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ABSTRACT
In the context of increasing NGO interest in the capacity of conservation agriculture methods to support sustainable agriculture across sub-Saharan Africa, this paper explores the experiences of farmers (n = 111) adopting the Tiyeni NGO's deep-bed farming (DBF) system in northern Malawi. The results of a field survey suggest that whilst DBF delivers significant livelihood benefits for farmers relative to traditional techniques (a factor arguably driving its rapid spontaneous adoption throughout the area), some asset-poor farmers are unable to sustain DBF due to its labor demands. We argue that to widen its beneficial impacts in a manner that can be sustained, there is a need for Tiyeni's DBF to be less prescriptive and more adaptive to specific social-ecological contexts.

KEYWORDS
Sub-Saharan Africa; conservation agriculture; NGO; social-ecological; livelihoods

Introduction

In spite of significant progress in recent years, achieving food security remains a key challenge for the vast majority of subsistence farmers throughout sub-Saharan Africa whose livelihood strategies often remain vulnerable to rapid demographic, socio-economic, political, and environmental change (NEPAD 2013; Niang et al. 2014; Serdeczny et al. 2017). While green revolution-style extension packages have gone some way in raising agricultural productivity, their variable effectiveness throughout Africa due to affordability, environmental requirements, and their top-down mode of implementation has been well-documented (Chambers, 1983; Dawson, Martin, and Sikor 2016; Evenson and Gollin 2003). Similarly, agricultural intensification initiatives have often been criticized for their negative impacts on the environment, in terms of land degradation and unsustainable yields in the absence of continuous inputs in the long term (MEA, 2005; Conway and Barbier 1990; Kopittke et al. 2019). Since the 1980s and the emergence of the 'farmer first' movement that sought to engage local farmers themselves in a process of participatory agricultural development, much attention has focused on how food security issues at the local level can be addressed through sustainable agricultural practices that

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deliver positive benefits for both people's livelihoods and the environment (Reij and Waters-Bayer 2001; Reijntjes, Haverkort, and Waters-Bayer 1992; Uphoff 2002). These alternative pathways to sustainable agriculture and food security have drawn on a wealth of empirical research from the field that has been situated within a diverse yet often overlapping range of disciplines and ideas emphasizing the importance of the cultural dimension of agricultural development (Pretty 2002; Warren, Slikkerveer, and Brokensha 1995), agroecology (Altieri 1989; Dalgaard, Hutchings, and Porter 2003) integrated landscape approaches (Reed et al. 2017; Sayer et al. 2013), social-ecological systems thinking (Berkes, Colding and Folke, 2003; Ostrom 2009) and asset-focused livelihoods approached (Scoones 1998, 2015; Carney, 2002). Even recent renewed policy drives toward sustainable agricultural intensification across the continent have sought to incorporate lessons from the past and take a more holistic approach, recognizing the importance of family farming and household dynamics (NEPAD 2013).

It is within this space that the concept and practice of Conservation Agriculture (CA) has emerged as " … *an approach to managing agroecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment*." (FAO 2008). Although the term itself is often used interchangeably to describe different combinations of environmentally sensitive agricultural practices (Giller et al. 2009), at its core are three key principles.

First, is the concept of 'zero tillage' (often synonymously referred to as 'no till' or 'direct seeding'), based on an assumption that it is the continuous mechanical soil disturbance during plowing that causes soil erosion, a decline in organic matter, and an overall decline in crop yields. By direct seeding that avoids soil tillage and trampling (by humans or livestock), a more porous soil structure can be maintained which promotes water infiltration, organic matter accumulation, and root growth.

Secondly, FAO (2008) further characterizes CA as having 'permanent organic soil cover', where the use of cover crops or mulching can protect the soil against wind and water erosion, thereby maintaining soil porosity and preventing compaction, desiccation, and crust formation. This subsequently promotes a microenvironment that supports the growth and development of beneficial soil organisms. Insects, fungi, and bacteria aid the decomposition of crop residues and support humus formation through biological tillage. The outcome is soil that retains its organic matter and water, while sustaining biodiversity.

The third principle of CA is the 'diversification of crop species grown in sequence or association', i.e. the integration of multicropping (which can include agroforestry) and/or crop rotations, which helps ensure a constant recycling of nutrients (often enhanced by the use of leguminous plants), a diversity in soil structure, and a reduced risk of the problems associated with persistent weeds, pests, or diseases. Furthermore, crop rotation and diversification reduce the risk of total crop failure, and hence has a key role to play in enhancing livelihood resilience. CA does not exclude the use of agrochemicals or artificial fertilizer, but rather it is practiced with an appreciation of how these can complement and enhance (rather than replace) organic and biological processes of soil management. Nonetheless, the attractiveness and proliferation of CA, particularly among development NGOs (Andersson and D'Souza, 2014) have in part been fuelled by its promise of sustainable agriculture based on a reduced dependency on external agricultural inputs – agrochemical, but also in terms of continued extension support. In effect, CA has been regarded as a good example of appropriate technology that can be modified and informed by farmers' own site-specific understanding of their environment and livelihood resources, and because it is not dependent upon external support, it is also increasingly being seen as a means of facilitating community-based adaptations to climate change (Concern Universal 2011) and 'climate smart' agriculture (FAO 2013).

Despite this popularity among NGOs, farmer adoption of CA across sub-Saharan Africa has reportedly been relatively small and slow, not least because of inconsistencies in the way it is defined and measured in different places (Anderson and D'Souza 2014), but also because of a range of social, political, cultural, and environmental adoption constraints operating at different scales from the household level upwards (Corbeels et al. 2014; Knowler and Bradshaw 2007). In the language of the much-adopted Sustainable Livelihoods Framework (Scoones 1998) many of these constraints can be directly linked to the relative availability of different livelihood assets – physical, social, financial, human, and social – in different places and at different times.

In terms of human capital, for example, Okoye (1998) identifies the age of a farmer as being a significant influence on adoption; older farmers are more likely to have more experience, knowledge, and access to larger areas of land where CA can be practiced alongside traditional agricultural practices. Female-headed households meanwhile, are more likely to be affected by labor constraints and are therefore less likely to extend into CA (Giller et al. 2009). Warriner and Moul (1992) draw a link between the level of formal education among farmers and the extent of CA adoption, since education also tends to be linked to the accumulation of financial and physical assets. The availability of financial capital similarly allows labor to be hired, and hence there is a further link here with CA adoption, which itself is more labor-intensive than traditional methods (Giller et al. 2009; Ngwira et al. 2014). In their review of several case studies in southern Africa, Corbeels et al. (2014) also identify the importance of social capital (i.e. the social networks of knowledge sharing, trust, and reciprocity), where membership of community groups, and access to farming networks (as well as land itself) were cited as critical determinants of CA adoption. Here, especially, adoption is inextricably linked with processes and structures beyond the household level. Having access to markets is of fundamental importance to farmers (as are having the ‘right’ market conditions themselves); CA adoption is only likely to be attractive if there is a financially worthwhile market for the produce. Both Corbeels et al. (2014) and Kassam, Friedrich, and Shaxson (2014) also emphasize the important role that local institutional structures play in facilitating an enabling environment in which farmers have the opportunity to develop flexible and adaptive practices in the field, that can in turn enhance the social and human capital necessary for successful CA. NGO advocates of CA have embraced this to some extent, by seeking to create local or institutional champions for CA alongside a commitment to a participatory research and an extension process that fully engages farmers and their own local organizations.

In the absence of many of these enabling conditions, CA adoption may be short-lived, and in the many instances where CA adoption is claimed by NGOs farmer commitment has ceased on completion of a specific project intervention (Giller et al. 2009). With the NGO ‘safety net’ removed farmers once again face the decision of whether CA is worth the effort in terms of returns to labor and input relative to their traditional agricultural practices, their available livelihood assets, and fundamentally whether their experiences of CA have resulted in any accrued benefits, especially in the short term. Here, again, there is conflicting evidence from around sub-Saharan Africa. In their systematic meta-analysis of experiences among smallholder farmers in Africa, Giller et al. (2009) question the link between zero-tillage and increasing soil fertility, and conclude that the crop yield benefits from CA are only likely to occur in the long term (while in the short term, some yield decreases have actually been observed). Similarly, Giller et al. (2009) cite evidence to suggest that one of the key perceived benefits of CA, a reduction in soil erosion, is only likely to occur in the long term. In the absence of immediate livelihood impacts, therefore, CA becomes less economically attractive to the smallholder household. In contrast, however, Corbeels et al. (2014) report consistently higher yields and income generation among CA adopters, albeit among farms where often the distinction between CA and non-CA agriculture is not as clear cut; in reality individual CA practices tend to be adopted and adapted selectively depending upon specific farm characteristics (e.g. maintaining permanent soil cover with crop residues tends not to be adopted in farms where livestock require them for feed). While this arguably evidences the importance of recognizing the flexibility and socio-ecological uniqueness of each farming context, conflicts with the ‘one size fits all’ approach that so often dominates NGO-driven CA field extension.

In summary, what the literature on CA points toward is a series of continuing debates and uncertainty surrounding the efficacy, transferability, and sustainability of CA. These relate to the purported environmental, social, and economic benefits of CA, but also, critically, the manner in which CA is being promoted, implemented, and adopted among NGOs and their target farming communities. Put simply, despite the increasing interest and enthusiasm in

CA as a means of addressing food insecurity, it is still not clear what works, where, and why. It is within this context that this paper presents the experiences of one form of CA known as deep-bed farming (DBF) which has spread rapidly throughout northern Malawi via the development and extension activities of the small NGO, Tiyeni. Following an outline of the DBF method itself, we discuss the results of a recent field study carried out with adopters and non-adopters that aimed to identify the key factors influencing their decision to adopt DBF. In particular, we discuss the strengths and weaknesses of the NGO-driven DBF extension, and identify some wider lessons.

Challenges for smallholder farmers in Malawi

Despite significant progress in recent years Malawi remains one of the world's poorest countries, ranking 172 out of 189 countries on the UNDP's Human Development Index (UNDP 2019) and with half of its 18 million inhabitants living below the national poverty line. While agriculture generates over 90% of export earnings and up to 40% of Gross National Income, an estimated 80% of the population continue to be engaged in subsistence agriculture under the customary land tenure system (ADB 2019; World Bank 2019). Beyond the production of the export crop tobacco, agriculture in Malawi is dominated by smallholder maize production, which provides up to 60% of the daily calorific intake of the average Malawian (Ortega et al. 2016). Within the smallholder maize production system, however, yields remain relatively low (only 20% of potential yields) mainly as a result of the persistent use of local seed varieties, the lack of availability and affordability of fertilizer, poor markets, and a range of environmental challenges which subsistence farmers must continuously adapt to. Food insecurity is, therefore endemic; famine is a regular occurrence in many areas and an estimated 33% of the population live in a state of very poor food security characterized by irregular quantities and frequencies of food intake (FAO 2014).

The main environmental challenge facing subsistence farmers is in many ways a consequence of the widespread reliance on maize itself; cultural preference for maize combined with government subsidies have encouraged the spread of conventional mono-cropping practices which have been blamed for declining soil fertility, reduced water availability, and high rates of soil erosion (Thierfelder et al. 2013b). Indeed, recent estimates suggest that Malawi loses on average around 29 tons of soil per hectare per year, with the highest rates of up to 39 ton/ha/yr occurring in Nkhata Bay District in the north (FAO 2018). The constant hoe tillage of soil on ridges and often sloping land without soil and water conservation measures implemented results in the erosion, desiccation, and compaction of productive topsoils. One consequence of this is the creation of soil hard-pans between 15 and 30 cm below the surface, which prevent the infiltration and percolation of rainfall, and are characteristically low in organic matter, have acidic pH, and hinder adequate rooting depth for crops. Previous studies have noted the abundance of these hardpans throughout northern Malawi, as observed by stunted root development for maize (often less than 15 cm) and via the oral testimonies of farmers (Douglas et al. 1999). These conditions are further exacerbated by the emerging impacts of climate change across the region where unpredictable, high-intensity or delayed rainfall events are proving challenging for farmers (Sutcliffe, Dougill, and Quinn 2016).

In the search for ways to address these challenges, many government and non-government organizations throughout Malawi have turned to CA as a potential means of improving food security and the livelihoods of smallholder farmers (Dougill et al. 2017; Fisher et al. 2018; Ngwira et al. 2014). Estimates suggest, however, that the uptake of CA in the field remains very low, with evidence of dis-adoption elsewhere (Anderson and D'Souza 2014; Corbeels et al. 2014; Giller et al. 2009; Phiri, Chilonda, and Manyamba 2012).

The Deep-Bed Farming System

Founded in 2005, Tiyeni Malawi is a small charity and non-governmental organization that supports the development of sustainable and resilient livelihoods among farmers in Malawi in response to environmental degradation. Its principal activities involve the provision of training and extension support of what has been widely considered throughout the region as an innovative 'deep-bed farming' (DBF) system. The DBF system was developed by a small team of practitioners based in Mzuzu and was directly inspired by Francis Shaxson's work on soil compaction, erosion, and agroecological approaches to land husbandry (Shaxson et al. 1997; Shaxson, Williams, and Kassam 2014), which itself draws on the long-recognized problem of soil compaction throughout southern Africa (Douglas et al. 1999; Trapnell 1943; Trapnell and Clothier 1937). Since 2005, when the first DBF demonstration garden was established, the method has been adopted by over 15,000 farmers throughout Malawi. As reports of its significant contribution to increased crop yields have spread, there has been a steady increase in demand for support, which at times has outstripped Tiyeni's capacity to supply its extension services. In acknowledging this demand, and being cognizant of its own technical and logistical capacity, Tiyeni has sought to develop collaborative linkages with the Ministry of Agriculture and Food Security, and to date have trained over 200 government extension workers from 28 EPAs (Extension Planning Areas) in the DBF system. While these extension workers similarly report a high demand for DBF from the field, formal extension support to farmers from government remains limited since DBF has yet to be certified by the government's Agricultural Technology Clearing Committee (ATCC). Once this is achieved (field testing by the Department for Agricultural Research Services is

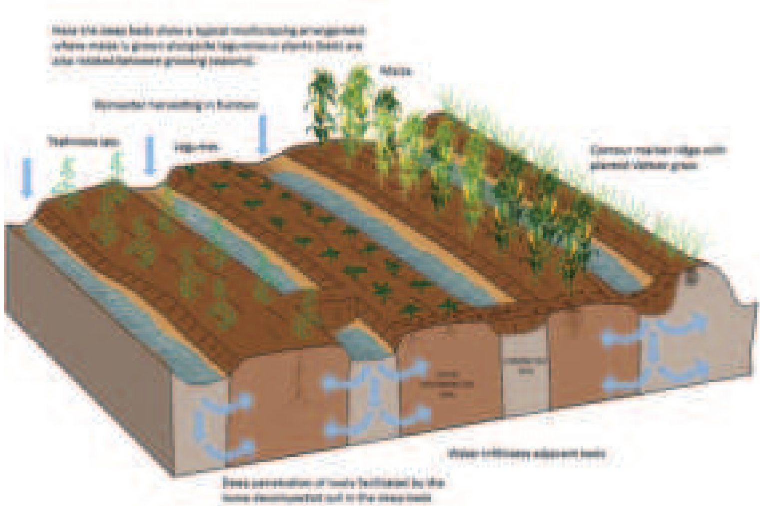

Figure 1. Tiyeni's deep-bed farming system.

ongoing), however, there is scope for the system to be implemented in every EPA across the country.

At its core, DBF (Figure 1) incorporates many of the principles and elements of CA outlined above, which continue to be adopted in CA systems around the world (Dixon et al. 2017; Friedrich, Derpsch, and Kassam 2012). The key innovation, however, is arguably the first stage of the land preparation process which involves the manual breakup and fracturing of the hardpan using pickaxes. This ensures a less compacted and more porous soil structure which enhances deeper root development, soil microbiological activity, and water infiltration (Shaxson 2016). Farmers then construct contoured marker ridges using poles and a line-level; these provide a reference point for the subsequent cultivation beds, but they are also planted with vetiver grass (*Vetiveria zizanioides*) as a means of stabilizing the soil, increasing water infiltration, reducing erosion, and providing a source of mulching material in addition to crop residues (see Grimshaw and Helfer 1995). The contoured marker ridges create adjacent furrows, which are closed at each end with soil to reduce runoff and erosion, and adjacent to these a series of raised cultivation beds are constructed. These 1-meter width beds are finely tilled, again as means of enhancing soil and water conservation, root growth, and the accumulation of organic matter, and after their construction farmers are instructed to avoid trampling on them as much as possible. Box ridges are made between the furrows of these beds as another additional physical feature to help with rainwater harvesting and preservation which provides extra moisture for the crops during critical growth phases when droughts or dry spells strike. Intercropping and crop rotation in these beds are encouraged to spread the risk of crop failure due to pests and diseases, and maize planted alongside leguminous species are particularly recommended. Tiyeni provides farmers with guidelines on a range of cultivation options, however, which draws upon experience of their effectiveness in the specific social-ecological context of northern Malawi over the years. Agroforestry is similarly encouraged; species such as *Tephrosia vogelii* and *Sesbania sesban* have long been associated with having a positive impact on maize production (Sileshi et al. 2008). Finally, mulching of the beds using crop residues and *Vetiveria zizanioides* is encouraged as a means of reducing evaporation and increasing soil organic matter content.

Tiyeni's system also involves training farmers in the production of bokashi compost, which can then be applied to the cultivation beds. Bokashi, meaning 'fermented organic matter', derives from traditional Japanese composting methods that involve the mixing of food waste with soils, with the key ingredient being 'efficient microorganisms' (yeasts and bacteria) which aid fermentation and the production of rich soil nutrients. Research has shown that in many cases bokashi manure can produce the same increases in soil fertility and crop production as artificial fertilizers (Quiroz and Cespedes 2019; Xiaohou et al. 2008). Because it uses local waste products found in and around the farm (crop residues, animal manure, ash, maize bran) bokashi manure is both environmentally friendly and low-cost. The production process takes between 2 and 3 weeks in dedicated composting sheds located adjacent to Tiyeni fields. Other types of organic manure Tiyeni advocates include *Changu* manure, compost, and *Mbeya* Manure, which are all made from locally available resources similar to those used to make bokashi.

This system is operationalized in the field as a responsive extension package which integrates formal training with farmer-to-farmer extension approaches (Franzel, Kiptot, and Degrande 2019; Moris 1991) in an attempt to embed and sustain the method at the community level. Until 2017 a centralized demonstration garden group extension approach was adopted, in which interested farmers would request support from one of Tiyeni's field officers who would then seek the designation of a community demonstration site from the village headman. This site became the focal point of training and extension in the area, where Tiyeni trained 'lead' farmers in the concepts and practice of DBF. Each demonstration garden received a package of pickaxes, hoes, a line level, 5 kg each of NPK and Urea fertilizer, and 1 kg each of maize, soya beans, and groundnut seeds sourced from local agricultural dealers. Tiyeni also provides two pigs as a means of producing manure and generating income from the sale of piglets. Typically, up to 30 lead farmers were involved in managing each demonstration garden, each tasked with disseminating and showcasing the DBF to other farmers as well via their own individual farms. These farmers received extension support (advice) from Tiyeni for a further three years. Following some emerging issues relating to shared responsibilities and equitable access to benefits in demonstration gardens, however, a new decentralized demonstration garden approach has been introduced. Since 2018, every farmer establishes a demonstration garden on their own farm, and in rotation they host one of Tiyeni's training activities thereby ensuring a more equitable distribution of resources and farmer esteem.

Most of the farmers engaging with DBF have been located in a 45 km radius around Mzuzu (Figure 2), but as word of the successes of the DBF has spread more widely, as of 2019 it is being practiced in districts as far away as Lilongwe, Blantyre, Zomba, Chikwawa, Chitipa, and Dowa. In those areas where DBF has been adopted, reports from the field consistently suggest that farmers experience a significant and sustained increase in crop production (usually more than double the conventional yield of maize) which clearly has the potential to make a significant contribution to food security and livelihood resilience (Gondwe 2018). Consequently, as is so often the case with many NGOs and CA itself, Tiyeni has become almost evangelical in its support for the wider adoption of DBF, which it clearly considers a panacea for food security issues throughout the country. Indeed, the almost exponential growth in farmer demand for the DBF since 2005 has further given Tiyeni the confidence to develop a 'gold standard' that incorporates a prescriptive set of DBF practices that farmers should follow and that, it is suggested, guarantees high yields alongside soil and water conservation. To date there has been no systematic attempt to qualify the impacts of DBF or the nature of its adoption by farmers in the area. Yet, as previous studies have highlighted, understanding the barriers and facilitators of adoption are critical if Tiyeni is to succeed and deliver long-lasting sustainable outcomes for people and the environment. The research outlined in the rest of this paper sought to address this gap via a small-scale investigation of farmer experiences, with a particular focus on understanding the advantages and disadvantages of the DBF system, what influences adoption, and what scope there is for improvement in Tiyeni's activities.

Methods: Researching DBF adoption

Study sites

The research was conducted in 36 communities that practice DBF located in five (EPAs), namely Zombwe, Emsizini, Chikwina, Bwengu, and Kavuzi (Figure 2) within the 45 km radius of Mzuzu city. These communities are located in Mzimba and Nkhata Bay districts in Mzuzu Agricultural Development Division (ADD). These communities represent Tiyeni's first catchment area since it began its work in 2005. Mzimba district, in which Zombwe, Emsizini, and Bwengu EPAs are found, is characterized by hilly and undulating terrain, inhabited by mainly Tumbuka and Ngoni people who are almost entirely dependent on maize for their daily food needs. Chikwina and Kavuzi, meanwhile, are more mountainous and have a higher population of Tonga people whose staple food is made from cassava. All these areas

Figure 2. Study sites showing the location of the five Extension Planning Areas (EPA) within Tiyeni's wider operational reach.

experience a unimodal rainfall pattern (1280 mm average per year) in which the rainy season occurs from November to April, and the dry season from May to October. Dry spells lasting about two weeks are common in the middle of the rainy season, and in worst cases in-season droughts may last longer than two weeks with far-reaching negative impacts on maize yields, and hence household and national food security. Temperatures range from 10° C during the winter and as high as 32° C in summer.

Farmers belonging to each of the 36 communities are typical of the many households in Malawi who depend on subsistence farming as their major livelihood activity. However, farmers in Nkhata Bay often own larger pieces of land than those found in Mzimba district due to differences in population densities. The major crops grown in all these study sites are maize, cassava, beans, sweet potatoes, potatoes, pumpkins, soya beans, ground beans, groundnuts, tobacco, and paprika in some cases. Many farmers in both Mzimba and Nkhata Bay districts diversify their livelihoods through engaging in small-scale business activities, e.g. selling fish, doughnuts, and other raw merchandise. Wetland (dimba) cultivation is also an important activity which brings in extra cash and food during lean periods of the year when earnings from rain-fed agriculture are exhausted (Wood and Thawe 2013). Brickmaking and charcoal production, while illegal, are also common yet seldom disclosed by farmers.

Sampling and data collection

The names of the farming groups or communities from each EPA were sourced from Tiyeni who keeps records of all the farmers they work with. Subsequently, participants were selected through proportional random sampling within the geographical clusters of the 36 communities. A total of 135 respondents were selected, although of these, 111 farmers gave their consent to being interviewed. Data were collected using a semi-structured interview containing questions relating to household characteristics, livelihood activities, farming practices, the impacts of Tiyeni, factors influencing adoption, as well as the strengths and weaknesses of the DBF system. A team of four trained data collectors implemented the survey in each farmer's home or an alternative convenient place, and in some cases, other family members were present. The face-to-face encounter between the interviewers and the respondents allowed farmers to elaborate upon their points and to be questioned further by the interviewers when the need for clarification arose. After each interview, the interviewer verified the accuracy of responses with each farmer to reduce the chances of misinterpretation. Farmers were also given an opportunity to freely ask any follow-up questions of their own. Each interview was recorded by hand and later transcribed for thematic and quantitative analysis.

Results

DBF adopters

Among the respondents in our survey, farmers practicing DBF range from as young as 18 years to over 75 years, with 48% falling within the 31–54 age range and 30% between 55 and 74 years. Younger farmers (18–30 years old) comprised 23%. Slightly more Tiyeni adopters were women farmers (52%), and in terms of educational level 72% of all farmers had a primary school education, 23% attended secondary school and 5% had experienced tertiary education.

The majority of Tiyeni farmers (69%) typically have between 5 and 8 family members while a further 24% have a family size of 2–4 members. Only 17% stated that all their family members were available for on-farm labor while 13% indicated that their family members are mobile and do not usually assist with farming. A small number of those interviewed (7%) indicated that they also had extended family members residing nearby.

Income diversification was evident in all communities with many households supplementing their agriculture-based livelihood with a range of other activities. For example 28% of all farmers ran small businesses such as doughnut production, marketing produce (tomato, onions, potatoes, vegetables, sugarcane, bananas, pumpkins, and fruits like oranges and mangoes), and selling fish. Other common activities included brickmaking and bricklaying, charcoal production (despite this being legislatively prohibited in some areas), running small grocery shops, working in saw mills, beekeeping, mat making, livestock selling, and tailoring. A small proportion of farmers (3%) also have formal employment. All of the 111 farmers interviewed practiced traditional ridge cultivation in addition to DBF.

Adoption and extension of DBF

In terms of their introduction to DBF, the most common cited source of information for DBF were visits by the Tiyeni extension agent (38%), with between 10% and 20% of farmers citing other forms of formal Tiyeni contact. Interestingly, 27% of farmers suggested that they learned about DBF through communication and observation of relatives and/or neighbors. Motivations for DBF adoption were diverse, although most farmers (87%) cited high crop yields as the major attraction; 90% reported a doubling of their yields over the use of traditional ridges while a further 10% suggested it had tripled. Many farmers (43%) cited cheap production costs linked to the use of organic fertilizers (locally made manure) which reduces the cost of buying expensive inorganic fertilizers. Just over a third of farmers (36%) also mentioned water conservation resulting from box ridge construction as an influential factor. Similarly, 23% of farmers perceived the DBF to be more labor saving than traditional agriculture, given the five year zero-tillage regime which was seen as allowing time to be spent on other activities such as dimba cultivation (winter farming), small businesses, and other livelihood activities. However, all farmers suggested that others may be discouraged to adopt because of the perception that tillage during the first year (especially breaking the hard pan) is hard work. Interestingly, a small proportion of farmers (15%) stated that they adopted DBF as an experiment in the first instance in order to verify the claims of high yields, and thereafter chose to continue. Other motivating factors mentioned by farmers included the potential improvements to soil fertility (12%) the prevention of crop wilting (12%), control of soil erosion (10.8%), the

Table 1. Extension of DBF from first to second year of implementation.

	Year 1			Year 2		
Coverage of DBF	Number of Farmers	% of farmers	Total area under DBF (acres)	Number of farmers	% of farmers	Total area under DBF (acres)
0.25 acre	110	99%	27.5	31	28%	7.75
0.5 acre	1	1%	0.5	66	59%	33
0.75 acre	0	0%	0	11	10%	8.25
1 acre	0	0%	0	3	3%	3
TOTAL	**111**	100%	**28**	**111**	100%	**52**

provision of inputs and support from Tiyeni (5%), crop diversification (3%) and the provision of pigs as part of the DBF package (3%). A further 1% of farmers linked their DBF adoption to their desire to " … *get help from white people that work with Tiyeni".*

Having adopted DBF, a significant proportion of farmers (72%) sought to extend its coverage during the next year by at least doubling the size of the DBF plot (from 0.25 to 0.5 acre) (Table 1). Overall this is estimated to have led to an 86% increase in the total land area under DBF from year 1 to year 2, which contrasts with the observations of Ngwira et al. (2014) who reported a very slow uptake of CA in Malawi. Again, when asked about the reasons for this rapid increase in DBF cultivation, farmers cited their experience of achieving high yields during the first year of cultivation along with the low production costs associated with using organic fertilizer treatments. In addition, a small number of farmers were motivated to win the prize of a pig in Tiyeni's 'best farmer' competition.

All the farmers who chose not to extend their DBF (28% of all farmers) attributed this to the difficulties associated with breaking the hard pan during the first year (it is perceived as 'hard work') and hence the implication here is that the availability of labor once again pays a critical role in adoption and extension. Some farmers cited their lack of access to animal manure as a further limiting factor; this, however, appears to be based on a misconception that large quantities of animal manure are required for the DBF when in reality Tiyeni encourages and trains farmers in different techniques of fertilizer production, many of which do not depend on animal manure. Moreover, the manure demands of DBF are not dissimilar to traditional agricultural practices (although it is recognized that many farmers simply do not have the livelihood assets to extend their traditional ridge cultivation, let alone DBF). Finally, and linked to this last point, was the assertion by some farmers that they did not have access to enough land to be able to extend their DBF further, especially since the practice requires wider spacing between the wide raised beds. There did, however, appear to be some confusion and inconsistencies regarding their perceptions of what measurements were required for DBF.

Given that communication with neighbors was found to be an important means of acquiring knowledge of DBF, not all the neighboring farmers of those surveyed had similarly adopted DBF. When asked about why their neighbors chose not to adopt, the majority of DBF farmers attributed this to the widespread perception that DBF is hard work, with many accusing their neighbors of either being 'lazy' or 'slow' to adopt new practices. There was, however, some recognition once again that the size of each farm was influential. Interestingly, those farmers not practicing DBF were found to have adopted some of its components including manure making, contour terraces, and the use of agroforestry plant species such as *tephrosia* in their fields.

As mentioned above, some farmers practicing DBF did not learn it via formal contact with any Tiyeni representatives, and during the fieldwork it emerged that a further 132 independent farmers across the 36 communities were independently practicing DBF. Based on this, it is estimated that as many as 3200 farmers, over double the official number receiving extension support, are actively engaged in DBF within Tiyeni's original 45 km operational radius. Again, the motivation here is arguably the pull (and evidence) of higher yields, alongside a conducive livelihood asset portfolio. There was a suggestion, however, that some DBF adopters seek to retain their independence from Tiyeni because they want to avoid any potential conflicts with other farmers (an issue precipitating the recent shift to a decentralized extension model). This issue of group conflict was also cited as one of the reasons why a small number of DBF adopters (n = 6) reported that they had temporarily abandoned the practice.

Tiyeni's strengths and weaknesses

When asked about the benefits and successes of DBF for them personally, all farmers stated that they had become more food secure. Figure 3 illustrates the further range of perceived benefits to farmers, and most notably the significance of receiving inputs and equipment, and being trained on manure production.

Of particular interest, however, is farmers' perceptions of how the DBF system and Tiyeni's extension activities could be improved. Here, a major concern was the relatively small size of the DBF starter package (5 kg NPK + 5 kg UREA fertilizer + 1 kg seed), along with the fact that this is only distributed to those practicing DBF for the first time. Not surprisingly, farmers stated that they would like to see this increased to 50 kg of UREA and 5 kg of seeds, and this being distributed to every farmer every year. Moreover, farmers were critical of the lack of Tiyeni undertaking a seed compatibility check in a particular area; around 70% said that were given seeds for crops which were incompatible with the soil and climate of their area. While expressing their gratitude for 'hard- working' Tiyeni staff, farmers also expressed a desire for more field officers who could facilitate more frequent support visits.

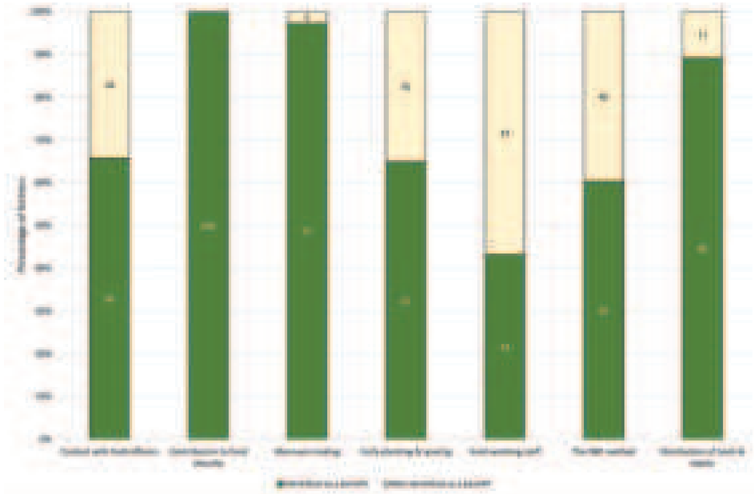

Figure 3. Farmers' perceptions of the relative importance of Tiyeni benefits.

Relative to the extension activities of other organizations, farmers suggested that the training facilitated by Tiyeni was the most valuable. However, 66% expressed a desire to have more training sessions per year, and for this training to be undertaken at a town-based training center with accommodation and a daily allowance included, in a similar manner to longer-established NGOs working in the area. Farmers were also critical of the livestock it provides, in particular the distribution of pigs, which they see as incompatible with the cultural and religious beliefs of some farmers.

The nature of Tiyeni's demonstration system has also meant that lead farmers (i.e. those who are directly trained by Tiyeni) often travel long distances to meet with the farmers to whom they have farmer-to-farmer extension responsibility. This is perceived as both time-consuming and tiring, and ideally addressed through the provision of bicycles as part of the original extension package for lead farmers. Other issues identified included: the need for Tiyeni to facilitate better access to field day celebrations, distribution of the starter package earlier in the farming calendar, and improved provision of advice and support on crop production that aligns with specific markets in the areas.

Discussion

This preliminary study of some farmer experiences of the DBF system raises some interesting findings in the context of wider debates concerning CA and its adoption across sub-Saharan Africa, not least in terms of the reasons for adoption (and disadoption) rates, livelihood impacts, and the long-term sustainability of the DBF and Tiyeni's goals. In contrast to the slow/low adoption rates of CA noted in various countries including Malawi (Corbeels et al. 2014; Giller et al. 2015, 2009; Kassam, Friedrich, and Shaxson 2014; Mloza-Banda, Makwiza, and Mloza-Banda 2016; Ngwira et al. 2014), this research suggests that DBF adoption by farmers has been rapid and sustained. This can be attributed to a range of factors, most significantly immediate and demonstrable high crop yields (especially maize) that contrast with the 'yield penalties' reported as explaining slow CA uptake elsewhere (Anderson and D'Souza 2014; Giller et al. 2009; Titonell and Giller 2013). The results of our study also indicate that farmers perceive a reduction in soil erosion from their DBF fields relative to the conventional ridge system. In conventional no-till CA systems erosion reduction has been attributed to crop residue mulching (Thierfelder et al. 2015; Ngwira et al. 2012; Mloza-Banda and Nanthambwe 2010), whereas farmers in our study singled out the influence of contoured box ridges alongside closed-end furrows. In the high gradient environments of northern Malawi, these physical structures ensure both soil and water remain in the catchment, and farmers report this as preventing crop wilting during dry spells and thus making smallholder farming more resilient to impacts of climate variability and change.

While ongoing field research is seeking to analyze the nature and dynamics of these benefits in more detail, the spontaneous adoption of DBF among those neighboring Tiyeni-trained farmers adds further weight to claims of DBF effectiveness. Moreover, this has been achieved through an informal process of farmer-to-farmer communication and observation (Dixon 2005; Mundy and Compton 1995), enhanced by strong social capital which Tiyeni itself has sought to enhance through regular extension visits and training. This echoes a process increasingly being seen as key to building capacity for sustainable and climate-resilient agriculture throughout Africa (Knowler and Bradshaw 2007; Sumane et al. 2018).

It is clear, however, that adoption of the DBF is also contingent on a wide range of household and site-specific biophysical variables, as has been the case elsewhere (Knowler and Bradshaw 2007; Thierfelder et al. 2013a). Although this requires more in-depth research, the availability of land and labor emerges as critical to adoption and intensification; DBF adopters possess the land and labor to pilot the new technology (alongside traditional techniques), while for the less asset-rich farmers DBF appears to be regarded as risky and too labor demanding to render it worthwhile. This, however, contrasts with the assertion by DBF farmers that DBF actually saves labor relative to traditional ridge cultivation in terms of reduced tillage after the first year of implementation. This raises important questions, not least for Tiyeni's extension team, about the perceived versus real labor demands, what influences these, and how potentially unfounded negative perceptions of DBF can be addressed in order to enhance adoption.

Beyond those who adopt and those who don't, our study identified a small number of farmers (n = 6) trained by Tiyeni but whom subsequently abandoned the DBF system. Some of these reverted purely to traditional ridge agriculture while others retained specific elements of DBF such as the box cultivation beds or contour terracing. This is consistent with the wider experiences of CA where livelihood benefits are often reportedly short-lived, or where direct external support for farmers is phased out (Giller et al. 2009; Titonell and Giller 2013). Although the reasons for abandonment of DBF are undoubtedly rooted in site-specific social-ecological characteristics, there is a sense from the study area that some farmers feel they cannot sustain DBF beyond the first few years in the absence of further handouts of seed and fertilizer, and continuous extension support. While labor demands are most likely influential here, this nonetheless raises more questions regarding the longer-term sustainability of DBF in economic, social, and environmental terms, as well as the effectiveness of Tiyeni's overall approach. Tiyeni has neither the resources nor the desire to support its farmers in perpetuity, and it is acutely aware of the need for appropriate exit strategies in order to avoid a culture of farmer dependency. Its collaboration with government extension services is further evidence of this. This is appropriate; NGO interventions should arguably aim to build institutional capacity and deliver long-lasting sustainable solutions that are embedded at the local-level (Banks and Hulme 2012). It could be argued, however, that Tiyeni also has an obligation to understand why some farmers abandon DBF, so that it can modify its extension approach or even elements of the DBF system itself, in order to become more responsive, inclusive, and sustainable. This would mean a shift for Tiyeni away from its prescriptive one-size-fits-all 'gold standard' approach to one where it tailored its DBF intervention to the social-ecological context of each farming household. Given that some 'disadopter' farmers are already selectively adopting practices from the DBF 'menu' – because that delivers benefits for them – there is arguably some merit in Tiyeni offering a more flexible and adaptive package. Indeed, should the DBF be formally approved by the government's ATCC and hence be implemented across Malawi's diverse social-ecological landscapes, the need for flexibility and adaptive practice becomes more pressing. A further benefit would be a shift away from the divisive and pervasive adopter/non-adopter polarized view of farmers, where the latter are often stigmatized in a manner not dissimilar to colonial times (Green 2009). Again, this debate echoes that of the wider CA movement, which tends to be characterized by a reluctance to appreciate the implications of diversity in agricultural contexts or deviation from a canon of practices (Anderson and D'Souza 2014; Giller et al. 2009).

Conclusions

This paper has presented the findings of the first small-scale study examining farmers' experiences of adopting Tiyeni's DBF system in northern Malawi. Fundamental to the DBF system is its integration of some key elements of mainstream conservation agriculture practice alongside several specific adaptations to the landscape of northern Malawi, most notably the loosening of the soil hardpan and the incorporation of contoured no-till raised beds. Those farmers adopting the DBF confirm its significant impact on their livelihoods relative to the traditional ridge cultivation in terms of a doubling or trebling of crop yields. In addition to the immediate benefits of higher crop yields, farmers suggest that the success and spread of Tiyeni are a result of cheaper production costs, fewer labor demands in tillage, discernible improvements to soil fertility, a reduction in soil erosion, water retention in the fields, and the provision of extension support in the form of training and a starter package of seed and fertilizer. Of particular significance is the widespread spontaneous adoption of the DBF system by many farmers who had not received any formal extension support from Tiyeni; the practices and benefits of DBF have been disseminated informally via farmer to farmer observation and word of mouth. This suggests further that DBF offers a significant improvement on existing agricultural techniques.

DBF is not without its problems, however. The study identified several instances of disadoption after several years that were attributed to the challenging labor demands of DBF relative to traditional agriculture, the lack of extension support after the first year, and conflicts with other farmers working on the same demonstration garden. While the latter has recently been addressed by Tiyeni in its move toward a decentralized demonstration garden approach that ensures equitable distribution of benefits for lead farmers, this study has identified the need to examine in more detail the circumstances under which farmers cease to benefit from the DBF. Tiyeni rightly recognizes the potential of the DBF to have a long-lasting impact on poverty across Malawi, and it has an ambitious program of extension and dissemination. The success of this, however, may rest on moving away from a prescriptive set of practices that potentially exclude asset-poor farmers, to a more flexible and adaptive menu of DBF options that can be selectively applied according to the needs of farmers in different social-ecological contexts. Moreover, Tiyeni has huge potential to learn from its 15000+ farmers whose knowledge and experience can inform the future evolution of the DBF. Whilst this approach risks being anathema to many in the wider CA movement, there is emerging consensus from across sub-Saharan Africa and beyond that capacity building for local-level adaption in social-ecological systems has a critical role to play in developing sustainable and climate-resilient agriculture throughout Africa.

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