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RESEARCH ARTICLE

MAKING AGRO-ECOSYSTEMS WORK FOR THE RURAL POOR

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ABSTRACT

This paper synthesizes the data gathered by the IDRC- funded Agri-Food Systems Project; and the McKnight Foundation-funded Scaling Up Project implemented by Bunda College of Agriculture to examine leading ideas underlying efforts to improve productivity of the agro-ecosystems in Malawi. The political ecology framework has been used to locate the actors, their power and interests that underlie resource allocation, extension and research on agricultural productivity. The results have revealed that farmers and all actors agree that agro-ecological systems in Malawi are degraded and productivity is declining. There are two leading ideas informing the strategies to deal with declining agricultural productivity. These are what we call "modernizing smallholder farmers" and "making smallholder farmers go local". These ideas are two extremes and powerful. They are 'boxing' smallholder farmers into either modern technologies such as chemical fertilizer and hybrid seeds or local technologies such as compost manure. By being so powerful the farmers believe that the only solution to declining agricultural productivity is modern or traditional technology. The actors have vested economic and intellectual interests in boxing smallholder farmers. Approaching agricultural productivity this way has created a dilemma, whereby, on the one hand few farmers can afford modern technologies and on the other hand adoption of local technologies is low. Amidst the dilemmas farmers are combining local and modern technologies to improve productivity of their agro-ecosystems. We call this idea a 'combined technology'. With this third idea farmers look for principles with which they can generate technologies to be used to reverse the decline in agricultural productivity. However, the 'combined technology' lacks support and investment from extension and research. It is our critical and professional extension argument that unless extension, research and investment supports the combined technology idea, efforts to build agricultural productivity and make agro-ecosystems work will make less impact.

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INTRODUCTION

Literature reveals that agriculture remains an important sector to the Malawi's economy as the sector accounts for over 35% of national income and 80% of export earnings, and employs 80% of the labour force (GoM, 2011a). The agriculture sector is dualistic as it is formally divided into commercial and smallholder sectors. But the split between 'commercial' and 'smallholder' is in itself misleading since it supposes that smallholder farmers are not 'commercial'. In reality smallholder farmers produce and generate cash from crops such as maize, soya beans, beans, tobacco, tea, coffee and sugar. The smallholder farmers are the majority as they account for over 70 percent of national populations. They play a significant role in the agriculture sector as they contribute over 80 percent of total agricultural production.

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Most of the agricultural work is done by women as they provide over 70 percent of the labour force. These smallholder farmers are characterized by high poverty levels and vulnerablity. They have to rely on safety nets such as cash transfers, public works and agricultural subsidies. Even the progressive farmers, virtually rely, too, on 'off-farm' employment and small businesses. They have myriad landholding sizes, with farmers in the Southern Region of Malawi owning less than 1 hectare of land while in the Northern Region the landholding size is up to 1.5 hectares on average. Cropping systems are dominated by maize, both local and hybrid, because it is the staple food, occupying over 70% of arable land (Alwang and Siegel, 1999). The farmers mostly plant maize in sole stand or they intercrop or rotate with leguminous crops. Other major crops grown are groundnut, pigeon pea, soybean, common bean, cowpea, sweet potatoes and cassava (MoAFS, 2012). Generally, crop yields are lower than the potential. For example, the average yield of hybrid maize varieties is 2 t ha^{-1} against the average potential yield of 10 t ha^{-1} (MoAFS, 2012). Consequently, food security situation among smallholder farmers is characterized by "ups" and "downs" depending on whether farmers have or do not have access to chemical fertilizers amidst other climatic conditions. It is an indisputable fact that productivity of smallholder farming systems is of a great concern to politicians, researchers and development practitioners in Malawi as it affects the majority of the population and the whole economy at large. It is also clear that different actors have different interests and take different positions in building agro-ecosystems or enhance agricultural productivity. This article is an effort to examine, from political ecology framework, the different initiatives by different actors namely: researchers, policy makers, private and public extension service providers, donors and the farmers as they tirelessly engage in soil fertility improvement initiatives to improve agricultural productivity in smallholder farming systems. A focus on power and interests reveals why some technologies are highly supported than others.

The information upon which this article is based has been gathered from the work done by two project implemented by Bunda College of Agriculture in Malawi from 2008 to 2013. One project was funded by the IDRC and titled Agri-Food Systems, and the other was funded by the McKnight Foundation and titled Scaling Project. Some specific objectives of these projects included: (1) to identify and promote local innovations and adaptation strategies that work for poor rural men and women to cope with food security vulnerabilities; and (2) to adapt and scale up sustainable innovations for promoting 'orphan' or traditional high value crops that enhance food security, increased income and promote ecosystem integrity in selected areas. Through repeated cycles of action research, the projects facilitated farmer experimentation to test, adapt and scale up a range of technologies and innovations for improving agricultural productivity of orphan or minor crops. These crops have the potential to enhance food security, promote nutrition security, provide income opportunities and diversify farming systems to become more resilient to climatic vulnerabilities (Tchuwa, 2012).

The projects were implemented by a multi-disciplinary team of researchers and development practioners in selected sites of Chikhwawa, Lilongwe and Kasungu districts in Malawi. The sites were selected based on the food security situation, agricultural potential and vulnerability level. Lilongwe represented food secure areas, Kasungu was considered to be border line food insecure, and Chikhwawa represented areas with acute food shortage and livelihood crisis.A variety of methods including observations, questionnaire surveys, focus group discussions, and key informant interviews were used to collect the data on the farmer practices. An extensive literature search was also used to understand the drivers and dynamics.

Two diverging perspectives to build degraded agro-ecosystems

A narrative about agricultural productivity highlights failure by agro-ecosystems to perform supporting services such as soil formation and nutrient recycling as the main reason for low productivity as it is evidenced by declining soil fertility in Malawi (MoAFS, 2005). On the basis of this narrative different actors take different positions, with some focusing on use of modern inputs while others emphasize on rebuilding agro-ecosystems by using local technologies. In this article, perspectives where the emphasis is on use of modern inputs is referred to as "modernizing smallholder farmers" or modern agriculture in short, while the other perspectives is called "making smallholder farmers go local" or local agriculture in short. The sub-sections below present some literature on these two perspectives as advocated in Malawi. The sub-sections also present the existing dilemma in efforts to enhance agricultural productivity and the disconnection between what experts advocate and what farmers do in their efforts to build and enhance agricultural productivity.

Modernizing smallholder farmers in Malawi – how is this happening

Efforts by Government, extension, researcher and donors to enhance agricultural productivity thereby make agro-ecosystems work for the rural poor are described here as "modernizing smallholder farmers". These efforts aim at encouraging smallholder farmers, especially the poor to use modern technologies such as chemical fertilizer and hybrid seeds. The article illuminates this through examining the Malawi Government program called the national agricultural farm input subsidy program (FISP). Worth noting is that there are also development partner programs such as the Alliance of Green Revolution in Africa (AGRA), specifically the Program for Africa Sees Systems and the Soil Health Program doing the same as the Malawi Government.

The Malawi Government has been implementing the FISP since 2005/06 to increase resource poor farmers' access to improved agricultural farm inputs in order to achieve food self-sufficiency and increase income for the these resource poor farmers through increased maize and legume production (GoM, 2013). Historically, farm input subsidy is not a new phenomenon in Malawi, as the Government has implemented various input subsidy programs such as the universal fertilizer subsidy, subsidized smallholder credit and controlled maize prices from the 1970s to early 1990s (Harrigan, 2003). The Government has also implemented free inputs programs such as the Universal Starter Pack and Targeted Input Program from 1998 to 2004 (Levy, 2005; Chinsinga, 2005). The FISP is well supported by the policy environment, research, extension, and rural and agricultural development practitioners. For example, the Malawi Growth and Development Strategy (GoM, 2011a) and the Agricultural Sector Wide Approach (GoM, 2011b) both target agriculture as the driver of economic growth and poverty alleviation. The Agricultural Development Program also guides development activities and investment programs in the agricultural sector (GoM, 2008). These policies have justified the need for smallholder farmers to access modern agricultural inputs to achieve food security and self-sufficiency which is to be achieved by increasing maize productivity, reducing post-harvest losses, diversifying food production, and managing risks through national food reserves (MoAFS, 2005). Over the years the FISP has annually reached over one million poor resource smallholder farmers (Table 1) with various farm inputs such as maize seed (open pollinated varieties and hybrid seed) and legumes (groundnut; soybean; bean; cowpea, and pigeon pea). The program has also provided subsidized storage pesticides to enable beneficiaries reduce maize post-harvest losses. The target are the poor. Makoka (2013), using the Malawi poverty line of MWK 37,002 and the ultra-poverty line of MWK 22,956 per person per year, found that the majority (72%) of the FISP beneficiary households in the districts of Machinga, Mchinji, Mzimba, Lilongwe, Mulanje and Chikhwawa were ultra-poor as they were living below the ultra-poverty line. As seen in Table 1, the number of farmers targeted remains constant for most years or increases in some year, a sign that the farmers are not graduating from the FISP program. Whether this situation is good or bad the important point is that the FISP is creating dependency in Malawi.

Table 1. Targeted amount fertilizer (2010 – 2013) and beneficiaries (2005 – 2013)

Fiscal Year	Targeted amount of fertilizer (MTS)	Targeted Beneficiaries (Million)
2006/07	200178	1.5
2007/08	216000	1.5
2009/10	195369	1.7
2010/11	160000	1.6
2011/12	160000	1.4
2012/13	154,440	1.54
2013/14	150,000	1.5

Sources: CISANET, 2014; Makoka, 2013, Chirwa and Doward (2013).

There are indications that the program has sometimes resulted into an increase in maize production from 1.2 million metric tonnes in 2004/05 up to 3.4 million metric tonnes in 2009/10 (GoM, 2011b). Indeed the country was at once known as shifting from a 'maize consuming, importing country' to a 'producing, exporting one'. As a result of this performance, the program has overshadowed other agricultural sector policies and it has caught the attention of policy-makers, politicians and donors at home and abroad. Whilst the agricultural input subsidy program has undoubtedly made great contribution to the overall food security in Malawi over the years, it presents economic and social sustainability challenges. The financial cost of the FISP in 2013/14 growing season rose to almost 60 billion Kwacha due to price hikes and program expansion. The program takes over 50% of the Ministry of Agriculture and Food Security budget allocation since 2007/08 (Chirwa *et. al*., 2013). It also relies on donor support, which is subject to policy shifts. Generally fewer farmers than expected receive the inputs such that food sufficiency is reached only by a small minority who produce enough to keep consumer price low thereby increasing access for the majority who always have to purchase maize and/or work for it. The fewer farmers who access fertilizer share with those who do not receive because failure to do so makes the latter not cooperate in community work. Once shared, the little fertilizer is 'stretched' to cover a larger area. This implies that farmers do not apply enough as per recommendations such that production per household might be below potential, although at national level the picture might be that the FISP has increased production.

Making smallholder farmer go traditional

Realizing that not all farmers can afford modern technologies there have been over 20 years of intensive research and extension into strategies to assist smallholder farmers rebuild their agro-ecosystems in Malawi. These efforts are described here as "making smallholder farmers go traditional" because they aim at increasing soil fertility by building agro-ecosystems with locally available resources without relying on modern inputs. This is in recognition by researchers, Government and donors that the fundamental challenge faced by poorer farmers has been the loss of soil nutrients from their farms and their inability to purchase fertilizer to replace those nutrients and raise their crop yields (Steven Carr, personal communication, *Ibid*). Poor farmers are also unable to buy modern inputs to protect their crops after harvesting. Just as with modernization, this realization has ignited another drive which is to encourage farmers to adopt local technologies such as compost manure, agro-forestry practices, conservation agriculture, and crop rotation to build the agro-ecosystems. The technologies are called low cost technologies, although there has not been enough cost benefit analysis to justify this claim. They are promoted under what is called sustainable agriculture or climate smart agriculture. The technologies are said to be affordable by most farmers who cannot afford modern technologies. Again, little economic analysis has been done to justify that these technologies are affordable by the poor. Donors, research and extension are also supporting the perspective "making smallholder farmers go traditional". Research institutions have or are developing 'low cost technologies', donors are providing funds for research, while the Government is committing extension human resources to manage those innovations that would substantially raise crop yields and provide families with nutritious diets without relying on purchased inputs. The dominant model here is the technology transfer model, where research develops technologies, extension transfers them to smallholder farmers to be use on their fields. In most cases farmers have been passive receivers.

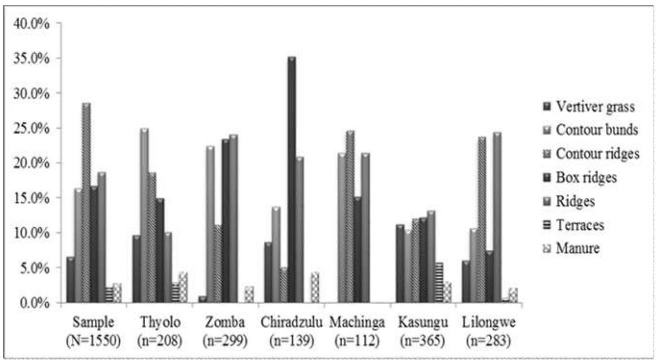
According to Stephen Carr (personal communication, *Ibid*) extensive research and extension work on local technologies in Malawi started in the 1990s with financial support from European Union (EU) and United States International Development Agency (USAID). At that time experts developed a three prong strategy as technical basis for helping the poor to improve productivity of agro-ecosystems. The strategy was as follows:

- Slow down the rate of nutrient loss by giving farmers a simple tool (made from three sticks, a stone and a piece of string) with which they should accurately mark the contours on their plots and realign their ridges and stop the loss of soil nutrients by erosion. On steep slopes farmers should use contour lines of Vetiver grass to strengthen the anti-erosion efforts.
- Introduce soya bean variety which could be grown without inoculation and would put back substantial amounts of nitrogen into the soil as well as producing highly nutritious food. In the Southern region where pigeon peas were grown farmers were encouraged to interplant the soya with pigeon pea and so obtain a double source of food and plant nutrients.
- Encourage farmers to use leguminous shrubs and trees to enrich soils without having to purchase imported inputs. The recommended shrubs have been Tephrosia, *Acacia albida* and *glyricidia*.

What has gone right or wrong? - Diffusion and adoption of local technologies

Stephen Carr (personal communication, *Ibid*) revealed further that at the end of about 8 years the EU funded a review of the national program. It found that only 85,000 farmers had adopted any significant proportion of the technologies which was about 3% of the farming population. It was clear that the three prong technology was not spreading across the country by "osmosis" from farmer to farmer but was largely confined to "project" farmers which indicated that the technology was not really working for most farmers. As a result the initiative was run down and the huge investment in extension and research on building agro-ecosystems failed. An analysis of the reasons behind this failure revealed the following important learning points:

Realigning ridges is a one off exercise but it involves a lot of work in the first year and obviously has no immediate direct impact on yields but good long term benefits. Farmers have not responded to these and so the majority of ridges are still not on the contour and a lot of nutrients are lost into streams, rivers and lakes every year. The soya bean variety is popular but farmers are unable to allocate a small part of their farm to the leguminous crop in pure stand so its impact on the overall nutrient status of the soils of the whole farm is limited. Inter-planted legumes other than pigeon pea make a minimal contribution to soil nitrogen stocks. Beans contribute nothing and soya and groundnuts grow much more weakly under the shade of maize and that, combined with their low overall numbers, account for this lack of impact. Tephrosia gives outstanding results after an eighteen month fallow but a six month fallow which was all that farmers could spare only produced a 20% increase in yield if everything was done right. The extra work involved combined with the loss of all intercrops meant that farmers rejected the technology. With Acacia, now called Faidherbia (*Msangu*), the technology was wrong to start with as it did not establish well. Although the trees are being planted, the pace has no impact on national maize production. It takes ten years before one starts seeing a benefit from these trees. The benefit then continues for 150 years but the initial wait is too long for most farmers. Other local technologies being promoted in Malawi have also suffered low adoption (Figure 2) (Barungi and Maonga, 2011). As can be seen in Figure 2, the highest level of adoption of is as low as 35 percent for box ridges.



Source: Barungi and Maonga, Journal for *Sustainable Development in Africa* (2011)

Figure 1. Percentage of adopters of soil management technologies in Malawi

A participatory evaluation of some local technologies such as compost manure and pigeon peas as soil fertility technologies has been done in Kasungu with 64 farmers to generate views and experiences on technological attributes that influence diffusion and adoption of technologies such as triability, observability, relative advantage, compatibility, reliability and complexity (Malaidza, 2013). These perceptions were scored using seven-point Likert-scale, where 1 was the lowest and 6 was the highest score (Table 2). Low mean scores reflect a perception that the attribute is relatively less important in influencing adoption and vice versa. Using an average score of 3, all attributes influence adoption and diffusion of the technologies under study. However, in case of compost manure, compatibility and relative advantage as well as observability and reliability were the main reasons behind low adoption and slow diffusion. While for pigeon peas all the attribute except reliability were the reasons for low adoption and slow diffusion. When ranked, the main attributes for compost manure were compatibility and relative advantage, while for pigeon peas the main attributes were compatibility and complexity. During focus group discussion farmers explained that they did not use compost manure because yields were lower than when they used inorganic fertilizer. Compost manure was also bulky to transport to the field. The process to prepare the manure was labour demanding. Besides, farmers have experienced that when they applied compost manure to groundnuts there was poor pod development while cassava had poor tuber development. Sweet potatoes developed poor taste and the tubers were watery. When applied to millet, the beverage prepared from the flour had unpleasant taste. The same happened when strawberries and local mustard were applied with compost manure. These observations have been confirmed with agronomists and nutritionists. With regard to pigeon peas, the crop was not compatible with smallholder farming system because livestock which were kept under free range destroy the crop when grazing. Besides, pigeon peas were heavily infested by pests. Moreover, there was a perception that the crop was not very popular.

The dilemma in agricultural productivity

The two perspectives taken to build agro-ecosystems present challenges requiring rethinking. The “modernizing smallholder farmers” is proving to be economically and socially challenging. As noted, only a small minority of farmers access modern inputs. Even those that access the inputs they do not get enough to produce to the potential. The result is that the Governments is stuck in ways to source enough inputs for the unlimited demand. Some circles even propose to stop subsidizing agricultural inputs for the poor. On the other hand the “making smallholder farmers go local” is unpopular as evidenced by low adoption levels. Obviously, the actors in agricultural productivity narrative are caught up between cost and poor attractiveness of the agricultural inputs and they have reached the end of thinking capacity (*commonly known as* etc). In this article we argue that a solution to challenges in agricultural productivity lies where little is known and researched, and extension and development practitioners have paid little attention, thus learning and understanding farmer practices. What one learns from these practices is that, instead of forcing the technology on the farmers, extension and research need to teach farmers the principles of various technologies for building agro-ecosystems. Once farmers learn about the principles they generate their own technologies that are relevant and appropriate for their socio-economic conditions.

So what makes agro-ecosystems work for the rural poor?

Either way the debate might go, fewer smallholder farmers tend to adopt modernization or try localization, while other famers blend the two perspectives depending on their social and economic status. This section focuses on the last group of farmers to reveal the missing links in efforts to enhance agricultural productivity. The living experiences of these farmers in terms of practices and knowledge that the rural poor use to manage agro-ecosystems are considered to be leverage points for ending the dilemma, which we call “the end of thinking capacity” in agricultural productivity debate.

Table 2. Means of farmer perceptions and ranking of compost and pigeon peas technologies

Attribute	Perception score (n = 64)					
	Compost manure			Pigeon peas		
	Mean score	Std dev.	Rank	Mean score	Std dev.	Rank
Triability	3.4	1.3	5	4.2	0.2	5
Observability	4.9	0.5	3	4.8	0.4	3
Relative advantage	5.0	0.3	2	4.5	0.6	4
Compatibility	5.1	0.3	1	4.0	0.2	1
Reliability	5.5	0.3	4	3.6	0.3	6
Complexity	3.2	0.6	6	4.9	0.4	2

Scale: 1 = Not important, 2 = Less important, 3 = Important, 4 = More important, 5 = Very important, 6 = Extremely important

Source: Malaidza, 2013

Other literature interpret these practices as coping strategies because it is assumed that farmers are in search for alternative ways whenever they do not have or have little access to modern technologies. But the concept of coping strategies undermines the importance of farmer knowledge and practices and the diversity in the smallholder farming system. As of now, these practices should be understood as 'farmer practices' as they are developed based on farmer observations and innovativeness. A close look on smallholder farmer practices reveals that farmers usually grow and mix a variety of crops, keep various livestock and use a combination of inputs for diversity and also after seeing the positive effects of their practices. This is the case in the study area, where smallholder farmers practice the type of agriculture where they combine traditional and modern technologies synonymous to what literature refers to as agro-ecological intensification (AEI) (see Figure 2). The AEI is an approach to farming that builds on the mobilization of ecological processes (i) to increase agricultural production and use efficiency of external inputs, labor, and natural resources, and (ii) to reduce losses to abiotic and biotic stresses (Côte, *et. al*., 2011).

Traditional	AEI	Modern
Use of diverse species and landraces	Strategic use of genetic diversity at all levels (gene, population, varieties, species)	Hybrids, systematic recombination and trialing
Biological inputs	Inputs from biological and other sources used	Input dependence; increased efficiencies
Nutrient recycling	Nutrient recycling	No nutrient recycling
Local germplasm exchange	Local and global germplasm exchange	Global germplasm exchange

Source: Collaborative Crop Research Program. The McKnight Foundation (2013)

Figure 2. The Agro-ecological Intensification

The combination of traditional and modern technology, it is argued, improves the performance of agricultural systems through integration of ecological principles into farm and system management (McKnight Foundation, 2013). The combination has the advantage that through functional diversification and careful matching of options to contexts, the risk is reduced, and resilience and productivity improved. This type of agriculture is worth the recognition of and the attention by the Government, researchers, donors, extensionists and agricultural development practitioners in Malawi, where most of the smallholder farmers are resource-constrained and in need of working within their resource limitations.

The next sub-sections present some practices that smallholder farmers follow in their farming system.

Farmer soil fertility practices for degraded agro-ecosystems

Farmers are aware of the extent of degradation of agro-ecosystems and they do not need numerous awareness meetings to change their attitude but support to enhance their knowledge and skills and change their attitudes and perceptions towards technologies for enriching their soils. In realization of soil fertility challenges farmers follow practices which are synonymous to what in literature is referred as integrated soil fertility management (ISFM). This is a set of soil fertility management practices that include the use of fertilizer, organic inputs and improved germplasm, combined with the knowledge on how to adapt these practices to local conditions, aimed at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity (Vanlauwe. *et al*., 2010). The practices where farmers enrich their soils by combining organic soil fertility measures, including manures and compost, biomass transfers and green manures are simply referred to as farmer soil fertility practices (FSFP) because the practices have not been fully developed and approved by the technology release committee.

Data from the McKnight Foundation - Scaling Project has revealed that the FSFP is common among the rural poor farmers in Kasungu and Mzimba districts. In these districts, Thawe (2011) found that 190 farmers practiced various ways to improve of soil fertility in their fields. These included use of inorganic fertilizer, compost manure, legume combined with fertilizer, compost combined with fertilizer, maize intercropped with legumes in rotation and crop residue incorporation. A total of 48 percent combined legumes with fertilizer while 49 percent combined compost manure and fertilizer. About 96 percent of the farmers practiced crop rotation, while 16 percent incorporated crop residues in maize field. In Kasungu only, farmers opted for basal micro-dosing with compost, incorporating groundnuts residues, planting legumes, and used chemical fertilizer as a top dressing (Wellard and Kambewa, 2009). Box 1 presents some results of 'combined technology'. According to Place *et. al*., (2003), combining organic soil fertility measures with chemical fertilizer improves the efficiency of fertilizer from 20 kg of grain per kg of nitrogen fertilizer applied to double or triple this response. Another FSFP in use by the farmers in Kasungu and Mzimba districts in Malawi is called the 'double up grain legume technology' (Sapp *et al*., 2002). According to Snapp *et al*., (2002), the technology involves rotating maize with a 'double up grain legume' system, where pigeon peas areintercropped with groundnuts or soya beans in year one. In year two, maize is grown and benefits from the dual legumes residues that have been incorporated.

Box 1: Results of FSFP in Kasungu and Karonga

In Kasungu, farmers mix 20kgs of compost manure with 20kgs of cattle or chicken manure and 5kgs of chemical fertilizer (Urea) and apply this as basal dressing and top dressing on a 400 square metre plot. Five farmers who followed the practice in 2012/13 season indicated that they harvested between 3 and 5 50kg bags of maize (Malaidza 2013). This harvest was much higher compared to the less than one 50kg bag they would have harvested if they had not mixed the inputs. In Karonga, one farmer mixed 5 kg of Urea fertilizer with 20 kg of maize bran and 20 kg of bokash manure and applied it to a 100 square metre plot and harvested 3 50kg bags of maize (Kambewa, 24th June, 2013, personal communication).

Table 3 shows results of a doubled up legume and continuous fertilized maize trial in five villages in Kasungu. The results show that there were no significant differences in maize yield following doubled up legumes and continuous fertilized maize (+46 N ha^{-1}). The average yield was 1.5 ton ha^{-1}. The yield of unfertilized maize averaged 0.85 ton ha^{-1}, much lower than in doubled up legumes. The overall yield might be lower due sporadic rains in the areas that might have affected availability of N to plant as there was not enough moisture to make the nitrogen available for plant use. Besides yield, multipurpose legumes such as pigeon peas, a crop that is common in the southern region of Malawi, offer the opportunity to improve both soil fertility and family nutrition (Kanyama-Phiri *et al*., 2010).

Table 3. Maize grain yield (Kgs) following legume systems in five villages, Mkanakhoti EPA. Kasungu

Treatment	Chaguma	Chisazima	Kaunda	Ndaya	Tchezo
Maize + 0N	1490	690	965	953	877
Maize + Urea	2236	1190	1710	1393	1622
PP + GN	2246	1201	1721	1708	1633
PP + SB	2143	1097	1617	2176	1529

Key: PP = Pigeon peas, GN= Groundnuts, SB= Soya bean
Source: Kanyama-Phiri *et al*., (2013)

Agro-diversity

There is a constant message about agricultural diversification but those pursuing it ignore the fact that the smallholder farming system is already diversified as the system enables the growing of a variety of crops in form of mixed cropping and keeping various livestock as the case of mixed farming. The smallholder farming system in Malawi should therefore be recognized as agro-bio diversified, which in literature is refers to the variety and variability of animals, plants and micro-organisms used directly or indirectly for food and agriculture (FAO, 1999). The data from the IDRC - Agri-Food Systems project has shown that 85.4 % of the 900 farmers interviewed grew 2 to 5 crops besides maize, tobacco and groundnuts. Most of the crops included millet, sorghum, Bambara nuts, cowpeas and most indigenous vegetables (Tchale 2012). These crops are now referred to as orphan crops because they do not receive attention from policy, research and extension such that their potentials are not known (Tchuwa, 2012). Despite registering lower production levels compared to modern ones, farmers use orphan crops for a number of reasons including local preferences, resilience to climatic variability, good storage characteristics and ease of recycling (Tchale, 2012). In Malingunde farmers complained that hybrid sweet potatoes rote easily in storage and besides they do not taste as good as local sweet potatoes (Tchale, 2012). Tchale (2012) further found that local crops play a vital role in food security. However, diversity in smallholder farming system is being lost because research, development programs and extension services tend to encourage farmers to specialize in hybrids and improved livestock neglecting local crops and livestock. This loss is mostly the case due to proliferation of technologies such as Sasakawa planting method which encourages sole cropping or single stand cultivation instead of mixed cropping. The loss is manifested in the growing scarcity of cuttings or seeds for crops such as local sweet potatoes. Much as the farmers would like to return to local varieties, seed and cuttings are scarce (Kathabwalika, 2012). If left unchecked, neglecting local crops and livestock might create more hunger in the smallholder farming system as important characteristics such as resilience to climatic variability, good storage and recyclability get lost.

Technologies for food secure society

Farmers are aware that making agro-ecosystems continue to provide the services such as improving soil fertility is not enough to create food secure society. They are therefore concerned with what to plant and how to keep what has been harvested. This section presents the seed systems and post-harvest technologies that smallholder farmers use to provide the technological richness of smallholder farming systems and the need for its recognition.

Seed systems for enhanced agricultural productivity

Seed is the most important ingredient for smallholder farmers to attain food security and to develop their households. Timely and readily availability of seed is therefore a must. There are two forms through which smallholder farmers access seeds for various crops and these are formal and informal systems. The formal seed system is, on one hand, where production and distribution of seed is through public (government) and private sector organizations (Mtenga, 1999). These organizations provide a regulatory framework to maintain seed standard quality, genetic purity and variety identity (Mwekundah, 2012; Louwaars *et al*., 1999). The source of seed is pure seed from the gene bank which contains materials that were originally collected from farmers by an agronomic research unit and state or private seed companies (FAO, 1999). The seed is multiplied under strict conditions to avoid mixture of varieties (Minot and Smale, 2007). The informal seed system on the other hand involves operations such as production, processing and distribution without an official mechanism for standard and quality control (Lazaro and Bisanda 2004; FAO, 2004; Mbwele *et al*., 2000). In this regard, the family is the main unit controlling and regulating the operations. Seed production consist of on-farm seed selection and multiplication by the farmers themselves depending on their knowledge (Sperling, *et al.,* 1995). The seed diffuses within and among the communities as the majority of farmers acquire seed from their parents, brothers and sisters while others get the seed from neighbors and other members of the community (Kasambala *et al.*, 2007). This indicates that under informal system seed is interchanged within the communities rather than introduced from outside. Smallholder farmers in Malawi use both formal and informal seed systems but the majority use informal system. Katende (2013) found that 100% (70) farmers in Malingunde used hybrid seed and their own seed for maize, Bambara nuts and sorghum. Of these farmers 20% used hybrid and seed saved from previous harvest while 80% only used seed they had saved from the previous harvest. Hybrid seed was accessed through the FISP. Being official, seed under the FISP must have passed through organized chain of activities including official seed certification by specialized breeders, certified seed producers and organized marketing agents.

Table 4. Mean number of dead *Bruchids* after treating Bambara nuts with cow dung ash

Location	Chikhwawa			Kasungu			Lilongwe		
Period (days)	30	60	90	30	60	90	30	60	90
Treated Bambara	2.424	2.483	2.477	2.407	2.589	2.590	2.355	2.678	2.596
Untreated Bambara	2.301	2.308	2.309	2.301	2.308	2.317	2.302	2.338	2.317
T	5.011	4.435	4.551	3.185	6.220	3.549	2.332	2.983	2.735
Df	22	22	22	22	22	22	22	22	22
p-value	***	***	***	**	***	**	**	**	**

* **&**denote significance at (P < 0.001) and (P < 0.05), respectively.

The farmer's own seed was produced, disseminated directly from their own harvest or they bartered with friends, neighbors and relatives, and the seed was mostly recycled several times (Katende, 2013). The situation where farmers rely heavily on informal seed system is not particular to Malingunde or Malawi only as it also applies to most countries in Africa where it is estimated that over 80% of the seed is produced through informal systems (Byerlee *et al*., 2007). For most crops, 100% of seed comes from the informal seed supply in developing countries and this situation is not going to change in the foreseeable future (FAO, 2010). In Ethiopia, self-sourced seed and the market respectively are the first and second most important sorghum seed sources (Teshome, 2001).

There are varieties of reasons why farmers use own seed, which is informal seed system. Katende (2013) found that in Malingunde 51% of 70 farmers relied on their own seed because it was readily available when they wanted to plant and it was affordable. In fact, the farmers believed that their own saved seed had good or even better quality than certified seed. Own seed also kept well under storage and tasted good compared to seed under formal systems, which is considered not readily available and also expensive. However, own seed yielded less than seed acquired through formal system. Despite the significance of informal seed systems, only the formal seed system receives support from donors, Government, researchers, extensionists and development practitioners. There are huge investments by AGRA and Millenium Challenge Account towards training, infrastructure development such as the agro-dealer networks aimed at making sure that quality seed is produced and smallholder farmers have access to that seed. Some extension messages openly discourage farmers from reusing seed. The level of training, development and publicity applied to formal systems does not happen to informal system. In fact the informal seed system, despite supporting majority of smallholder farmers to access seed, is the least understood and neglected. Private corporations such as Monsanto, Cargill, Yara, etc support this neglect as (since they support privatization or modernization of seed and other input supply) as it creates a vacuum and serve their interests. As this neglect goes unchecked the smallholder farmers is at a disadvantage as they may not be able to reuse their seed but buy new seed every planting season. There is also a threat to loss of biodiversity that exits in the agro-ecosystems.

Post-harvest technologies for food secure society

A food secure society in Malawi is impossible as it is acutely challenged by the losses due to post-harvest grain damage by storage pests (World Bank, 2010). Mangwela (2001) reported losses of up to 30% in maize and about 50% in fruits. The findings of Mangwela also agree with Giblert and Jones (2012), who further attributed that for fear of such losses farmers end up selling their crops soon after harvest. The period of selling coincided with the time of abundant supply of the crops, which in turn drive down prices. Recognizing this challenge, the IDRC - Agri-Food Systems Project has identify traditional grain protectants (TGP) as local innovations that the resource poor farmers use to cope with food security vulnerabilities caused by storage pests. These TGPs include the use cow dung ash, neem leaves and tobacco ash to protect beans, sorghum, millet, maize, cowpeas, pigeon peas and Bambara nuts. The farmers also use sand and ash to protect sweet potatoes in storage. Maligold, Lantana camara, Leek (*adyo*), delia, *Tephrosia vogelli*, aleovera are used as repellents against pests in the field. One challenge that has been recorded is lack to confidence in effectiveness of TGPs among the farmers themselves. When asked, about 47.6% of 145 farmers who used TGPs stated that TGPs were not effective. This observation necessitated the need to conduct trials using cow dung ash on *Bruchids* in Bambara in study sites in Lilongwe, Chikhwawa and Kasungu districts. A total of 36 farmers participated in trials and 144 samples of treated and untreated Bambara nuts were tested.

The application rate was 9kg of cow dung ash per 50kg of Bambara nuts. The trials were assessed by host farmers, extension workers and the surrounding communities after every thirty days for a period of 90 days. Results of the trials are presented in Table 4. The results in Table 3 show that the cow dung was an effective pesticide for *Bruchids* since it recorded significantly high mortality rates in treated as opposed to untreated samples. Natural mortality is ruled out on the basis that *Bruchids* conducive breeding temperature is greater than 20°C. All the tree sites where the study took place have an average temperature of above 20°C. According to Ernst *et. al* (2011) *Bruchids* have minimum life-span that varies between 4 and 40 days. Other literature indicated that life-span for hatching of the fist-instar larva is 22 days at the temperature regime of 20/15 °C (day/night) and 15 days at a temperature regime of 32/15 °C.

Since the experiments were conducted over a period of 90 days it suggests that all the new larva or beetles born during the study period died due to cow dung. The results were shared with 7 extension workers, an NGO (Self-Help Africa) and other farmers through field days, open days and famer visits. When farmers saw the results they renewed their confidence in cow dung ash as a local pesticide against *Bruchids*. As a result of this renewed confidence the number of farmers using cow dung ash increased from the initial 36 farmers (12 males and 24 Females) at the start of the experiments in 2010 to 310 (89 males and 221 females) by 2113 (Yotamu, 2013). Before the project farmers used to struggle to keep seed for Bambara nuts and they failed to plant due to lack of seed. The situation changed after the experiments and the farmers readily and timely accessed seeds from their own stores and planted timely.

DISCUSSION

The main actors in the quest to enhance productivity of degraded agro-ecosystems are the Government, donors, researchers, extensionists, development practitioners and the farmers. These actors are under the influence of two perspectives, which are "modernizing smallholder farmers" and "making smallholder farmers go traditional". Either of these perspectives is 'boxing' the rural poor farmers. On the one hand, the "modernizing smallholder farmers" is 'boxing' farmers into modern technologies as farmers are not given options but recommendations to follow these modern technologies of hybrids and chemical fertilizers. On the other hand, "making smallholder farmers go traditional" is 'boxing' farmers into local technologies. These perspectives have social and ecological implications. For example, "modernizing smallholder farmers" creates a dependency relationship at two levels. Ecologically, with reference to the FISP, the initiative only replenishes the lost nutrients with chemical fertilizer without enhancing the capability of the agro-ecosystems to regenerate or restore its properties. This means that agro-ecosystems will not function without depending on external input. To farmers, this means they have to buy chemical fertilizer every planting season. By encouraging farmers to use hybrids, the FISP creates a situation where farmers have to buy new seeds every planting season as hybrids cannot be recycled. To some extent, smallholder farmers are captured by modernization as they are being made to believe that agro-ecosystems cannot yield anything if they do not apply chemical fertilizer or if they do not plant hybrid.

But by assuming that all farmers can afford and use modern technologies the "modernizing smallholder farmers" perspective ignores that not all farmers are the same. This perspective might only be true for the 'commercial' sector and it may not apply to the 'smallholder' sector, which is highly differentiated, whereby without subsidies, most smallholder farmers cannot afford to obtain sufficient seed and fertilizer to produce good maize (and other) harvests. By failing to recognize this differentiation, researchers, development practitioners and extensionists have failed to produce a menu of technologies from which farmers can choose according to their capacities and capabilities. Recognizing the existing differentiation is important in Malawi where the majority of farmers (about 60 percent) in the smallholder sector are poor and incapable to use modern technologies such as chemical fertilizer and hybrid seed. Some of these farmers live in remote areas so that they are rarely visited by researchers or by agricultural development programs.

Agricultural production is highly diversified with local livestock breeds and underutilized, neglected or orphan crops such as millet, sorghum, Bambara nuts and indigenous vegetables. Some of these crops and small livestock are said to be the responsibility of women due to cultural conceptions and they are considered "low value or less important". The alternative perspective is the "making smallholder farmers go traditional". However, the years of intensive research and extension into strategies to assist small scale farmers increase the fertility of their soils without having to purchase fertilizer have not yielded the much needed results. The results have been small groups of families who are given intensive help and supervision by extension adopt traditional technologies. But there are no signs at all of the technologies spreading to the majority of the farming community.

The major challenge is that the technologies under the "making smallholder farmers go traditional" perspective are less attractive because they fail the test of relative advantage, complexity and compatibility (Malaidza, 2013). However, both perspectives ignore what farmers are doing to make agro-ecosystems work. According to this article, it appears a solution to problems of agricultural productivity lies in a "combined technology" or a combination of approaches and technologies. What this means is that, instead of one technology or practice for everyone (be it modern or traditional alone), the variety and diversity are important elements for making agro-ecosystems work for the rural poor in Malawi. These practices conform to what is referred to as agroecological intensification (AEI). The combination of technologies exploits the advantages and overcomes the constraints of both the modern technologies and the traditional knowledge. However, the 'combined technology' has not received the attention it deserves from the development programmes such as FISP, or from research and extension agendas because these programs and agendas are obsessed with 'boxing' the farmers into one perspective where they have to use chemical fertilizer or not.

They have to use improved seeds or not. They have to use organic and traditional technologies or not. Contrary to these programmes and agendas farmers obtain economic returns from chemical fertilizer and improved seeds if combined with organic matter improving technologies, such as grain legume rotation, compost and green manures. As explained, elements of 'combined technology' are already being practised in the smallholder farming system. But a successful 'combined technology' requires more support from research and extension to generate and disseminate knowledge on those technologies and practices that work, and improve those that are not so successful. Policy direction and political will also need to be revisited. For example, instead of putting all the money into the FISP to buy fertilizer and improved seed for smallholder farmers, some of the budget would be used to support research and extension on technologies that are necessary to have a meaningful 'combined technology model'. Some important issues and challenges to be considered in the 'combined technology' approach include the following:

- Making biological soil fertility options as well as orphan crops more attractive to smallholder farmers. For example, through composting in-field, multipurpose legumes, output markets for improved grain legume and orphan crops.
- Developing markets for orphan crops through value chain and market studies.
- Providing a range of biological and inorganic fertilizer options, together with ways of adapting these to individual farm situation. For example, large scale on–farm testing of technology, provision of extension materials.
- With farmers, testing, adapting and developing husbandry practices for orphan crops through agronomic trials and entomological studies.

Conclusion

Malawi has made advances in food security in times of favourable climatic conditions and the FISP. However, FISP or subsidy programmes are not the only answer. Typically, "there is no one shoe that fits all". Elements of 'combined technology' are already being practised in the smallholder farming system, but the level of adoption of technologies to sustain the 'combined technology' approach is low. This requires prioritization of research, extension and development programmes towards a 'combined technology' model as an alternative to make smallholder farming systems to be more self-reliant for the poor.

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