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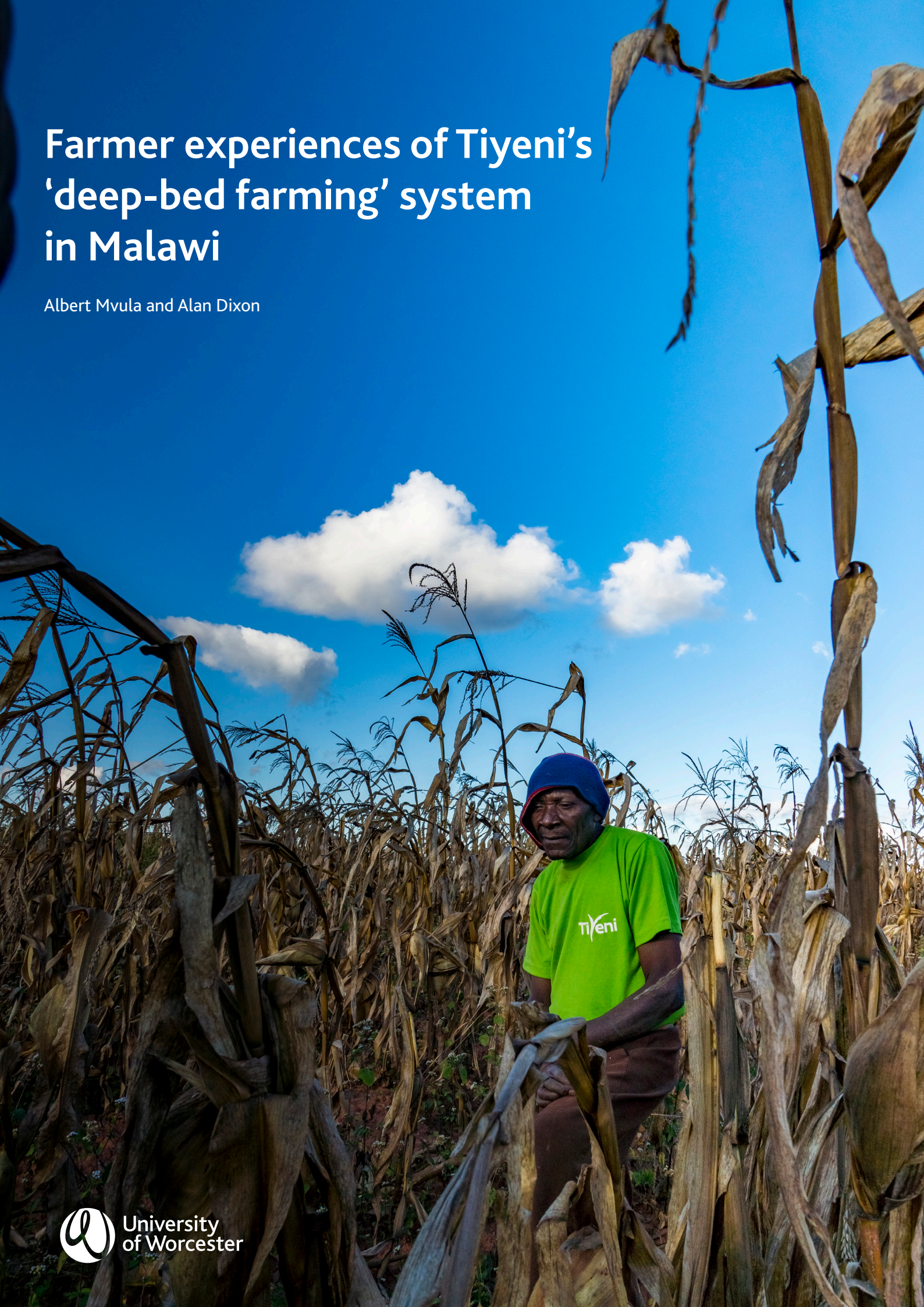
Albert Mvula and Alan Dixon



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Key points

- Environmental change in northern Malawi is having a significant impact on people's livelihood and food security;
- Tiyeni's 'Deep Bed Farming' system offers the potential to improve food security in an environmentally, economically and socially sustainable manner;
- Our research investigates the experiences of farmers (n=111) adopting the DBF via a field survey undertaken in 2017;
- Results suggests positive experiences among most Tiyeni farmers characterised by signfiicant increases in crop yield and the wider spontaneous adoption of the DBF throughout northern Malawi;
- Whilst DBF delivers significant livelihood benefits for most farmers relative to traditional techniques, a small number of asset-poor farmers are unable to sustain DBF due to its labour demands;
- There is a need for further research to examine the relationship between different social-ecological contexts and DBF adoption.

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 (World Bank, 2019; ADB, 2019). Beyond the production of the export crop tobacco, agriculture in Malawi is dominated by smallholder maize production, which provides up to 60 per cent 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 fertiliser, 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 low poor security characterised 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. 2013). 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 tillage of soil on often sloping land without soil and water conservation measures implemented, results in the erosion, desiccation and mineralisation of productive topsoils. One consequence of this is the creation of soil hard-pans which prevent the infiltration and percolation of rainfall, and are characteristically low in organic matter, have acidic pH, and provide insufficient rooting depth for crops. 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 et al. 2016).

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

The Deep-Bed Farming System

Founded in 2005, Tiyeni Malawi is a small charity and non-governmental organisation 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 the '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 agro-ecological approaches to land husbandry (Shaxson et al. 1997; Shaxson et al. 2014), which itself draws on the long-recognised problem of soil compaction throughout

Tiyeni

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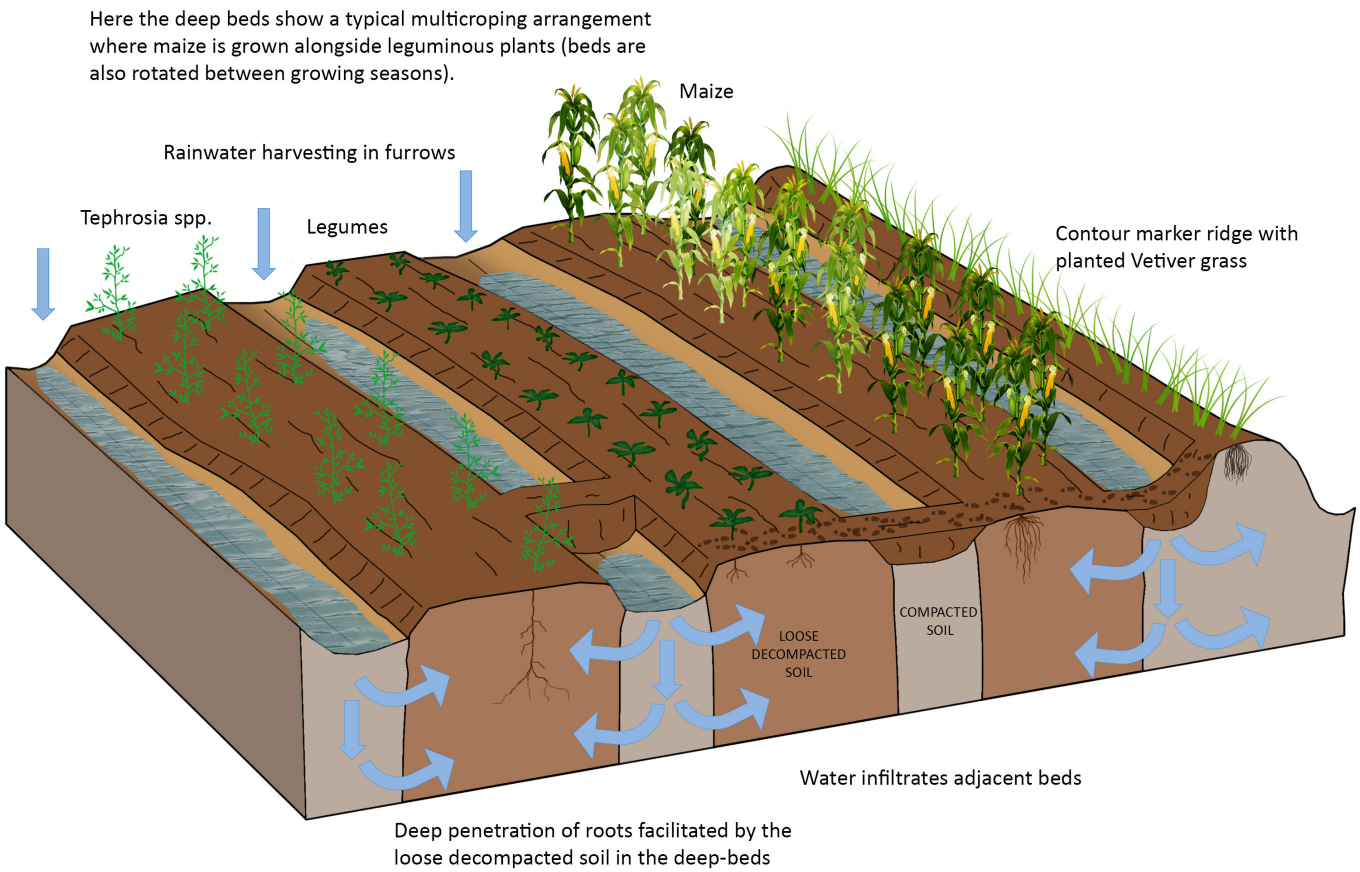
southern Africa (Trapnell and Clothier, 1937; Trapnell, 1943). Since 2005, when the first DBF demonstration garden was established, the method has been adopted by over 12,000 farmers throughout Malawi. As reports of its significant contribution to increased crop yields have spread, there has been a steady increase in demand for support, which at times has outstripped Tiyeni's capacity to supply its extension services.

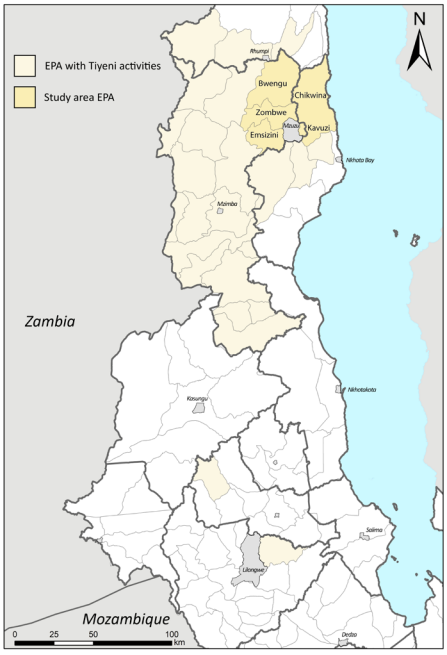
At its core, DBF incorporates many of the principles and elements of CA outlined above, which continue to be adopted in CA systems around the world (Friedrich et al. 2012; Dixon et al. 2017). A key innovation, however, is the first stage of land preparation which involves the manual break-up and fracturing of the hardpan using pickaxes and hoes. This ensures a looser, less compacted 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 stabilising 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 metre 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 vetiver 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 fertilisers (Xiaohou et al. 2008; Quiroz and Cespedes, 2019). 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 for include Changu manure, compost, and Mbeya Manure, which are all made from locally available resources such those used to make bokashi.

This system is operationalised in the field as a responsive extension package which integrates formal training with farmer-to-farmer extension approaches (Moris, 1991; Franzel et al. 2019) in an attempt to embed and sustain the method at the community level. Until 2017 a centralised 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, 5kg each of NPK and Urea fertiliser, and 1kg each of maize, soya beans and groundnut seeds sourced from local agricultural dealers. Tiyeni also provides pigs and goats as a means of producing manure and generating income. 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 decentralised 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 45km radius around Mzuzu, but as word of the successes of the DBF has spread more widely, as of 2019 it is being practised in districts as far away as Lilongwe, Blantyre, Zomba, Chikwawa, Chitipa and Dowa. 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, Tiyeni has strongly supported he wider adoption of DBF which it considers a panacea for food security issues throughout the country. Indeed, the almost exponential growth in farmer demand for the DBF since 2005 has lead to development of a 'gold standard' of DBF practices that famers 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 is critical if Tiyeni is to succeed and deliver long-lasting sustainable outcomes for people and the environment. The research outlined in this paper was concieved to address this gap via a small-scale prelminary 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 undertaken in June 2017 among 36 communities practising DBF located in five Extension Planning Areas (EPAs), namely Zombwe, Emsizini, Chikwina, Bwengu and Kavuzi within the 45km radius of Mzuzu city. These communities are located in Mzimba and Nkhatabay 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 characterised 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 experience a unimodal rainfall pattern (1280mm 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 100 C during the winter and as high as 320 C in summer.

Farmers belonging to each of the 36 groups 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 (dambo) 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.

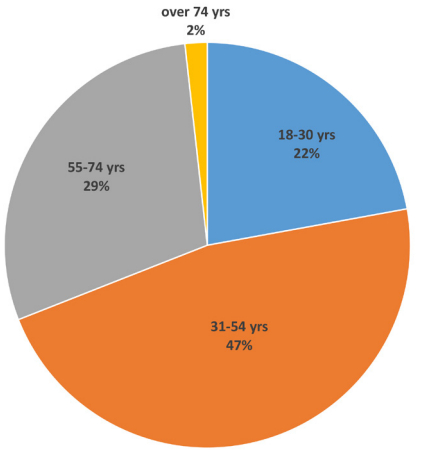
Sampling and data collection

The names of the farming groups or communities from each EPA were sourced from Tiyeni who keep records of all the farmers they work with. Subsequently, participants were selected through proportional random sampling within the geographical clusters of the 36 groups. 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

In our survey, farmers practising DBF range from as young as 18 years to over 75 years, with 48% falling within the 31-54 age range and 30% between 55-74 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 5-8 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 labour 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.



"All of the 111 farmers interviewed practised traditional ridge cultivation in addition to DBF."

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 practised traditional ridge cultivation in addition to DBF.

Adoption and extension of DBF

"90% reported a doubling of their yields over the use traditional ridges while a further 10% suggested it had tripled."

In terms of their introduction to DBF, the most common cited source of information for DBF was visits by the Tiyeni extension agent (38%), with between 10-20% 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 neighbours. Motivations for DBF adoption were found to be diverse, although most farmers (87%) cited high crop yields as the major attraction; 90% reported a doubling of their yields over the use traditional ridges while a further 10% suggested it had tripled. Many farmers (43%) cited cheap production costs linked to the use of organic fertilisers (locally made manure) which reduces the cost of buying expensive inorganic fertilisers. 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 labour 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 a 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 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) (see 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.

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**

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 fertiliser treatments. In addition, some 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 labour 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 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 fertiliser 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 recognised 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.

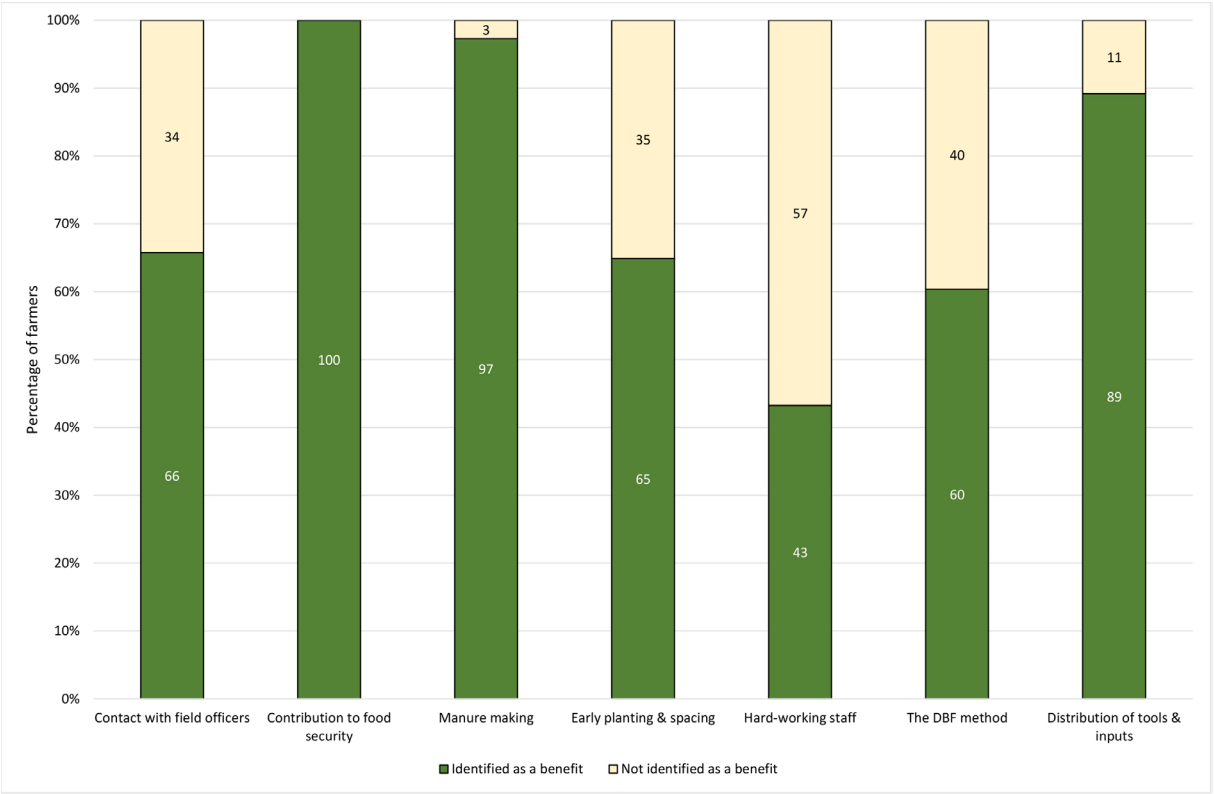
"Access to land can limit DBF extensification"

Given that communication with neighbours was found to be an important means of acquiring knowledge of DBF, not all the neighbouring farmers of those surveyed had similarly adopted DBF. When asked about why their neighbours chose not to adopt, the majority of DBF farmers attributed this to the widespread perception that DBF is hard work, with many accusing their neighbours 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 practising 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 practising 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 practising 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 45km 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 decentralised 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. The figure below 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 (5kg NPK + 5kg UREA fertiliser + 1kg seed), along with the fact that this is only distributed to those practising DBF for the first time. Not surprisingly, farmers stated that they would like to see this increased to one 50kg of UREA and 5kg 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.

Relative to the extension activities of other organisations, 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 centre 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 provided at the time, 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 to specific markets in the areas.

Discussion

"Our research suggests that DBF adoption by farmers has been rapid and sustained."

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 (Kassam et al. 2014; Giller et al. 2009; Giller et al. 2015; Mloza-Banda et al. 2016; Ngwira et al. 2014; Corbeels et al. 2014), our 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 (Titonell and Giller, 2013; Giller et al. 2009; Anderson and D'Souza, 2014). 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 on-going PhD field research is seeking to analyse the nature and dynamics of these benefits in more detail, the spontaneous adoption of DBF among those neighbouring 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 (Mundy and Compton, 1995; Dixon, 2005), 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. 2013). Although this requires more in-depth research, the availability of land and labour emerges as critical to adoption and extensification; DBF adopters possess the land and labour to pilot the new technology (alongside traditional techniques), while for the less asset-rich farmers DBF appears to be regarded as risky and too labour demanding to render it worthwhile. This, however, contrasts with the assertion by DBF farmers that DBF actually saves labour 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 labour demands, what influences these, and how potentially unfounded negative perceptions of DBF can be addressed in order to enhance adoption.

"DBF actually saves labour relative to traditional ridge cultivation in terms of reduced tillage after the first year of implementation."

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 fertiliser, and continuous extension support. While labour demands are most likely influential here, this nonetheless raises more questions regarding the longer-term sustainability of DBF in economic, social and environmental terms for a small number of farmers. Tiyeni has neither the resources nor the desire to support its farmers in perpetuity, and it is acutely aware of the importance of appropriate exit strategies in order to avoid a culture of farmer dependency. This is appropriate; NGO interventions should aim to deliver long-lasting sustainable solutions that are embedded at the local-level. Nonetheless, there is clearly a need to understand further why a small proportion of farmers abandon DBF so that Tiyeni could adapt its extension message, or potentially even elements of the DBF system itself, in order to achieve greater coverage, inclusivity and sustainability. While diverging from the 'gold standard' DBF system in order to accommodate those farmers experiencing land / labour issues undoubtedly risks diluting its wider effectiveness, there is at least some justification for considering the development of a more flexible and adaptive package alongside this; one which is sensitive to more challenging social-ecological contexts.

"There is a need to understand further why a small proportion of farmers abandon DBF"

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 is a result of cheaper production costs, fewer labour 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 fertiliser. 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.

"...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."

"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 study did, however, identify several instances of disadoption after several years that were attributed to the challenging labour demands of DBF relative to traditional agriculture, the percieved lack of extension support after the first year, and conflicts with other farmers working on the same demonstration garden. While the latter has already been addressed by Tiyeni in its move towards a decentralised demonstration garden approach, this research has identified the need to examine further the circumstances under which some farmers cease to benefit from the DBF. Tiyeni's DBF

has huge potential to make a long-lasting impact on poverty across Malawi, and we would suggest that one way of sustaining these benefits for the future is to learn from the 12000+ farmers whose knowledge and experience can inform the future evolution of the system. Indeed, there is a growing consenus from across sub-Saharan Africa and beyond that locally-informed adaptations in social-ecological systems are an essential pre-requisite to sustainable and climate-resilient agriculture.

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