) how farmers value seeds based on various agronomic and post-harvest qualities; and 3) how these values inform practices of seed experimentation.

We find that as community-managed centres of seed production, storage, and distribution, CSBs can strengthen farmers' seed systems by increasing access to locally adapted seeds with preferable agronomic and post-harvest qualities. CSBs can also expand farmers' adaptive capacity by supplying members with a variety of seeds. Group events organized by CSB leadership (such as workshops or seed/food fairs) promote social cohesion and seed sharing, and can open up alternative avenues of seed access outside the commercial sphere. By serving as a platform for exchange and experimentation, CSBs can also help farmers develop risk-reducing strategies to manage climate variability. We note, however, that as member-based institutions embedded in local politics, CSBs are not inherently equitable. Access to these benefits is mitigated by physical distance to the CSB,

wealth, and community power dynamics. Lack of political and institutional support also hinders CSB scalability and sustainability; increased networking with government, public research and extension institutions could lead to greater political recognition and support for farmers' seed systems. Overall, through investigating the role of CSBs in a particular socio-political and geographic context, this case study highlights the potential of community-based seed institutions to strengthen farmers' seed

systems and improve interlinkages between farmers' and commercial seed sectors.

2. Methods

2.1. Study area

Fieldwork was conducted in 22 different village areas within Mzimba and Rumphi districts of Northern Malawi (Figure 1). This zone is mid-altitude (1000–1200 m asl) sub-tropical region with unimodal rainfall

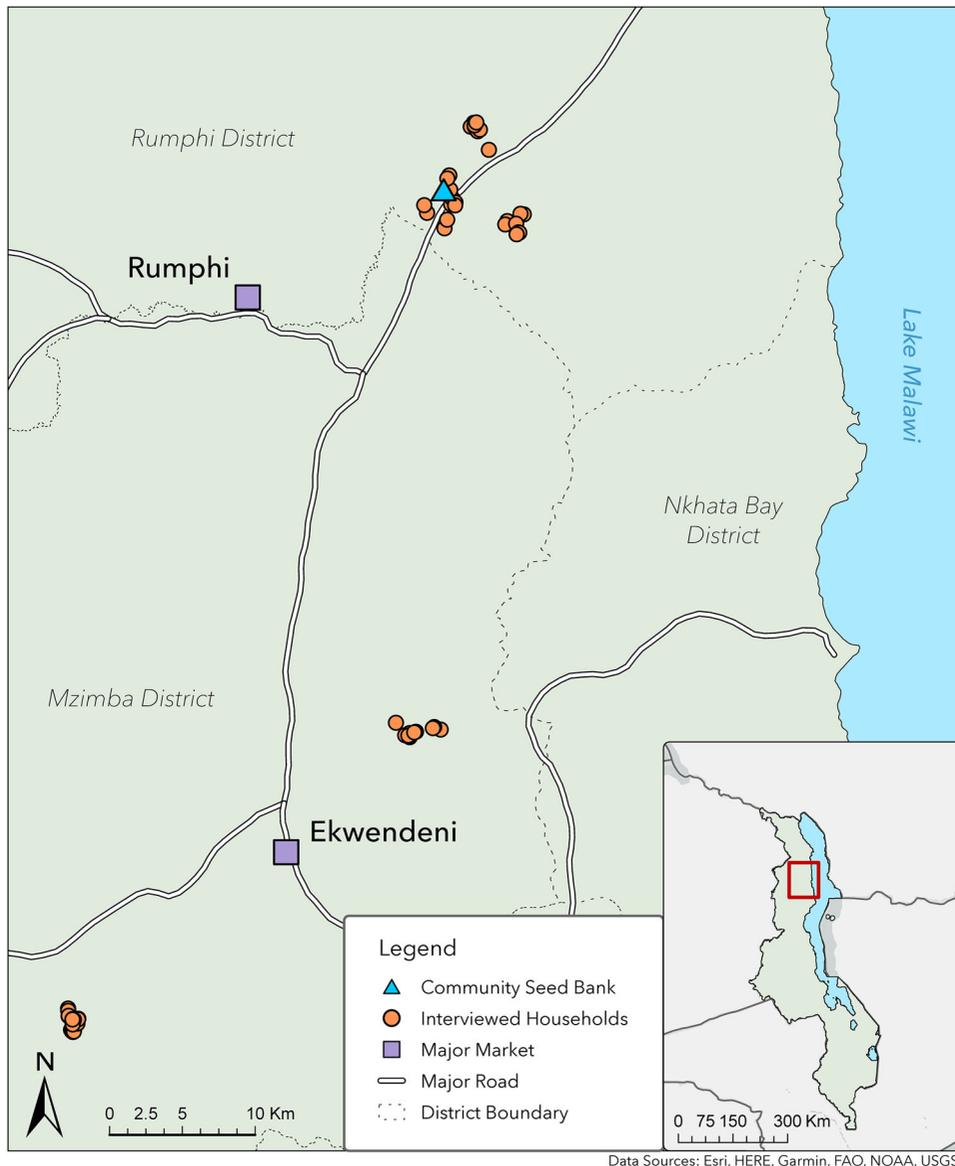


Figure 1. Map of study area. Note: Individual households are marked as clusters to depict the locations of households selected for semi-structured interviews (Source: Authors).

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 can impact agricultural systems across relatively short distances. Smallholder farmers in both regions practice rain-fed agriculture and are therefore vulnerable to unexpected fluctuations in precipitation patterns. 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.

Our case study is centred on the Mkombezi Community Seed Bank (*Image 1*), one of four regional CSBs in Rumphidistrict supported by the national non-profit Biodiversity Conservation Initiative (BCI). The seed bank was built in 2010 and has since attracted 82 members, the majority of which live in villages within a 5 km radius. The seed bank has a room for group meetings, a library, and two seed storage rooms in which seeds are stored in cool, dark conditions. One such room is dedicated to germplasm storage, where local varieties of maize, beans, groundnuts, and other common crop seeds are stocked in small, labelled jars arranged on wooden shelves. The other room contains

large bags of seed resting on wooden platforms; this bulk storage area contains repaid seed loans from the last growing season. Behind the building, seeds are planted for multiplication and demonstrative purposes in small plots (*Image 2*). 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 (Hunduma & Ortiz, 2015).

While BCI fieldworkers help coordinate events and workshops, a local volunteer chairperson and an executive committee oversee day-to-day operations at each CSB. 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. Although BCI describes the CSB as an institution principally occupied with conservation of local agrobiodiversity, they also provide auxiliary services such as: producing and exhibiting farmer-preferred varieties in designated seed multiplication fields, coordinating 'field days,' seed and food fairs with partner CSBs, as well as 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 the CSBs in Rumphidistrict.



2.2. Data collection

This case study focuses on farmer perspectives as the primary source of qualitative and quantitative information, acknowledging the farmers' deep location-specific knowledge of local climate conditions, agricultural systems, social customs, and political practices. This approach seeks to integrate academia with experiential and farmer-derived knowledge in a transdisciplinary fashion to understand better farmers' seed systems, which is done in part by acknowledging the important role of smallholders as the principal actors (rather than simply consumers) within these systems.

The first author conducted fieldwork during March and April of 2019 in collaboration with two national NGOs: BCI and Soils, Food and Healthy Communities (SFHC), an organisation involved in participatory action research with communities in Northern Malawi. The NGOs facilitated researcher access to the CSB and villages within the designated study areas but were intentionally excluded from data collection activities, including household and key informant selection as well as farmer and key informant interviews. The first author conducted 60 semi-structured interviews (averaging 1 h in length) 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. In Mzimba district, 30 households were selected from two different village areas. All study sites had about the same distance to the closest major markets (25 km) in Rumphi and Ekwendeni, respectively (Figure 1). In both districts, we purposefully sampled households to gather perspectives from a pool of farmers with diverse gender, age, and family profiles (Table 1). In Rumphi district, we also sampled households at variable distances from the seed bank, along with a mix of member and non-member respondents (21 members, 9 non-members) to gather data from non-member households within physical proximity to the seed bank. As a result, there are a greater number of non-member respondents overall than CSB member respondents. Longer, in-depth interviews (1–2 h in length) were also conducted with key informants: the Mkombezi CSB chairperson and a village elder from the Mzimba district. These discussions provided information on seed bank operations and a historical perspective on seed sharing practices.

Table 1. Profile of interviewed households by district.

	Rumphi District	Mzimba District	Total Study Area
Total Respondents [n]	30	30	60
Men	12	14	26
Women	18	16	34
Single/divorced/ widowed households	4	7	11
Married households	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)
Men	46.67 (17.21)	44.29 (11.91)	45.38 (14.34)
Women	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)
Agricultural Wage Labour	53.33 (16)	56.67 (17)	55 (33)
Non-Agricultural Wage Labour	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)

Note: Values are presented as the mean value with the standard deviation in parentheses unless otherwise noted. The 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, ratios between 1–2 indicate medium dependency, and ratios > 2 indicate high dependency.

All interviews were completed with the help of an independent translator, as most of the farmers speak only the local language, Tumbuka. Farmers were asked to give informed consent prior to participation, permitting photos of their maize seed to be taken and their GPS location to be anonymously recorded.² A semi-structured interview format was chosen to gather quantitative information using standardized questions pertaining to the respondent's livelihood strategies and maize cultivation practices, as well as to obtain qualitative information on respondent preferences and perspectives. The predetermined interview questions were developed and revised in collaboration with leaders from SFHC, BCI, and the Mkombezi CSB. Incorporating feedback from local

experts and stakeholders 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.

During the interview, farmers were asked to name all maize varieties they cultivated during the 2018/2019 season and evaluate them across 8 characteristic categories using the ratings 'poor', 'average' and 'good'. Using this system, respondents could give independent evaluations for each variety trait.³ By asking farmers to specify variety names, we avoided the ambiguity of self-reported categorization of 'commercial' vs. 'local' seed. Farmers assessed 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 colour. 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 engaged in longstanding projects with farmers in the region.

We also collected data from participant observation, through both 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. The Mkombezi Community Seed Bank hosted the second farmer field day with 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 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 software environment R (R Core Team, 2021) was used for the analyses. The number of varieties and sources used by each household were analyzed with

generalized linear models allowing for underdispersion (quasi Poisson). The analyses were adjusted for household size. The preference data was analyzed feature-by-feature. Since farmers only rarely used the score 'poor', we collapsed the answer categories 'poor' and 'average,' and used generalized linear mixed models (GLMMs), based on logistic regression. CSB membership (yes or no) and maize type (local or hybrid/OPV) and their interaction were included as fixed effects, and household was included as a random effect so as to take within-household correlation into account. An overall score was computed for each combination of household and maize type, namely the percentage of the characteristics that were evaluated as 'good.' The overall score was analyzed with a Gaussian linear mixed model (LMM) with the same fixed and random effects as the GLMMs. For all analyses (quasi Poisson, GLMM, LMM) non-CSB households from Rumphi ($n=9$) were excluded, and it was a priori verified that differences between the two village areas in Mzimba were not statistically significant. Since Rumphi and Mzimba districts are otherwise similar we interpret potential differences as CSB-related despite the confounding with district.

3. Results

3.1. Livelihoods in the study areas

The socio-economic profiles of interviewed households remain relatively consistent across village areas and districts (Table 1). More women (57% of respondents) than men (43% of respondents) were available for interviews, often due to men being occupied with off-farm activities or away for migratory labour. In Northern Malawi, men are the primary land owners, giving them final decision-making authority when it comes to land management, although women often play a key role in seed selection and storage (Bezner Kerr, 2013, 2014). A majority of the households interviewed are married couples with this power dynamic, while a minority are single/widowed women. Almost all households rely on agriculture-based income, whether it is selling cash crops, marketing produce or livestock, or informal piecework labour on others' fields (known locally as *ganyu*). Households that earn money through self-employment usually sell agricultural products at independent market stalls. Households generally receive remittances from family members engaged in labour on

estates or through sharecropping on smallholder farms, either in other parts of Malawi or abroad.

On average, the interviewed households cultivate 3–4 acres (1–2 hectares) of land, of which they report devoting 58% to maize production. This ratio is in accordance with other published findings on the subject (Kawaye & Hutchinson, 2018; Snapp et al., 2019). We asked each farmer to report the acreage of land they allocated for maize production in the 2018/19 growing year, including both the total land area and the acreage for each maize type. Farmers that grow both local and commercial maize allocate on average 52% of their land for local varieties and 48% for commercial varieties, providing no indication of land prioritization based on maize type.

Figure 2 illustrates the types of maize grown by interviewed households, with maize varieties categorized as either local or commercial (hybrid/OPV) based on the variety names reported by the farmers (Table S1). We aggregated commercial hybrids and commercial OPVs in the same category as only two households report growing the latter type. Although only reported as being grown by farmers in a few cases, ‘recycled’ hybrid varieties were also included in the hybrid/OPV category as farmers’ perceived them as commercial, and thereby distinct from farmer-saved seed. We categorized varieties with specific local names or the generic name ‘lokolo’ as local varieties. 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 fewer grow exclusively commercial hybrid/OPV maize, Fisher’s exact test results show no statistically significant difference between household groups.

Overall, source and variety counts reveal that most households grow more than one variety of maize and usually obtain their maize seed from multiple sources. These findings are consistent with other studies in sub-Saharan Africa documenting smallholder seed sources that report multiple access channels for one crop (Almekinders et al., 2021; Bezner Kerr, 2013; McGuire, 2008; Mulesa et al., 2021; Sperling et al., 2008; Westengen et al., 2019). Comparisons between CSB households from Rumphu and non-CSB households from Mzimba indicate that the former grow a greater number of maize varieties from a greater number of sources. On average, CSB households grow between 2–3 varieties (mean = 2.2, SD = .70) from an average of 2–3 sources (mean = 2.3, SD = .90); non-members grow on average between 1–2 varieties (mean = 1.8, SD = .98) from an average of 1–2 sources (mean = 1.9, SD = .71). GLM analysis finds that CSB membership is associated with an increase in the number of varieties by a factor of 1.21 (95% CI 0.97–1.52) but the difference is not statistically significant ($p = .096$). Similarly, CSB-membership is estimated to increase the number of maize sources by a factor of 1.20 (95% CI 0.97–1.47), but the difference is also not statistically significant ($p = .097$).

Several studies have documented how smallholder farmers in Malawi grow a portfolio of maize varieties to fulfil various social, economic and food security priorities (Gibson, 2009; Lunduka et al., 2012; Snapp et al., 2019). For example, farmers might grow short-stalked, early maturing dent-type maize for consumption soon after harvest and flint maize with hard grains for long-term storage. In other instances, based on their respective storage and production capacities, smallholders grow local varieties for

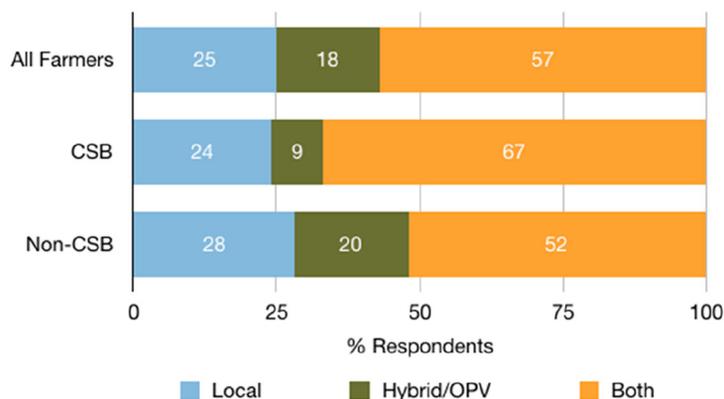


Figure 2. Types of maize grown. Proportions of farmers that grow exclusively local maize, exclusively commercial (hybrid/OPV) maize, and a mix of both are presented for CSB households ($n = 21$), Non-CSB households ($n = 39$), and all farmers interviewed ($n = 60$).

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. About 86% of CSB members grow more than one type of maize, compared to 56% of non-CSB households. Discussions with BCI representatives 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*' (Informal interview⁴). 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. This emphasis on variation includes the adoption of commercial maize. While the CSB does not loan hybrid/OPV seed to farmers, they also do not discourage farmers from growing commercial maize along with local varieties and, in some past years, have included commercial seed in demonstration plots to facilitate comparisons between local, hybrid, and OPV maize.

3.2. Maize seed access and availability

Saving seeds from the previous harvest is a common practice in farmers' seed systems across most of Sub-Saharan Africa. 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 & Pascual, 2013; Westengen et al., 2014). Households interviewed in Northern Malawi confirmed the persistence of this tradition, with the vast majority of local seed 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 cultivating home-saved maize report having kept their local maize seed over many years. These reports echo a 2019 study by Snapp et al., which finds at least half of recorded local landrace varieties in Northern Malawi to have been cultivated for over a decade. While only 6% of interviewed farmers report having purchased their local maize, an even smaller percentage (2%) report having sourced their local maize at the local market. This discrepancy suggests that in some instances, villagers purchase local seeds from other community members.

Of the 60 farmers interviewed, a total of 54 farmers (90%) report desiring a seed variety they cannot access. Overall, 91% of farmers report at least one type of hybrid seed as desired but inaccessible, whereas 46% find desired local seeds to be inaccessible (no commercial OPV varieties were mentioned in response to this question). The constraints for

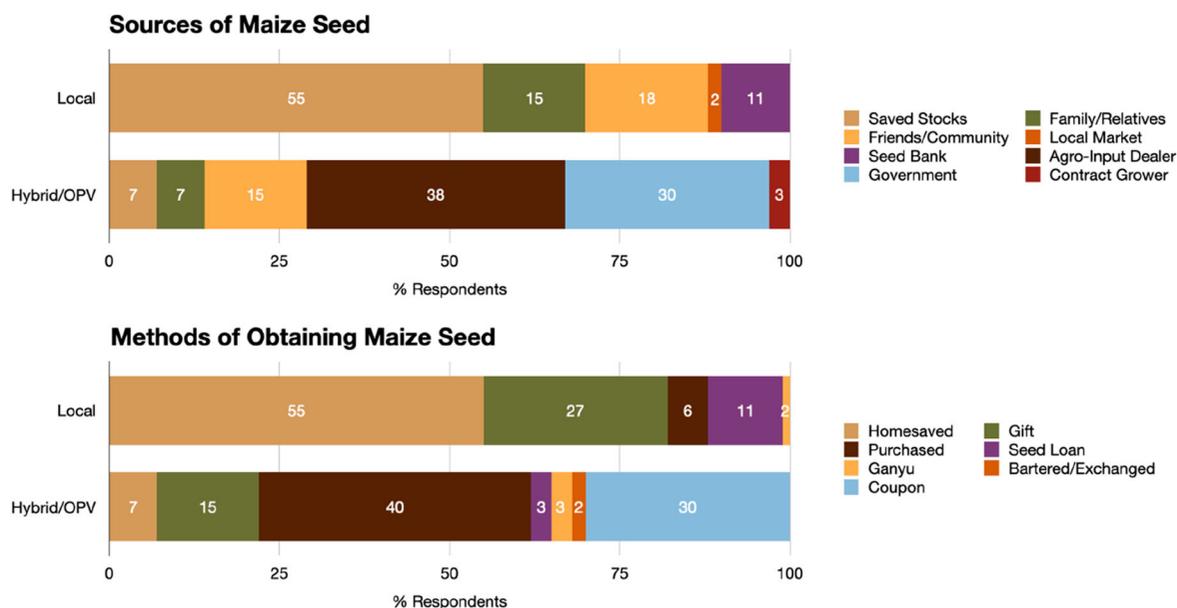


Figure 3. Sources and methods of obtaining maize seeds. Sources indicated by farmers and methods for obtaining local and hybrid/OPV maize varieties that were planted during the 2018/2019 growing season ($n = 60$).

accessing these varieties are relatively uniform across the study population, as the Mkombezi CSB does not store hybrid/OPV seed. Farmers often view commercial maize (commonly referred to as 'boma' or '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 [from another farmer]. Before it was easier to share seeds, but now you can't rely on your friends, just shops for quality seed' (Semi-structured interview⁵). This reluctance towards purchasing hybrid/OPV seeds from the community can stem from the 'yield penalty' incurred by recycling hybrid maize seeds due to loss of vigour (Jakobsen & Westengen, 2022). Indeed, relatively few interviewed farmers (12%) accessed hybrid/OPV seed through their friends, family, or the community compared to the 82% who sourced such seed from formal commercial channels (government subsidies and agro-input dealers) (Figure 3). This difference indicates that the principal barriers faced by all interviewed households to accessing hybrid/OPV seed are therefore largely financial and logistic; prohibitive seed prices and transportation costs (both monetary and physical) prevent farmers from purchasing hybrid/OPV seed (Figure 4).

Since farmers in Malawi traditionally transfer local seeds through social channels, access issues can arise from fragmentation in community relations. Both CSB and non-CSB farmers who 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 4). When asked what prevented them from acquiring their desired local variety, some farmers referenced social barriers such as reluctance to ask for seed, or 'beg' from

neighbours. In some cases, farmers who struggled to find the desired seed in the village are geographically situated near other interviewed farmers cultivating the sought variety. These instances suggest that inequity, limited communication and seed exchanges among community members can hinder farmers' access to preferred maize varieties. Although not all respondents shared this discomfort with accessing seed from the community, positive and negative responses are generally clustered by village, indicating that norms surrounding seed sharing are dependent on social relations within specific communities.

During 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 interview⁶).

Other farmers also described the cultural changes accompanying seed commodification, a transition that has slowly permeated rural areas following Malawian independence. As an elder woman, who had spent the last 70 years in her village, described:

'Now, people want to sell more compared to the past. During the early years of the Banda era, we used to share, but since then we can no longer give away seeds ... When I was young, there were no seed shops' (Key informant interview⁷).

While other older farmers could recall 'a time nobody went hungry because people shared' (Semi-structured interview⁸), younger respondents conversely

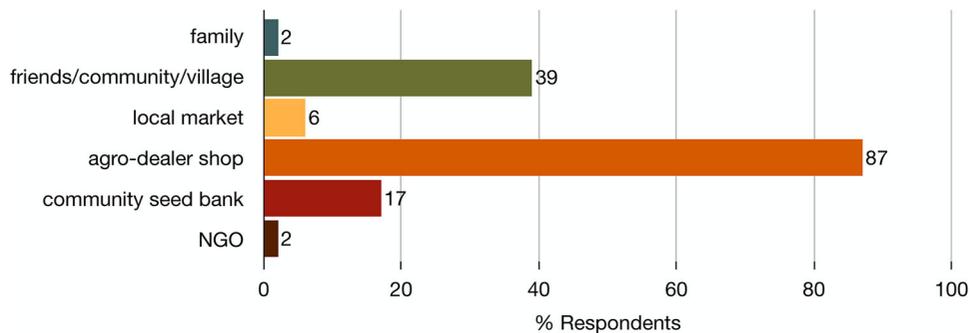


Figure 4. Sources of desired maize seed reported as inaccessible. Sources indicated by farmers and methods for obtaining local and hybrid/OPV maize varieties that were planted during the 2018/2019 growing season (n = 60). Note: respondents could select multiple sources.

described purchasing seeds from neighbours as a longstanding practice. According to one young woman, *'Here, we have always had to buy seed. But we help one another – if I grow enough maize I can sell to my neighbour so they don't have to pay for transport or walk to the town, which is far'* (Semi-structured interview⁹). In these cases, the farmers perceived selling seed as reinforcing, rather than hindering, community relations. A young man reported, however, that he is not always comfortable asking neighbours for maize because most times they do not give away quality seed (Semi-structured interview¹⁰). A middle-aged woman affirmed this notion by saying, *'My [seed] quality is the best, I cannot exchange with neighbours'* (Semi-structured interview¹¹). These observations indicate that farmers are more likely to exchange (or sell) lower quality seed with people outside the family sphere. This practice of giving or selling only 'cast-off' seed can potentially reinforce existing inter-community divisions in wealth and status, excluding those with weak kinship ties, stigmatized health conditions (such as being HIV positive), or land tenancy (vs. ownership) (Bezner Kerr, 2013).

While not all respondents believed seed sharing to be a bygone custom, these interviews show how shifts in social relations and degrees of community interdependency are inextricably tied to behaviours surrounding seed access. The responses follow a global pattern of changing customs governing farmer seed exchange networks. Studies that explore farmers' seed systems as social systems describe seed exchanges as integral to building and maintaining social cohesion among relatives and communities, strengthening inter-generational ties and reaffirming notions of cultural heritage (Badstue et al., 2006; Rattunde et al., 2021; van Niekerk & Wynberg, 2017). Though rooted in tradition, farmers' seed systems are vulnerable to sociopolitical shocks that may disrupt social ties, such as conflict (McGuire, 2008). Seed sharing customs are also changing in response to commercial and regulatory pressure to treat all seeds as commodities, local and commercial alike. In Northern Malawi, Bezner Kerr (2013) observed a general decline in seed sharing among smallholders due to an increased reliance on commercial seed production and monetary income to cover costs of living. While the farmer interviews here indicate a similar trend, the reported desire for unattainable local varieties underlines the salience of local seed despite increasing commercialization and monetization of farmer seed exchange networks.

CSBs offer an alternative to this market-oriented system, equitably distributing seed to members through a non-monetized loan and payback scheme. Through field days, seed/food fairs, exchange visits and workshops, CSBs can also help farmers to expand their social networks by giving them a means to meet with other farmers outside their normal sphere of interaction and communication. As one man summarized, *'[At the CSB] you learn a lot by being together with friends, like how to live in a community'* (Semi-structured interview¹²). 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 seeds. One woman member said that by visiting other members' fields to see how they manage their crops, she has discovered many new crop varieties and farming practices (Semi-structured interview¹³). Through directly observing seed production at the CSB and in their fellow farmers' fields, farmers have greater quality assurance and reduced uncertainty regarding environmental adaptation. Overall, discussions with members about how and why they participated in the CSB yielded several strong response trends, one of which is 'knowledge exchange.' Members mentioned 'learning about new varieties,' 'new farming and seed storage techniques,' and 'exchange visits' with other CSBs in the region as primary reasons for their membership. These responses indicate that farmers benefit from the farm and seed extension services offered at the CSB. It also illustrates the ability of such interventions to strengthen farmers' seed systems by facilitating practices of seed exchange, knowledge sharing, and the spread of genetic diversity (van Niekerk & Wynberg, 2017).

Despite the potential of CSBs to augment equitable access to a diversity of local maize varieties, we note that only 44% of interviewed seed bank members sourced maize seed from the CSB. Indeed, most farmers who reported a local variety as inaccessible (55%) are CSB members. Some of these farmers named the CSB as where they could not access their desired variety (Figure 4). These farmers cited barriers such as high demand, or their own late planning in taking out a seed loan. At the time of the interviews, it was unclear whether these limited supplies were

also due to the CSB's miscalculation of local demand and/or technical issues experienced during seed multiplication/storage – or reflective of a greater lack in financial/institutional support for CSB operations. For most CSBs, 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). It is also possible that low seed supplies were linked with high seed loan default rates, which can be due to pests, drought, or other extreme climatic events, as has been observed in other African contexts (Nyantakyi-Frimpong, 2019). Yet it seems that these limitations do not prevent the 'late' farmers from obtaining local maize seed altogether, as households primarily sourced their local seed through seed exchanges outside of the CSB network and/or home-saved their stocks (Figure 3).

The households that did use the CSB sourced on average only 45% of their seed supply (measured in kg) from the seed bank. None of the CSB member households exclusively obtained their maize from the CSB; they also grew varieties acquired from other sources such as friends/family, or home-saving. The CSB farmers therefore did not rely on the CSB as the principal source of their maize seed, but rather used the CSB to supplement and diversify their maize seed supply. This finding suggests that in this case, the principal contribution of the CSB to farmers' maize seed systems cannot be measured through direct seed provision. Instead, it appears that the CSB supports farmers' maize seed systems to a greater degree through other vital functions, namely social and educational services. As a hub for knowledge exchange, the CSB can indirectly improve farmers' maize seed access through multiple channels, such as by a) exemplifying seed storage techniques to support home-saving, b) hosting seed/food fairs for farmers to socialize and strengthen seed sharing networks, and c) providing a market outlet to support members' incomes, thereby enabling seed purchases. Such contributions to farmers' seed systems are difficult to measure and can be often overlooked. Yet our data suggests that the social impacts of the CSB may be more important than its capacity to directly supply farmers with seed.

3.3. Farmer seed preferences

To understand why farmers desire certain types of seeds over others, we asked interviewed farmers

to evaluate the varieties they had planted in the 2018/2019 growing season for eight agronomic and post-harvest traits. Aggregate evaluations for local and hybrid/OPV varieties provide an indication of the farmer's satisfaction with their planted maize varieties across different characteristic categories. Recycled hybrids, though only reported in a few cases, are grouped with hybrids/OPVs as only a small share of the farmers in the study cultivate such seed, which is generally perceived to be of the same quality as newly-purchased commercial seed.

Table 2 compares farmer maize variety evaluations for different traits by CSB membership status and maize type. There is no statistically significant effect of CSB membership on how farmers evaluate local maize across characteristic categories. For hybrid and OPV maize however, CSB membership seems to influence how farmers evaluate their varieties for drought tolerance, storability, poundability, taste, and colour. For example, 26.7% of CSB members rate the storability of their commercial seed as 'good', compared to 94% of non-members. The frequency of 'poor/avg.' and 'good' ratings per household shows that CSB membership seems to influence overall evaluations of hybrid/OPV maize, with non-members rating hybrid/OPV varieties more positively than CSB members.

We also compare how CSB members and non-members distinguish between local vs. hybrid/OPV maize in their evaluations (Table 2). CSB members have significantly different evaluations for local maize compared to hybrid/OPV maize when evaluating for drought tolerance, storability, poundability, taste, and colour. CSB members also seem to show greater preference for local maize over hybrid/OPV maize: a higher percentage of farmers (81.5%) rate their local seed as 'good' across characteristic categories, compared to 45% for hybrid/OPV seed overall.

As both groups faced similar barriers and opportunities to access hybrid maize (both study areas were the same distance from major markets and agro-dealer shops), such results indicate a potential influence of CSB participation on farmers' perceptions of maize performance. For CSB members, there also appears to be fewer instances of consensus regarding the rating of local varieties across different traits, which could possibly indicate a more critical appraisal of differences between varieties. One reason for this could be that the experimental demonstration plots and seed multiplication fields at the CSB allow

Table 2. Comparisons of household maize variety evaluations by CSB membership status and maize type.

	Seed Quality		Mat. Period		Yield		Drought Tol.		Storability		Poundability		Taste		Colour		Overall	
	Poor/ avg.	Good																
Local	5.1	94.9	15.8	84.2	52.6	47.4	52.6	47.4	15.8	84.2	2.6	97.4	2.6	97.4	2.6	97.4	2.6	97.4
Non-CSB	10	90.0	6	94.0	33.3	66.7	38	62.0	0	100	0	100	0	100	2	98.0	11.3	88.7
CSB vs. Non-CSB	$p = .68$		$p = .34$		$p = .17$		$p = .20$								$p = .92$		$p = .15$	
Hybrid/OPV	25.0	75.0	43.8	56.2	46.9	53.1	93.7	6.3	73.3	26.7	53.3	46.7	57.7	42.3	43.8	56.2	55.0	45.0
Non-CSB	13.6	86.4	11.4	88.6	15.9	84.1	28.4	71.6	6.0	94.0	14.8	85.2	7.1	92.9	1.1	98.9	13.2	86.8
CSB vs. Non-CSB	$p = .48$		$p = .17$		$p = .07$		$p = .0007^*$		$p = .0001^*$		$p = .03^*$		$p = .003^*$		$p = .02^*$		$p < .0001^*$	
Local vs. Hybrid/OPV	$p = .25$		$p = .14$		$p = .66$		$p = .007^*$		$p = .0002^*$		$p = .06^*$		$p = .002^*$		$p = .03^*$		$p < .0001^*$	
Non-CSB	$p = .70$		$p = .42$		$p = .27$		$p = .70$								$p = .85$		$p = .65$	

Note: For each maize variety characteristic, the percentages are given for farmers within each household group/maize type that rated the variety as 'poor' or 'average' (combined here as 'Poor/avg.'). An 'overall' score is also calculated based on the frequency of 'Poor/avg.' and 'Good' ratings per household. The effect of CSB membership (CSB vs. Non-CSB) is calculated for each maize type and listed by maize variety characteristic in order to assess if CSB members rate local or hybrid/OPV seed differently than non-members. The effect of maize type is also calculated (Local vs. Hybrid/OPV) for CSB members and Non-CSB members, in order to assess if either household group distinguishes between local and hybrid/OPV maize types in their variety evaluations. Comparisons involving groups with 100% response in one category cannot be carried out and are marked with '-'. Non-members from Rumphu ($n = 9$) are excluded from the analysis. Statistically significant differences between groups are marked with an '*'.

farmers, regardless of whether they grow the variety themselves, to critically compare the performances of a large range of local maize varieties. In previous years, the Mkombezi CSB even had trials that included local, OPV and hybrid varieties. CSB members therefore might have an expanded frame of reference for maize seed evaluation. Through learning about the varying potentials of many local varieties, respondents may be better equipped to make critical assessments of commercial maize. Therefore, by creating a space that facilitates farmer-to-farmer exchange and experimentation, the CSB can give smallholders the tools they need to make informed decisions on which seeds to cultivate.

To decipher the underlying values that drive maize seed adoption patterns, interviewees were asked to list their top three most important maize seed traits. Here, the most popular answers are poundability, yield, and taste (Table 3). Overall, these responses indicate that long-term food security and cultural foodways figure as important as agronomic productivity for Malawian smallholders. They also show prioritization of post-production appeal, the facility of pounding and preparing meals with the maize harvest. Most local varieties have harder flint kernels, characterized by hard pericarps that protect the grain from maize weevils in storage and are better suited to the local processes of de-hulling (pounding) (Kydd, 1989). Despite longstanding documentation of Malawian farmer preferences for flint varieties, formal breeding programmes have prioritized the development of dent hybrids, characterized by a softer pericarp ideal for large-scale milling but less suitable for traditional processing (Bezner Kerr, 2013; Jakobsen & Westengen, 2022; Kydd, 1989; Lunduka et al., 2012).

CSB members were more likely to rank poundability and storability as high priorities compared to non-members. These differences suggest that greater exposure to a multitude of local varieties – with more desirable storability and poundability characteristics – can give CSB participants more insight and experience 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.

3.4. Patterns of seed experimentation

The reasons why farmers choose to adopt and discontinue maize varieties also reflect their tendency to prioritize certain maize variety traits. We note that

Table 3. Most important maize characteristics.

CSB Members (n = 21)	
Maize Variety Characteristic	Frequency of Responses [% (n)]
Poundability*	81 (17)
Storability	48 (10)
Yield	48 (10)
Taste	43 (9)
Seed Quality	29 (6)
Drought Tolerance	29 (6)
Maturation Period	24 (5)
Colour	0 (0)
Total Responses: 63	
Non-CSB Members (n = 39)	
Maize Variety Characteristic	Frequency of Responses [% (n)]
Yield	62 (24)
Taste	54 (21)
Poundability*	51 (20)
Seed Quality	49 (19)
Drought Tolerance	44 (17)
Storability	23 (9)
Maturation Period	18 (7)
Colour	0 (0)
Total Responses: 117	
All Farmers (n = 60)	
Maize Variety Characteristic	Frequency of Responses [% (n)]
Poundability	62 (37)
Yield	57 (34)
Taste	50 (30)
Seed Quality	42 (25)
Drought Tolerance	38 (23)
Storability	32 (19)
Maturation Period	20 (12)
Colour	0 (0)
Total Responses: 180	

Note: 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 and Non-CSB respondents, a Fisher's exact test of independence was conducted to compare proportions for each characteristic. Significant differences between groups are marked as follows: * = $p < .05$.

cultivators of local varieties have home-saved their seeds over many seasons, and thus most newly adopted seeds reported are hybrid/OPVs. According to farmer interviews, one of the principal reasons for seed adoption and discontinuity is perceived and realized yield (Table 4). These results coincide with those found by Westengen et al. (2019), who identify 'high yield' to be the most frequently cited reason for adopting hybrid/OPV varieties across Malawi, Ethiopia, and Tanzania. Farmers here also prefer traits linked with climate risk avoidance and resilience, such as early maturation and drought tolerance. This

aligns with a study by Atube et al. (2022) in Northern Uganda, which finds strategic crop varietal selection, including drought-resistant and early maturing varieties, to be the most common climate change adaptation strategy for smallholder farmers. As one of the principal considerations for all farmers is maize poundability (Table 3), farmers are possibly incorporating what they perceive to be higher yielding varieties to supplement their stock of 'poundable' (most likely local) seed for home consumption.

As most rural households do not have easy access to a platform to compare commercial varieties (outside of the occasional government-sponsored field day), perceptions of yield are largely the result of informal exchanges among community members. In interviews, some respondents who adopted new commercial seed attributed their decision to friends or family who already grew the variety in question, saying for example, '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 interviews¹⁴). 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, yet 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 interview¹⁵). 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. These observations align with findings in innovation-diffusion research that show how social processes, such as exchanges that create perceived advantages of innovations, can override empirical assessments of new technologies (Stone, 2007).

Farmers that chose to discontinue certain varieties also did so due to production and resilience concerns: disappointing yields and poor drought tolerance (Table 4). While post-harvest traits do 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 productivity, resilience (or yield stability) and consumption dominate in decisions concerning adoption and discontinuation of maize varieties. When comparing the frequency of responses between CSB and non-CSB households, it appears that while fewer CSB members are adopting varieties based on projected yield than non-CSB farmers, they are perhaps more likely to discontinue

Table 4. Drivers of maize adoption and discontinuation.

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 FISP 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 homesaving	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)

Note: Results are presented as percentages followed by the number of farmers who gave that specific response. Percentages 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.

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. The price of hybrid seeds was mentioned by non-CSB members as frequently as disappointing yields as a reason for variety discontinuation. These results are simple comparisons, but nevertheless suggest that CSB members seem more likely to prioritize drought tolerance than yield for adopting a variety, and discontinue varieties based on dissatisfaction with qualities that they value (such as yield and poundability) rather than financial limitations.

A reason for these trends might be that CSB members have access to more knowledge, both from exchanges with fellow members and from more formal extension events. 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, seed/food fairs, 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 seems to influence patterns of maize seed adoption, notably which types of maize farmers grow and what

characteristics they prefer. Such opportunities help capacitate smallholders to make informed decisions through exposure to distinct local varieties and their respective field and storage management techniques. As noted by Waldman et al. (2017), the availability of information on seed performance and the facility of smallholders to access this information can influence patterns of seed adoption. In this case, we find that CSB members favoured local maize over commercial, showing lower levels of satisfaction for hybrid/OPV maize than other farmers (Table 2).

Through untangling the social, economic, and agronomic influences behind patterns of seed experimentation, our findings challenge the dominant narrative that commercial maize is always more productive in smallholder fields than local varieties. This assumption posits adoption to be a linear trajectory where technology diffusion and uptake are sequential. In reality, farmers engage in dynamic processes of trial, error and modification. Research in Sub-Saharan Africa that directly links low hybrid adoption rates with low maize production underwrites policies that fortify the commercial sector, often through increased regulations addressing plant variety protection, variety registration, certification, and regulatory harmonization across borders. 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). These types of sweeping approaches to addressing climate shocks 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 & Sperling, 2013). Such neoliberal measures, championed by states and donors that favour private sector agricultural development, often ignore the prominence of farmers' seed systems and post-harvest qualities that are of interest to smallholders and thus risk becoming counterproductive in addressing issues of seed and food security for agrarian households (Almekinders et al., 2021; de Boef et al., 2010; Hambloch et al., 2021; Sperling et al., 2008).

Alternatively, by encouraging inter-community seed exchange, facilitating experimentation, and 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. Overall, our results indicate that CSBs strengthen farmers' seed systems 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 traditional social networks.

4. 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 centres 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 & 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 (Thornton et al., 2018; Westengen et al., 2018; Wiggins & 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. Yet 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.

Although most CSBs were originally established for seed conservation, the organization can evolve to also serve as a platform for community development, promoting increased seed access and availability, and ensuring seed and food sovereignty for smallholders (Vernooy et al., 2015). The potential of a CSB to expand its role beyond that of a local *ex-situ* seed storage facility 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 non-certified seeds of unregistered varieties in non-emergency contexts (Westengen et al., 2018). In some countries however, current policies and laws support farmer-led efforts to safeguard local agrobiodiversity and protect traditional seed production and exchange. In Brazil, three states (Paraíba, Alagoas and 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). Pressure from grassroots organizations has yielded greater national recognition of farmers' seed systems; a 2013 National Plan for Agroecology and Organic Production even included some investment in CSB infrastructure (Peschard, 2017). 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 favourable for CSBs. The Ministry of Agriculture introduced a National Guideline on CSBs in 2018, and 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). Ethiopia's Seed System Development Strategy also acknowledges the salience of local crop varieties in farmers' seed systems, and outlines plans for supporting community-based seed production systems (including CSBs) as part of the 'intermediate seed sector.' By encouraging decentralized

production systems of both local and improved varieties, the policy aims to improve interlinkages between the commonly dichotomized 'informal' and 'formal' seed sectors (FAO, 2015). These policies exemplify how CSBs can be incorporated into legal frameworks. 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 2018 National Seed Policy – with provisions that were later incorporated and passed in the Malawi Government's 2022 Seed Bill – stopped short of declaring farmers' varieties illegal but did not provide any support to farmers' seed systems or the organizations that work within them (Government of Malawi, 2018). This policy poses a challenge to the longevity of CSBs in the Rumphi district. In an interview, the chairperson of the Mkombezi CSB 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. Indeed, our data reveals some access issues with local maize varieties at the CSB, potentially due to inadequate seed supplies. Greater policy and financial support from the government and other external agencies could bolster both seed production capacity at the CSB and the members' ability to repay seed loans.

While a committee of local members internally manages this seed bank, 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 external inputs for the experimental plots, while also helping with the funding and facilitation of thematic workshops. For the Mkombezi chairperson, the presence of BCI encourages good teamwork between the members (Key informant interview¹⁶). These observations reinforce the need for human and social capital within the CSB. According to Shrestha et al. (2015), '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 embedded in traditional practices of seed sharing and exchange, while also introducing new concepts of gender equality and teamwork to strengthen community cohesion. An internal committee manages the allocation of leadership roles and decision-making, and through BCI field days and workshops, technical expertise is transferred to the membership. As BCI continues to capacitate the members through programmes aimed at conservation, access and availability, and food sovereignty, the CSB might gain greater legitimacy in the eyes of the community.

As member-based institutions that are funded partially 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 politics and power dynamics. In our case study, a majority of the CSB's 82 members live within 2–4 km of the seed bank within the valley, except for a group of members from a mountain village located 5–6 km away. The mountain farmers participate from a distance, making fewer trips to the storage facility and attending only obligatory meetings. To compensate, these members had established a small experimental plot to test CSB-sourced varieties in their local agro-climate and showcase the diversity of available seed at the CSB. Members made up a sizable portion of the village population. Yet when non-CSB farmers in the mountain village were asked about barriers to participation, they described an exclusive process of existing members handpicking new members. According to them, CSB membership is conditioned by having relatives down in the valley. 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. Farmer stories on this subject speak to the importance of evaluating the efficacy of an institution in its specific socio-political context. This particular example indicates how CSBs, like other village-level institutions, are embedded in local political hierarchies. In this case, the partiality exercised by local leadership limited the potential of the Mkombezi CSB to deliver socially equitable benefits. Nyantakyi-Frimpong (2019) makes similar observations in an analysis of CSBs in Northern Ghana, finding that male farmers with direct connections to CSB membership in some Ghanaian villages receive higher amounts of seed, with project benefits distributed on a basis of kinship and

gender. His analysis illustrates how the micro-politics of gender, resource access and control can 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 a case study on three CSBs in India, she finds that many farmers perceived the CSBs to be accessible only to elites in the villages, a status that stemmed from 'a combination of caste, class, landholdings, irrigation access, education, or affiliation with village leadership' (Reisman, 2017). Such perceptions of selectivity might also occur if the CSB uses community status to determine whether potential members can be trusted with seed loans. These findings challenge the common assumption that CSBs are open to all farmers who desire seed. In the case of Mkombezi, 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. Standardized procedures for assessing potential members by CSB leadership should also be made public to increase the transparency of member selection.

In the absence of a supportive political environment, institutional collaboration and regional networking can also increase the impact of CSB operations. CSBs in the north of Mali have formed a formal network that frequently collaborates with CSB networks in southern Mali to support the conservation and exchange of local varieties through seed fairs, visits and exchange workshops. These networks 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 (Goita et al., 2015). Partnerships with national gene banks can also increase the robustness of local institutions. Once unique to the formal seed sector, 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 Bioversity 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. Farmers evaluated the varieties for their climate resilience as well as other important characteristics and later incorporated the seeds 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 four 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 across the region. 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 ultimately increasing the CSBs' seed production capacity to meet demand for local maize varieties. Furthermore, establishing partnerships with extension services could also help the CSB expand its crop profile to include OPVs bred through public breeding programmes, thereby improving complementarity between farmers' seed systems and the formal seed sector.

Closer collaboration with government divisions and research organizations in seed bank operations could also help CSBs further empower smallholder farmers. 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 & McNamara, 2018). Yet participatory institutions (such as CSBs) require high levels of collaboration between trained public officials and motivated citizens to increase participant welfare. A study by Porcuna-Ferrer et al. (2020) in Guatemala reports that occasional seed flows between case study CSBs and the International Maize and Wheat Improvement Centre (CIMMYT) helped integrate the farmers as actors in scientific plant breeding processes and contributed to a 'successful institutional context for seed sovereignty.' In Northern Malawi, BCI has conducted workshops to educate CSB members on their rights as farmers, and facilitated

the organization and mobilization of farmer groups to advocate for their rights to save and sell their local seeds (GFAR, 2018). Since the data was collected, some of the authors have also had opportunity to informally observe farmers participating in discussions and advocacy related to government seed policies. Though it was not an explicit focus of our research, our findings suggest can CSBs empower smallholder farmers through greater knowledge networks and closer collaboration with government divisions and research organizations, which provide opportunities to involve them in policy processes and plant breeding operations. Our data supporting how prominently post-harvest seed traits factor into farmer preferences and patterns of seed experimentation underscores the importance of farmer engagement in the management and multiplication of local seed varieties. Further strategic partnerships and initiatives to strengthen farmers' engagement in variety trait selection, plant breeding and seed production could increase access to and availability of the local crop diversity integral to farmers' seed systems.

Coupling these efforts with strategies to increase economic returns (through i.e. seed sales to non-members, group-marketing schemes) would serve to both economically empower farmers and improve the financial independence of the CSBs. Overall, observations from this case study indicate that the scalability and sustainability of CSBs are not bound by the physical size of the facility. While the Mkombezi CSB still relies on external funding, its embedded position within the local seed system and socio-political framework shows great promise for long-term institutional sustainability.

5. Conclusion

Even in a policy environment that favours the homogenization of seed supplies, farmers' seed systems in Malawi persist in times of increasing climatic stress (IPCC, 2022), pointing towards the need to include the strength of farmers' seed 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 farmers' seed systems and the formal sector through an integrated approach that favours farmer participation in varietal development and seed supply (Almekinders et al., 1994; Cleveland et al., 1994; de Boef et al., 2010; Louwaars & de Boef, 2012).

The CSB in Mkombezi was selected as a focus of study to assess its potential to support farmers' seed systems by a) serving as a centre for exchange and experimentation and b) providing farmers with varieties that contain qualities generally lacking in commercial seeds. Despite high demand and national subsidies for hybrid/OPV seed, access and availability of commercial maize is restricted by financial and geographic circumstances. Local varieties are usually home-saved or obtained through informal mechanisms of seed exchange. Yet, as such access channels become increasingly monetized, cultivation of desirable local seeds is largely conditioned by social capital, including levels of community inter-communication and co-dependence. It was found that the CSB could help reinforce community ties that underlie local seed exchanges through increasing the access to and transparency of knowledge around the cultivation of local maize varieties.

We find that while the CSB could also increase the availability of local maize varieties, most members did not rely on the CSB for their maize seed supply. This is perhaps because issues with internal organization, inadequate finances, and lack of institutional support limited the volume of seed available and reduced access to certain seeds in high demand. Indeed, no farmers exclusively relied on the CSB for maize seed. Farmers that did receive seed loans also sourced maize seed from other members of the community, friends/family, or their own home-saved stocks. While some farmers might have used the CSB to supplement or diversify their maize seed supply, the value of the CSB cannot be solely derived from the volume of seed distributed. Rather, our interviews suggest the farmers may have gained more indirect, intangible benefits from CSB participation, through using the space as a hub for experimentation and learning. Overall, member testimonies on CSB participation were overwhelmingly positive, farmers especially appreciated the benefits of the seed bank's auxiliary services: providing a platform for group marketing, workshops, and knowledge exchange through field days, seed/food fairs, as well as exchange visits.

Maize variety evaluations indicate that CSB farmers were less satisfied with commercial seed than non-members regarding a range of post-harvest characteristics, including poundability, storability, taste, and colour. CSB members seem to prefer local maize to hybrid/OPV maize for these same characteristics.

CSB access may therefore expand a farmer's frame of reference and influence patterns of seed adoption. CSB members appeared to place greater value on post-production seed traits such as poundability and storability, where non-members prioritized yield. These values may influence CSB members' patterns of (primarily) hybrid/OPV adoption and discontinuation. Alternatively, non-members were likely to adopt based on rumours or perceptions of high yield and discontinue varieties due to disappointing yields and/or financial constraints. With access to knowledge resources such as farmer networks and extension events, CSB members can make informed decisions regarding maize seed experimentation.

These findings illustrate how the Mkombezi CSB bolsters farmers' seed systems 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 farmers' seed systems and encouraging the cultivation of a diverse array of desirable maize varieties, the Mkombezi CSB improves seed security for participating farmers. Given the perceived exclusivity within the CSB, measures to increase the transparency of member selection procedures and overall expand equitable access to membership should be a primary strategy for increasing institutional scalability. Involvement in the CSB could be augmented with greater impartial outreach to surrounding villages. Increased collaboration with government, public research and extension institutions could further increase the integration of farmers' seed systems with the formal sector, although this also requires actors within commercial seed systems 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 strengthening farmers' seed systems as a path to improving seed security and seed sovereignty.

Notes

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. 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. No personal information was recorded that could link response to the personal identity of the respondent. The project was therefore exempt from the ethics approval process as stipulated by the Norwegian Centre for Research Data (NSD).
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.
4. BCI representative (man), Rumphi district, Informal Interview, 22/03/2019
5. Farmer (woman), Mzimba district, Interview 33, 1/04/2019
6. Farmer (woman), Mzimba district, Interview 48, 15/04/2019
7. Village elder (woman), Mzimba district, Key Informant Interview 2, 17/04/2019
8. Farmer (woman), Mzimba district, Interview 54, 16/04/2019
9. Farmer (man), Interview 31, 11/04/2019
10. Farmer (man), Rumphi district, Interview 15, 4/04/2019
11. Farmer (woman), Rumphi district, Interview 13, 3/04/2019
12. Farmer (man), Rumphi district, Interview 10, 2/04/2019
13. Farmer (woman), Rumphi district, Interview 21, 5/04/2019
14. Farmer (woman), Mzimba district, Interview 42, 12/04/2019; Farmer (man), Mzimba district, Interview 51, 16/04/2019
15. Farmer (woman), Rumphi district, Interview 13, 3/04/2019
16. Mkombezi CSB Chairperson (man), Rumphi district, Key Informant Interview 1, 9/04/2019

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Author contributions

ECV and OW had the conception of the study within the guidelines of the grant agreement to contribute to the ACCESS Project, (PI: OW). ECV designed the

study (with guidance from RBK and OW) and conducted the data collection in Malawi. HS led the data analysis and modelling, with inputs from co-authors on the interpretation of the results. All co-authors (ECV, OW, RBK, HS, IP) contributed to the writing of the manuscript and approved its publication.

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Table S1. Varieties Grown by Interviewed Farmers

Local varieties		Hybrid/OPV varieties		Recycled Hybrid varieties	
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		
Kamtepatapa	1	'Pioneer'	2		
Bera	1	'Demeter OPV'	2		
		MH18	1		
		MH33	1		
		MH26	1		
		SC537 'Mbizi'	1		

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