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A pathway to inclusive sustainable intensification in agriculture? Assessing evidence on the application of agroecology in Tanzania

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Abstract

Neo-Malthusian narratives argue that the world urgently needs to produce more food for an expanding global population in the face of climate change; and that food security can only be assured through high input and large scale agricultural production. This paper explores agroecology as an alternative approach to this narrative. Can a second 'green revolution' be more 'climate smart' and inclusive than the first one, through driving a process of genuinely sustainable intensification? Using a livelihoods framework we assess evidence on the adoption of agroecological practices in the Uluguru Mountains in Tanzania, through a meta-analysis of four empirical studies, and conclude that the supported adoption of agroecological practice in conjunction with suitable market access has considerable potential for creating inclusive sustainable agricultural livelihoods.

Keywords: Tanzania, sustainable intensification, agriculture, agroecology

Introduction

The Sustainable Development Goals (SDGs) establish targets that will frame future discourse in agricultural transformation. Goal 12 specifically seeks a commitment to decreasing food waste in food production and consumption systems, and more significantly an ambition to 'de-link economic growth from natural resource exploitation' (UN 2016). Set alongside goal 1, the eradication of absolute poverty and goal 2, ending hunger, achieving food security and promoting nutrition and sustainable agriculture, we see a clear imperative for agricultural transformation that is both inclusive and environmentally beneficial.

Future agricultural transformation is associated with both driving structural economic transformation in Sub-Saharan Africa, and as key to addressing climate change and achieving environmental sustainability (Mdee, Lemma and Emmott 2016).

Narratives on agricultural transformation are commonly expressed in terms of the Green Revolution, which revolutionised agriculture in many parts of Latin America and Asia in the 1960s. Similar technologies, based on hybrid seeds, chemical fertilizers and insecticides, and where feasible mechanisation, are now being promoted as the solution for Africa, in what is sometimes called a Second Green Revolution. To put this in context it is helpful to follow scholars such as Raj Patel (Patel 2013) who set out to understand the forces that drove the first Green Revolution.

In 1941 the Rockefeller Foundation agreed a programme with the Mexican government to develop high-yielding varieties of food crops, especially wheat which could be grown on large mechanised farms. A few years later, new varieties of maize were created in India, even though it was not an important food crop in that country, and new varieties of rice were developed in the Philippines.

All these depended on chemical fertilizers and insecticides, and were hybrids, which meant that farmers using them have to purchase new seeds each year, making them extremely attractive to companies selling seeds. The Rockefeller (and later also the Ford) Foundations worked closely with international chemical and seed companies and concentrated their activities where there were large or relatively large mechanised farms. What became known as the Green Revolution was further extended, for countries willing to allow the use of genetically modified seeds, when the Monsanto company created varieties that would resist its weed killer Roundup.

However, by 1970 this first phase of the Green Revolution was winding down. It had led to greatly increased production of cereals, with very large areas planted with identical seeds. New pests and weeds were appearing, yields were no longer increasing, irrigated land was becoming saline, and the wider consequences were becoming recognised, including the fact that many small farmers had lost their land and were living in poverty. The problems of small and more marginalised farmers were exacerbated by their inability to resource the required inputs of seeds, pesticides and fertilisers (Patel 2013). In addition, the increased use of pesticides, mono-cropping and fertilisers had negative environmental impacts and there were adverse public health consequences from the powerful insecticides and weed killers (Ngowi, Mrema and Kishinhiet al. 2016; Westegen and Banik 2016). Many governments were also discouraged from providing the subsidies for fertilizers on which the whole programme depended, although we have seen a re-emergence of support for fertiliser subsidy in recent years (Jayne and Rashid 2013).

Research stations and seed companies were still creating new varieties, and there were parts of the world where the technologies had not spread widely, especially in Africa. The technology is scale-neutral, in the sense that all farmers, irrespective of scale, can use purchased seeds, fertilizers and sprays. However, it is easier for large companies to deal with a few large farmers rather than many small ones, and many small farmers do not have the resources or credit to purchase inputs. We should recognise that there were successes from the adoption of such technologies. Thus Rasmussen (1986) wrote of "The Green Revolution in the Southern Highlands" in Tanzania, based on improved varieties of maize (not all hybrids) and subsidized fertilizers, and since then hybrids have spread widely in the South-West of Tanzania, enabling the country to get close to self-sufficiency in maize, mainly grown on small farms.

Narratives of food scarcity are used as a humanitarian driver to argue for scaled up investment to ensure food security, although the form that this 'second green revolution' should take is far from agreed (Hallegatte et al. 2015). In common with the first, it tends to seek increase in production through external inputs of improved seeds, fertilisers and pesticides. Africa is deemed to have missed out and must catch up quickly if it is to feed rapidly increasing numbers of hungry mouths and governments are responding to this message. In 2016, Dawson, Martin and Sikor reported on the ‘imposed innovation’ being implemented by the Government in Rwanda, in which small farmers were being compelled to grow hybrid maize and to abandon their traditional crops. The Government prescribes what crops farmers must grow, forcefully imposes ‘modern’ seeds through legislation and enforced a turn away from poly-cropping agricultural production and other techniques, which lessen the risks facing small farmers and improve their diets. The authors show, on the basis of surveys in eight villages in the hill areas of Western Rwanda, that only a small percentage of wealthier farmers could adhere to the modernisation packages. A significant proportion of farmers found their production disrupted, their poverty exacerbated and their land tenure increasingly precarious. This had led to increased production of maize, but it had also led to many farmers losing their land – poverty and inequality had greatly increased. The numbers of livestock had decreased, and many farmers had stopped selling the crops they previously sold. Just as with the Green Revolution in India, most of the benefits had gone to the better off farmers (Dawson, Martin and Sikor 2016).

This narrative thrust underpins the familiar urge of African Ministries of Agriculture that agricultural production must be ‘modernised’ and ‘commercialised’. This continues a theme that can be traced from the time of colonial occupation (Poku and Mdee 2011, Coulson 2013, 2015). Major bilateral donors (USAID, DFID) along with the new philanthropists have sought to fund the new push for agricultural transformation in Africa, with an emphasis on land tenure formalisation, access to modern inputs and export driven production (Morvaridi 2016, Westegen and Banik 2016).

The path followed by the first green revolution is problematic in the current context. Agricultural transformation is recognised in the debates on structural economic transformation as necessary for addressing climate change and facilitating environmental sustainability (Mdee, Lemma and Emmott 2016). It promises increases in the productivity of labour, so releasing labour for industrialisation. However, there is no fixed route for this. Mechanised agricultural production practices have been developed to minimise the use of labour. These are a major source of carbon emissions, and the technologies, to the extent that they are adopted, will release far more labour than can be employed in a modern industrial sector.

However, there are other ways in which investment, and intensification of labour in small-scale farming can be a route to improvement in agricultural livelihoods (Mdee, Lemma and Emmott 2016, Wiggins 2016). A significant change since the first green revolution is the increased attention to 'sustainable intensification' (Campbell et al. 2014), and 'climate-smart agriculture' (Firbank 2012, Pretty et al. 2011) within the mainstream literature, including the World Bank Shock Waves Report (Hallegatte et al. 2015, Conceição et al. 2016, Holt-Giménez et al. 2012). The extent to which the growing urge for the second green revolution to be built on a more 'climate-smart' agriculture (CSA) is not yet clear. It is certain that this will be contested terrain, with CSA already critiqued as a contradictory 'business as usual' approach (Taylor 2018). One erroneous interpretation of climate-smart agriculture is an assumption that all it requires is the adoption of irrigation in the face of water shortage[1]. Irrigation has a part to play, especially the more efficient use of water, but other changes in cultivation practices and choices of

[1] Personal observation at The Mastercard Summit Youth Africa Works- Marriott Hotel, Kigali 16th-17th February 2017

crops are more fundamental (Manjengwa, Hanlon and Smart 2014, Wiggins 2016, FAO 2016, Harrison and Mdee 2017b).

Championing the small farmer as the driving force of agricultural change is often associated with the concept of food sovereignty. There are many definitions of food sovereignty, but here we refer to the one adopted by Via Campesina in the Nyeleni declaration.

'Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems[2]'.

The idea of food sovereignty offers a more socio-political perspective on food scarcity and food systems and provides a powerful critique to the dominant neo-liberal food regime (McMichael 2009, Ngcoya and Kumankulasingum 2016, Roman-Alacala 2016, Bush and Martiniello 2016). However, food sovereignty is also a contested concept. Its meanings are multiple (Alonso-Fradejas 2015). It is accused of being over focused on peasants and small-scale production, and this can have the impact of marginalising the approach in policy spaces. Further, as Agarwal (2014) argues, food sovereignty may not address more localised dynamics of distribution- such as gendered access to production resources within the family farming unit. Just as it is often unhelpful to approach agricultural transformation through the lens of small vs large farmers, so casting food security and food sovereignty as competing alternatives is not helpful (Clapp 2014). The science and philosophy of agroecology, on which our paper focuses, appears to have become associated with overtly political food sovereignty approaches, perhaps too much so. This allows Bernstein (2014) to suggest, incorrectly, that the approach assumes that

[2] Declaration of Nyeleni- https://nyeleni.org/spip.php?article290

‘peasants’ are a morally, socially and ecologically superior to other farmers and hence he dismisses its potential to transform the livelihoods of small-scale food producers. However, we would argue that the scientific and practice basis of agroecology is more effective when implemented within a framework of food sovereignty, as this requires an engagement with issues of power and resource distribution that shape the food systems in which producers are embedded.

Low-input agricultural models of production (such as agroecology) have received some, but insufficient mainstream attention, and their potential contribution to inclusive, scientific, climate resilient and environmentally positive food production systems has up to now often been missed (IFAD 2011). However, the necessity of a more robust policy engagement with agroecology and other forms of low-input, low environmental impact agriculture, as a critical component of ‘sustainable intensification’, is now very pressing, for both climate change mitigation, adaptation and ensuring food security (Conceição et al. 2016).

This article therefore attempts to address the following question: to what extent can the adoption of the science and practice of agroecology enable the creation of sustainable livelihoods for currently small-scale subsistence farmers?

It is divided into three parts. The first part sets out how a conceptual framework of the application of the science and practice of agroecology can be integrated into a livelihoods analysis. The second part of the paper applies this framework to a case study of agroecological production in the Uluguru Mountains in Tanzania, and, through a combination of data from four empirical studies, develops a dynamic and holistic livelihoods analysis of small scale farmers. It details the methodology used in these studies and presents mixed methods evidence on production, social relations, institutions and resource access. The third part of the paper presents findings of significant improvements in agricultural production and well-being in the livelihoods of farmers who have adopted agroecological practices. However, these livelihoods are under threat from their perceived damaging impact on water resources, so our conclusions have potentially critical implications for reconfiguring the relationships between farmers and the institutional bodies that mediate access to land and water.

The potential of an agroecological approach to transform agricultural livelihoods

The concept of sustainable agriculture, and the science and philosophy of agroecology has begun to receive more mainstream attention (Sillici 2014).

Altieri (1995, 2002) outlines the principles of agroecology[3] as:

- Increasing biomass and balance in nutrient flows
- Promoting high levels of soil organic matter and an active soil biology through mulching and cover crops
- Minimising nutrient losses
- Promoting functional biodiversity- within and between species, above and below ground.
- Promoting increased biological interactions and synergies to enable pest management and soil fertility which do not rely on external inputs.

This creates an agricultural mode of production that limits external inputs and focusses on increasing soil fertility.

Studies show that farms with high levels of agroecological integration can produce higher total production per unit area with fewer off-farm inputs (Altieri 2002, Funes et al. 2002, Funes-Monzote 2008, 2010, van de Merwe, Cloete and van der Hoeven et al. 2010, Rosset et al. 2011, Pretty et al. 2010., Nyantakyi-Frimpong 2016, Pandey et al.. 2016, Ghosh 2014, Brown 2016). In addition, a body of work confirms the productivity and

[3] There are many similarities with Conservation Agriculture- the two approaches are closely related. We focus on agroecology in relation to it as an approach for transformation for the small farmer.

viability of this production mode under the wider heading of sustainable agriculture- see Pretty 2001, 2002, 2003), as well as the environmental benefits of soil and water conservation practices (West et al. 2014, Scoones 2001). Whilst many of these conclusions are drawn on the basis of small case studies, there is wider evidence that an agroecological approach can be transformatory on a much larger scale.

Over the past thirty years Cuba has offered something of a natural experiment. Following the collapse of the Soviet Union, a crisis of funding (the so-called 'special period') necessitated a reinvention of agriculture in Cuba, to favour low input production. This suggests that it is possible to deliver agricultural transformation with a low level of external inputs and greater cooperation and social awareness (Funes-Monzote 2008, Rosset et al. 2011, Stricker 2010). Rosset et al. (2011) outline three significant findings in their study of Cuban agriculture: (1) that a social process methodology, in which groups of farmers worked together both to improve their environment and increase production, contributed to spread of agroecological practices; (2) that farming practices evolved over time and increased production and (3) this also produced increased resilience to climate change. Rosset et al. (2011) suggest that small-scale agriculture in Southern agroecological systems could over the long term outperform conventional monocropping in total outputs per area.

In 2013 Bhutan made a national commitment to convert to 100% organic[4] (actually agroecological) agricultural production by 2020 (Neuhoff et al. 2014). These large scale commitments set alongside the small scale project evidence of increased production with minimal or positive environmental impact, leads some to ask why wouldn't countries in

[4] In this paper- we refer to 'organic' agriculture when production is certified as such. We do not use 'organic' to mean the non-use of inorganic inputs.

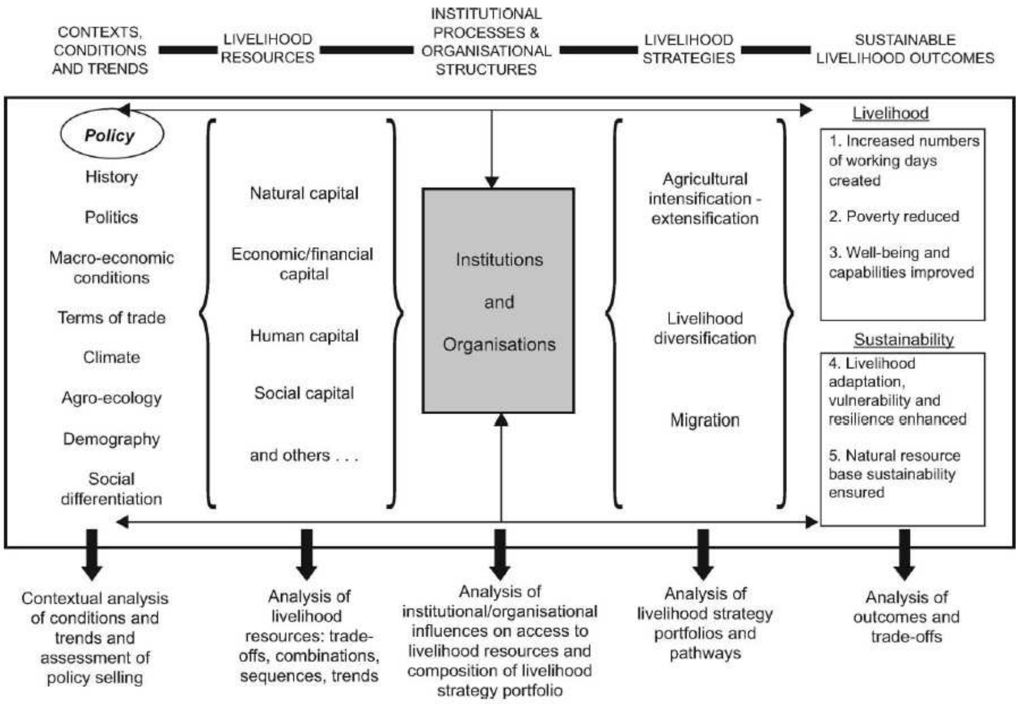
Sub-Saharan Africa incorporate such approaches in agricultural policy in order to promote inclusive and environmentally beneficial agriculture (Mdee, Lemma & Emmott 2016, Nyantakyi-Frimpong et al. 2016)?

In 2010, there was a Directive from the AU Heads of State and Government a Decision on Organic Farming (Doc. EX.CL/631 (XVIII). The Summit decision requested the African Union Commission (AUC) and the New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency (NPCA) 'to initiate and provide guidance for an AU-led coalition of international partners on the establishment of an African organic farming platform based on available best practices; and to provide guidance in support of the development of sustainable organic farming systems' (IFOAM 2013,12). In practice, governments in Sub-Saharan Africa have been slow or resistant to incorporate agroecological approaches. Through research on Uganda, Isgren (2016) suggests that whilst government is paying more attention to agriculture, seeking both economic growth and poverty reduction, there is a pressure to focus on increasing the size of land holdings and in moving subsistence and small-holder farmers away from agriculture. The narratives of modern agriculture are very powerful and diminish low input agriculture as backward and unmodern. We see observe this same narrative repeated in Tanzania (See also Mbunda 2013, Coulson 2015). Agriculture is to be modernised and commercialised, and this is perceived as incompatible with small-scale agriculture. Isgren (ibid) notes there is also a cultural pressure against the desirability of working in agriculture that prevents innovation and knowledge accumulation; and that the knowledge and labour intensity of the adoption of agroecological practices can be a barrier to their adoption.

What is therefore required is a greater engagement with how agroecology as both a science and a set of practices shifts and shapes livelihoods. How does the adoption of agroecology link to the operation of markets, the design of policy, the assets that people have access to and the institutions that shape them? This has been captured to some degree in Latin America (Altieri & Toledo 2011, Altieri, Funes-Monzote and Petersen 2012, Rossett et al. 2011), but much less so in Sub-Saharan Africa. To overcome the inherent prejudice towards agroecology (as noted above by Isgren 2016), then more detailed explanations of its transformational potential are required.

Our research in Tanzania analyses evidence on small farmer adoption of agroecological practices using the sustainable livelihoods framework outlined in figure 1. Such frameworks have been the dominant tool for understanding rural development over the past 15 years (Scoones 2009). Their strength lies in the attempt to construct a holistic and multi-dimensional assessment of how the livelihoods strategies of individuals are shaped by their access to assets, their social, political, economic and environmental context, and by the way that institutions operate. No conceptual framework can fully capture the complexity of livelihoods systems, and in this paper, we deploy the framework as a means of making sense of multiple sources of data on the phenomenon under examination. Our application of the framework is heavily influenced by political ecology, and in this sense builds on the work of Amekawa (2011) and Adinsall et al. (2015) in their attempts to integrate a livelihoods approach, with agroecology.

Figure 1- Sustainable Livelihoods Framework (Scoones 2009: 177)



This framework makes it possible to analyse the incorporation of an agroecological approach into an existing livelihoods system, and to highlight the outcomes and institutional dynamics of doing so.

Our livelihoods analysis is set out under five headings in order to explore the adoption of practices of agroecology in Tanzania:

1. ***Contexts, conditions and trends***

   How have livelihoods evolved in the locality? What are the geographic, climatic, social, economic and political factors that shape livelihood patterns? How did the science and practice of agroecology fit into this context?

2. ***Livelihood resources***

   What resources do different individuals and groups use to build livelihoods. How have these changed over time? Which resources are overused and which resources exist but are not fully utilized? Which resources are absent entirely? How was agroecology adopted, and implemented? What barriers and dilemmas were faced in the process?

3. ***Institutional processes and structures***

   How do institutional patterns, rules, laws and policy influence the shape and nature of livelihoods? How was the adoption of agroecology shaped by institutional processes and structures?

4. ***Livelihood strategies***

   What are the strategies that people use over the longer term to both survive and to meet the demands of wider kin and social groups? What has influenced these changes? Have livelihoods strategies changed through the adoption of agroecology?

5. ***Livelihoods outcomes***

   To what degree are livelihood strategies able to be sustainable- that is can they meet household needs, improve well-being and enhance capabilities without depleting or damaging the natural resource base? To what extent can agroecology offer potential improvements in well-being, and environmental sustainability? How sustainable are the livelihoods that have incorporated it into their strategies?

These questions raise issues about the role of knowledge, politics, scale and dynamics in shaping the livelihoods outcomes and make it possible to continue the process of framing a new research agenda around agricultural transformation through agroecology.

Agroecological production in the Ulugurus- inclusive green agriculture?

This section draws on data from four recent empirical research studies which investigate livelihoods in the Uluguru mountains on the Morogoro river catchment. We use these studies to attempt a complex livelihoods analysis. The frame of this analysis is on the adoption of agroecology within livelihoods strategies and the outcomes that this has for local livelihoods strategies and outcomes. The four studies are not directly comparable, rather we use their findings in order to triangulate responses to the questions set out above (Denzin 2017). The studies are described below, and an overview is provided in table 1.

- Anna Mdee conducted an anthropological study of the Choma area, in the mountains above Morogoro town, from 2013-14, as part of research on small-scale irrigation. Working with local researchers, she conducted a structured survey of 115 individuals, and extended interviews with 60 farmers. She also interviewed key informants in local NGOs, Sokoine University of Agriculture (SUA), Wami-Ruvu River Basin Office (WRRBO) and Morogoro Urban Water and Sanitation Authority (MOROUWASA). This work is published in Mdee et al. 2014, Mdee 2017, Harrison & Mdee 2017a, 2017b.

- Alex Wostry conducted a participatory study with 30 farmers, 19 females and 11 males, in Ruvuma, Choma and Tulo in the Morogoro River watershed in 2013. All were small-scale farmers who produce for home use and sell the surplus at the local market. They had received technical support from Sustainable Agriculture Tanzania (SAT), a local organisation focusing on sustainable solutions for small scale farmers with strong links to the Sokoine University of Agriculture.[5] and were aware of the technologies of terracing, making compost and producing liquid

[5] Sustainable Agriculture Tanzania (SAT) has worked for more than 5 years with farmer groups in the Uluguru Mountains, in total 386 small-scale farmers. The first group to be trained, and later the first to be certified under the "Participatory Guarantee System", was the Maendeleo (Swahili for "progress") group from Ruvuma village. The remaining groups are currently striving for this certification. In total there are 14 farmer groups in 12 villages (Kimimcho (Choma), Maendeleo (Ruvuma), Mazingira (Mlali), Mshikamano (Mfumbwe), Mwanzo Ngumu (Bigwa), Nguvu Kazi (Tulo), Tughetse (Langali), Twikinde (Diovuna Kenge), Twiyavile (Mgambazi), Umoja Group (Mahembe), Upatacho (Langali), Lamka (Kinole), Kaloleni (Kinole), Twaweza (Mundu)) SAT also provides these farmers with market access for their organic produce. In April 2012, SAT opened the first organic food store in Morogoro ("SAT Organic Shop"), illustrating a new way of developing a local organic market. The farmers who produce for the Organic Shop do so under the East African Organic Product Standard and have previously undergone training with SAT.

fertilizer and botanical pesticides. The extent of their experiences differed from village to village. The Ruvuma farmers had practised agroecology for three years and were "certified organic producers". The Choma farmers had received training for a year and a half and aimed to become certified producers by 2014. The Tulo farmers were being trained by Ruvuma farmers through a farmer to farmer project, but their exposure was limited to a period of five months. agroecological. More details on this research can be found in Wostry 2014.

- Research by Chie Miyashita (2015) (Sokoine University of Agriculture) of farmers from the Ulugurus and surrounding low land areas. This included a quantitative survey of 160 agroecological farmers (purposively selected on the basis of their farming practice in 20 villages) and 164 comparison farmers (randomly selected from 4 of the 20 villages), which explored costs and benefits of production. Efforts were made to ensure the sample was comparable between plot size and location. It was supplemented with qualitative interviewing of a smaller sub-sample of the surveyed farmers.
- SAT End of Line survey and evaluation of the Bustani ya Tushikamane Project (2009-2016), in the Ulugurus and in the low land areas surrounding Morogoro, of which Wostry (2014) deals with a sub-sample of upland farmers. A total of 329 farmers were interviewed, 61% of the sample were women.

Table 1- overview of empirical studies used in meta-analysis

Source	Geographical area	Sampling frame
Mdee (2014)	Choma area	Survey of 115 randomly selected farmers. Qualitative interviews with political ecology framework
Wostry (2014)	Choma, Ruvuma, Tulo	In-depth participatory study with 30 farmers (19 female and 11 male- all active adopters of agroecological practices.
Miyashita (2015)	Upland area and lowland surrounding area– 20 villages	Survey of 324 farmers- 160 farmers purposively selected on

		basis of agroecological adoption, 164 non-adopters selected from 4 of the 20 villages With supplementary qualitative interviewing.
SAT (2016) survey on Bustani ya Tushikamane project	Upland and lowland villages where SAT operates	Survey of 329 participating farmers (61 % women)

The four studies contain a range of data types including: survey, qualitative interview, observation, mapping. Data is used thematically in response to the categories and questions set out in the livelihoods framework. No one type of data is privileged over another. Where we present descriptive statistics for example, we attempt to triangulate these by drawing on other sources in the data set.

Contexts, conditions and trends

The Uluguru Mountains, lie 120 miles inland from Dar es Salaam, and form part of the Eastern Arc Mountains in Tanzania. Like the Usambara and Pare mountains further North, the slopes are steep and the soils of moderate fertility. The rainfall and temperatures of the uplands are conducive to agriculture and settlement. Meteorological records suggest that rainfall on the higher slopes of the Ulugurus has increased since 1977, whilst rainfall on the plains has decreased over the same period (Mdee et al. (2014). Young and Fosbrooke (1960) suggest that while some reports suggest that the Mountains were settled in the 17th century, oral history indicates that indigenous people were already living in the area and were displaced by incoming settlers. The population increased during the 19th century when there were violent conflicts in the plains around the mountains (ibid)

The predominant residents of the Ulugurus are the Luguru ethnic group. The survey by Mdee et al. (2014) found that 97% of residents in Choma were resident on the mountain since their birth. The Luguru practice matrilineal inheritance, and land is still treatedas a collective asset, with permission from the Luguru clans being required in cases of purchase or transfer (Young & Fosbrooke 1960; Jones 1996; Wostry 2014). Jones (1999) also notes that there is relatively little gendered differentiation in agricultural labour.

This research areas in this study are close to the city of Morogoro. The steep forested Northern slopes of the Ulugurus, with forests above about 2,000m, are a significant water catchment, and feed into the Ngerengere river, a source of the Ruvu river. This river is the main source of water for the major commercial city of Dar-es-Salaam and therefore given political significance in debates over water scarcity in the urban areas (Mdee 2017). Agriculture is possible on these slopes, and since German occupation, there has been fierce debate on how the residents of the Ulugurus treat the land. For at least 80 years, it has been alleged that the Luguru farmers are causing erosion, encroaching on the forest, burning the scrub, polluting the water courses and over extracting water (Bagshawe 1930). Attempts to enforce soil conservation measures through terracing were implemented under the Uluguru Land Usage Scheme between 1947 and 1955, but this poorly implemented and under resourced scheme led to riots in some parts of the Ulugurus (Young & Fosbrooke 1960: 141-167). These riots occurred in response to enforced terrace building, with the aim of preventing erosion, and are seen as one of the seminal examples of peasant resistance to late-colonial agricultural impositions (Young & Fosbrooke, 1960; Jones 1996, 1999; Coulson 2013, compare Scott 1985).

Agricultural plots are small and fragmented, and getting more so as the population grows. In Choma, land holdings ranged in size from 0.25-7 acres. The average holding was 2.5 acres (Mdee et al. 2014); comprising of 1.4 acres of irrigated land and 1.1 acres of rain-fed. Most households had a mixture of plots, some irrigated and others rainfed, for the production of maize and beans. This finding is confirmed in Jones (1996), Miyashita (2015), Wostry (2014) and SAT (2016).

The Luguru have for many generations practiced irrigation with water diverted from streams into furrows, many involving stone constructions, though in some areas this was banned. Over the last 15 years, many farmers purchased plastic hosepipes, which are much cheaper and require less maintenance than the traditional furrows, and connected them to small sprinklers, using the naturally high pressure from the steep mountain streams. This has obvious labour and efficiency advantages (Harrison and Mdee 2017a). With cool temperatures and access to irrigation water, the production of high value horticultural crops has expanded (Jones 1999). Morogoro town provides a ready market for horticultural crops, and in the case of some crops, such as strawberries, the long-distance bus routes give access to markets in Dar-es-Salaam and Arusha (Mdee et al.. 2014; Harrison and Mdee 2017).

Jones, writing in the 1990s, suggested that soil fertility had declined and environmental degradation increased as farmers were too poor to invest in soil fertility improvements measures; specifically, they could not justify using labour on terracing, and were experiencing the ‘shock’ of the removal of agricultural subsidies at that time (Jones 1999). Her analysis chimes with that of Van Donge (1992), who saw the farmers of the Ulugurus as trapped in decline. In contrast, Ponte (2001) argues that this decline was not inevitable and might be addressed through extensification, intensification and diversification, especially where market linkages are strong. Improvements in livelihoods and agricultural production are reported in Mdee et al. (2014), and this is in contrast to Jones, whose fieldwork was conducted at a time when the performance of agriculture in Tanzania had been disrupted by the country’s economic difficulties, and both policy makers and academics were very pessimistic about the future of small scale agriculture (Jones 1996a, 1996b).

Through the work of local NGOs, and particularly SAT, awareness of agroecological methods in our study areas is high: From a random sample of 115 farmers in Choma village 85% of the farmers practice conservation tillage, and 84% use compost or manure. 53% say that have learnt these methods from the NGOs (Mdee et al. 2014).

Farmers certified as organic through the SAT facilitated participatory guarantee scheme (PGS) report significant improvement in their livelihoods (Wostry 2014) and we will explore this further below. So, should we conclude that this is success? Further, that agricultural livelihoods are improving and that the positive uptake of agroecological practice offers an example that should be promoted more widely? This is only half the story. The water use of the Luguru farmer's is in the eyes of the state, illegal; and the Luguru continue to be blamed for land degradation, polluting the water courses and for contributing to water scarcity in rapidly growing urban Morogoro. An effort to evict the farmers failed in 2006/7 but their livelihoods remain under threat (Harrison and Mdee 2017).

Livelihood resources

The apparently successful uptake of agroecological agricultural practice and the subsequent improvement in livelihoods outcomes (addressed in the section appears to come from four key livelihood resource factors:

Whilst a small number of the farmers were formerly heavy pesticide and fertilizer users. Many others were already practising low input agriculture, because they could not afford to purchase inputs of seeds and fertilisers. There are low financial barriers to the adoption of techniques such as compost making and using biopesticides and fertilisers from locally available sources. This approach enabled adopting farmers to build on, extend and value existing local knowledge, as well as relevant practices that might be dismissed as 'unmodern'. Acceptance of the agroecological approach has spread quickly from farmer to farmer, and through the use of demonstration plots.. Miyashita's data, summarised in Table 2, illustrates the relatively low use of chemical fertilisers and pesticides for all farmers in their study. Only 21.3% of the comparison group of farmers use chemical fertilisers and pesticides.

Table 2 Farming practices (adapted from Miyashita 2015)

Farming practices	**Agroecological farmers (n = 160) (%)**	**Comparison farmers (n = 164) (%)**
Organic fertilizers	90.0	35.4
Organic pesticides	71.9	3.0
Crop rotation	81.9	25.6
Mulching	81.2	19.5
Terracing	63.1	34.1
Intercropping	75.0	74.4
Cover crops	88.8	78.0
Chemical fertilizers	13.8	21.3
Chemical pesticides	13.8	21.3

Farmers were also very receptive to agroecological knowledge as practice as is illustrated by the following quotations (from Miyashita 2015):

"We do not need to struggle in farming shops to purchase inputs when we can make our own." (Old woman in Kauzeni)

"We used to see weeds as functionless and throw them away. Surprising enough they have their role (for fertilizers)." (Old woman in Ruvuma)

Farmers also observed improvements in the quality of their crops:

"When I harvested carrots which were grown with chemical pesticides, the carrots used to become rotten. But they do not now." (Old woman in Ruvuma)

"When we used agro-chemicals, plants used to become bad in summer season. They turn to yellow colour. But after starting organic farming with fertilizer of animal manure, plants are okay even under strong sun. They grow well. Moreover, vegetables do not get so many diseases as many as they used to have when we used agro-*chemicals."(Old* woman in Ruvuma)

Some Farmers also expressed concerns for family health from the consumption of crops treated with pesticides:

“When we started organic farming as a group, I made one of my farms as an organic farm for family uses, because I want my family to eat non-harmful food. I left other farms as conventional for commercial uses”. (Man in Ruvuma)

Concerns relating to excessive pesticide use in commercial production in Tanzania are also noted in Ngowi et al. (2016)

The strong social ties and embedded resource sharing arrangements in this area promote the spread of knowledge; and also, support labour requirements for labour intensive activities such as terrace building. The ethnographic research by Mdee et al. (2014) highlights the effective management of water resources for irrigation through co-operative social and kin relationships. Terrace building, once resisted as a colonial imposition, has now been adopted in certain places where the soil is deep enough as a key technique to improve long-term soil fertility improvements (Wostry 2014). Whilst farmers experience a fertility and productivity decline after initial terrace building, they can see increased productivity in the second and third years. The risks are also reduced through observing the experiences of relatives and neighbours in achieving long term productivity increases after terracing (Wostry 2014; Mdee et al.. 2014Increased imports of cheaper plastic household and agricultural goods have changed the access of farmers to some types of technology. Plastic hosepipes and sprinklers have enabled a technological transformation in irrigation, and spread quickly, especially after the banning of furrow irrigation approximately 10 years ago (See Mdee 2017, Harrison and Mdee 2017a for more details on this). Farmers also occupy an advantageous hydrological position at the top of the water course, therefore they have access to water for irrigation throughout the year.

Expanding market opportunities have underpinned improved livelihood prospects. Proximity to the urban environment allows more possibilities for the sale of horticultural crops, with strawberry and other berry production being particularly profitable (Mdee et al. 2014). SAT supports a participatory guarantee system for organic certification, which enables some farmers to supply organic-labelled products to local suppliers, and to SAT's own shop (Wostry 2014). However, organic-labelled produce does not necessarily attract a price premium in the local market. Table 3 shows the comparative advantage in terms of market availability for the agroecological farmers (43% have a reliable market as opposed to only 8.5% of the comparison farmers), and this is probably due to the market support through SAT, but also the types of higher value horticultural produce that the farmers grow. In addition, the considerable agricultural knowledge resources are available in the area due to the proximity of Sokoine University of Agriculture (SUA).

Table 3- Market access (Adapted from Miyashita 2015)

Market engagement	Response	Agroecological farmers (n =160)	Comparison farmers (n = 164)
Whether they have a reliable market	Yes	69 (43.1%)*	14 (8.5%)*
Whether they have a contract with trader/buyers	Yes	12 (7.5)	0 (0)

*** The numbers in brackets are percentages**

Institutional processes and structures

The institutional context for the Luguru Farmers illustrates a tension between the socially-embedded production system of the farmers, that has successfully adopted agroecological methods, and the more formal regulatory structures of the Tanzanian state. Land access is relatively secure, through kin networks. On the other hand, access to water is contested (Harrison and Mdee 2017a). From the perspective of the local administration, the Luguru farmers are illegal water users, as they do not have water permits from the Wami-Ruvu River Basin Office. In 2006/7 there was an attempt to evict them from the mountain, on the basis that they were causing environmental degradation and water shortages downstream in Morogoro. The Wami-Ruvu River Basin Office does not have the technical capacity to measure water flows in the river at the upper levels, and so it is difficult to ascertain the level of extraction by the Farmers. What is clear is that the Morogoro Urban Water & Sanitation Authority (MORUWASA) does not currently have sufficient water resources to meet urban demand throughout the year. They believe that the Farmers' water use is impacting on water availability for the urban area, and therefore Morogoro Municipal Council are under pressure to move the farmers from the water catchment. This eviction attempt was thwarted by intervention from the then President, Jakaya Kikwete, but the institutional tension has persisted. Existing bye-laws were enforced to prevent farming within 60m of the water course, and in 2016 some houses in the valley bottoms were demolished on the orders of the Municipal Council. In 2017 the military used force to cut some water pipes.

The Farmers in Choma were actively resisting incorporation by the state (Scott 1985). They do not want to formalise to form a water users' association which would require them to pay fees for water access, given that they regard their own management of the water resources to be equitable and consensual. Mdee was told that the Wami-Ruvu River Basin Office would be willing to issue a permit for the multiple small hosepipe water intakes, but the farmers are suspicious. Many regard the local government as having done little to support them (Mdee et al. 2014).

As was noted above, external interventions to counteract environmental degradation of the Ulugurus extend back over a considerable time period. Payment for ecosystem service (PES) approaches were recently piloted by the World Wildlife Fund (WWF) in conjunction with Care International and funded by the UK Department for International Development. PES approaches work on the theory that payments are made by a user of environmental services to those that protect or sustain a particular resource. In this case, the intention was for the Dar-es-Salaam water authority and Coca-Cola Tanzania to make payments to the Ulugurus farmers, in return for them reducing their water usage and desisting from harmful practices. However, these efforts, were ultimately unsustainable, as the commitment of the commercial partners did not materialise and so the project was dependent on donor funds (Kwayu, Sallu and Paavolaet al. 2014). Of current interventions, only those that have worked from, and in support of the existing livelihoods of the Luguru farmers have seen widespread adoption, as is evidenced by Wostry (2014), Mdee et al. (2014), Miyashita (2015) and SAT (2016). The identity and social cohesion of the Luguru remains strong; the importance of the clan in allocations of land and collective decision-making persists. At the same time, as for the rest of Tanzania, customary institutions have only limited and insecure jurisdiction as the formal institutions of the state overlay and co-exist with more customary arrangements (for an interesting comparison see work on Mafia Island by Caplan 2007).

The SAT supported farmer-to-farmer Bustani ya Tushikamane (ByT) project has provided a locally embedded and reliable support structure to support the uptake of agroecological practice, and critically has also supported elements of market development e.g. in relation to the PGS scheme. It has a strong vision of its own, and has sought out donors who support this vision, rather than responding to a framework imposed by a donor. In the Ulugurus it has earned the trust and respect of farmers and is gaining increasing international recognition for its methods and achievements. Wostry (2014) asserts that the increased use of agroecological practices could lessen the negative impact of the farmers on the catchment. However, the positive uptake of agroecological practices and improved livelihoods of the Luguru farmers is threatened by the institutional impasse in relation to the legitimate use of water.

Livelihood strategies

Whilst previous research (such as Van Donge 1992, Jones 1999) found that in the 1990s Luguru farmers were struggling to make a living, this research suggests that agricultural livelihoods are thriving for those with access to irrigation water in tandem the adoption of agroecological practices. Farmers talk proudly of producing food, free of pesticides, for their families, but now also for local and national markets (Mdee et al.. 2014). 91% of the farmers in the ByT project derive income from sales of their crops, and thus this remains the dominant livelihoods strategy- See table 4 (SAT 2016 data). In addition, 46% of farmers, participating in the ByT project have additional income from small business activities- examples include operating motorbike taxis, owning a small shop or selling other products such as clay sticks consumed by pregnant women across Tanzania (see also Mdee et al.. 2014)

Table 4 -Income source	**(%) (SAT 2016)**
Sales of crops	91
Formal employment	1
Sales of livestock and livestock products	22
Small business	46
Wages from piece work	16
Other sources (inc remittances)	5

In terms of agricultural strategies, farmers have adopted various aspects of agroecological practice, with the majority of farmers practicing the use of botanical extracts (as fertilisers and pesticides), crop rotation and intercropping as shown in table 5 (based on SAT 2016

Table 5- Pests and Diseases management	**Adoption (%) (SAT 2016)**
Using botanical extracts	77
Intercropping	60
Crop rotation	53
Using repellant plants	15
Using industrial pesticides	4
Using trap plants	2

data).

Table 6- Soil fertility method	Adoption (%) (SAT 2016)
Leaving residuals	90
Incorporating residuals in the soil	80
Applying animal manure	56
Planting legume plants	47
Using compost	45
Mulching	44
Other soil management ways	3

Farmers also have high adoption levels of soil conservation and improvement techniques with more than 90% leaving plant residuals in the soil (Table 6- SAT 2016 data).

Only around 17% of all farmers in the SAT ByT survey (upland and lowland) use terracing as an erosion control method, but 50% were planting trees and 32% other cover crops to prevent erosion. For farmers in the upland areas, the adoption of terraces is 64% reflecting the nature of the terrain. The active avoidance of using fire in 82% of cases is significant, given that this has previously been a critical strategy used by farmers to clear land for cultivation (Table 7 SAT 2016 data).

Table 7- Adoption of social erosion control measures (from SAT 2016)

Soil erosion control measures	Adoption (%)

Avoiding fire burning	82
Planting trees around the farm	50
Planting cover crops	32
Contour farming	21
Using terraces	17
Other erosion management ways	10

There is an active engagement by the farmers and SAT with the challenge of developing and extending marketing opportunities- through the participatory guarantee scheme (PGS) and through a proposal for an agroecological certified market in Morogoro (SAT 2016 and Wostry 2014). As will be discussed below, this does not rely on certified goods being paid a premium for their status as 'organic' but is pursued on the basis that this livelihood strategy enables agriculture that is more profitable, given that it can lower the cost of inputs and improve productivity.

In addition, improvements in livelihoods are enabling farmers to prioritise expenditure on education for their children, with the aim that the children are able to pursue more urban-based livelihoods. This is essentially a positive migration[6] which if successful could reduce population pressure in the longer term.

Livelihoods outcomes

The above analysis paints a picture of Luguru farmers adopting a range of agroecological practices as part of diversified livelihoods strategies, and in the face of contestation over their access to and use of water. The growing urbanisation of Morogoro and wider economic growth in Tanzania provides a market for horticultural production, and this has improved the income of these farmers. However, if their water use remains problematic

[6] Personal comment- Alex Wostry

and contested, it is difficult to say that their livelihoods are sustainable; but one of the primary aims in writing this article is to present evidence to challenge the position of the water management institutions. We assert that is it possible for the Luguru farmers to improve their livelihoods and enhance the natural resource base; and for the state authorities to recognise their livelihood strategies as legitimate

All four of our included empirical studies report improvements in livelihoods from the adoption of agroecological practices . The data suggests that agroecological production has had a number of significant benefits in terms of both poverty reduction, improving soil fertility, reducing environmental degradation, and even in regenerating environmental resources.

Mdee at al. (2014) found farmers prioritising the efficient use of water resources, both through socialco-operation, and the adoption of hosepipes and sprinklers. Farmers reported livelihoods improvements, which they measure in relation to being able to purchase solar panels and pay fees for secondary school for their children. Wostry (2014) finds evidence that the terracing and the adoption of agroecological systems reduced the need for irrigation, with improved soil water management. 13 out of 18 farmers involved in his participatory research reported a reduction in their water demand, through improved soil management. Whilst this result might require further confirmation in a wider study, the implication is that through the spread of agroecological practice, water demand for irrigation can be reduced. This is particularly significant in the face of the accusations of illegal extraction of water.

Wostry (2014) also found that following conversion to certified organic status, farmers' perception of their wealth had increased. In his detailed participatory study 14 out of 20 participants in Ruvuma and Choma viewed themselves as being of average status or as poor before conversion. Following conversion to agroecological and certified organic production, 16 out of 20 farmers perceived themselves as rich. One elderly female farmer in Ruvuma suggested she had moved from being very poor to being rich in the course of three years.

Miyashita (2015) also reported positive qualitative and quantitative data on livelihood outcomes for adopting farmers. Table 8 suggests that the prices received by the agroecological farmers were higher for some crops (e.g. Chinese cabbage), but lower for others (e.g. tomatoes), although the disparity in the numbers of farmers cultivating each crop makes direct comparison difficult. In addition, the high value berry and horticultural crops are not included in the comparison. Table 9 also suggests higher production estimates for agroecological farmers, as compared to the sample of non-agroecological farmers, but again we should be a little wary of these type of farmer estimates.

Table 8 Average price of 1kg of crop products sold (TZS) (from Miyashita 2015)

Crop	Agroecological farmers				Comparison farmers			
	N	Min	Max	Average	N	Min	Max	Average
Maize	31	150	1400	526.45	40	30	750	490.02
Rice	16	100	1500	745.12	3	400	700	530
Banana	95	80	1080	304.38	7	100	450	202.00
Cow pea	13	70	2910	920.00	19	320	2000	1070.95
Pumpkins	25	114	700	304.92	19	100	1800	516.47
Chinese cabbage	53	400	2000	1241.51	8	50	1200	407.12
Tomato	44	150	1000	497.66	13	125	1800	490
Cabbage	28	70	1600	342.25	80	100	666	214.12

Table 9 Mean of estimated production from 1 ha (Kg) (from Miyashita 2015)

Crops	Farming style	N	Mean
Maize	Agroecological	141	1156.3
	Comparison	162	1039.44
Cow pea	Agroecological	80	207.77
	Comparison	92	186.31
Pumpkins	Agroecological	95	409.62
	Comparison	81	261.83

However, we do find these findings are reinforced through qualitative interviewing:

"When we used agro-chemicals, if you planted maize, some of them grew well but some did not grow well. It made us to buy fertilizer to make them grow again. But organic maize grows well without that process. It gives us a lot of profit." (Old woman in Ruvuma)

Both Wostry (2014) and Miyashita (2015) report increased profitability of production for agroecological farmers. This is due to the lower input costs of agroecological practice, but also enhanced productivity as compared to the comparison group of farmers. It should be remembered that the comparison group is cultivating with relatively low use of pesticides and fertilisers due to their high cost. This is not a comparison of so called 'conventional' or 'modernised' production. However, what this does show is that agroecological adoption can improve profitability. Table 10 shows the gross income of the agroecological farmers to be significantly higher than comparison farmers, and their costs to be significantly lower. As table 11 illustrates- this necessarily increases profitability- from Miyashita (2015). Miyashita's qualitative interviewing finds that conventional farmers more often take on larger debts in order to purchase inputs, and this impacts figures on average profitability.

Table 10- Gross income and costs (from Miyashita 2015)

Variable described	n	Min	Max	Mean
Gross income of agroecological farmers	160	0	56005000	1842657.20
Gross income of comparison farmers	164	0	17255000	378872.99
Total costs of agroecological farmers	160	0	1269000	206049
Total costs of comparison farmers	164	0	2382500	231902

Table 11- Profit (TZS) of production (from Miyashita 2015)

Framing group	n	Min	Max	Mean	F	Sig.
Agroecological farmers	160	-391000	54736000	1636608.14	13.652	0.000*
Comparison farmers	164	-1879000	16625500	146970.55		

*significant at 0.001 level

Wostry (2014) also shows this this to be the case even when taking into account the higher labour costs associated with some agroecological practices, such as making pesticides from botanical extracts. Wostry (2014) finds that 19 out of 20 farmers have experienced an increase in productivity of 10% or more after one year of adoption. After three years, 9 farmers from Ruvuma observed productivity increases of an average of 43%.

Mdee et al. (2014) also confirm reported high profitability in the production of the Uluguru farmers, and in this case they compare this to the much lower profitability of a highly subsidized USAID supported rice irrigation scheme at Dakawa (See Harrison & Mdee 2017b for more details).

Adoption of agroecological methods has additional environmental benefits. Table 6 and 7 above show the wide spread adoption of soil fertility and improvement measures, and the very significant number (82%) of farmers who no longer use fire as part of their land clearance cycle.

"*We used to fire farms. Now we know that there are good microorganisms and we stopped using fire*." (Middle aged woman in Kauzeni)

In Wostry (2014) 95% of the farmers stated they no longer use the "slash & burn" principle which contributes to soil erosion and release of carbon dioxide, compared to 90% of farmers using it before switching to organic agriculture. Soil fertility enhancements and erosion control measures in theory improve the water retaining capacity of the soils and prevent soil loss from the steep hillsides. They are also encouraging the planting of trees and cover crops. In addition, the avoidance of pesticides and chemicals avoids pollution of the water course, although the use of uncomposted animal manure could pose an issue with run-off. Further research on these aspects of the production cycle will be vital in fully understanding the impact of the adoption of agroecological methods by farmers. Farmers increasingly view themselves as environmental stewards and have recently interacted (facilitated by SAT) with the local government stakeholders who were previously seeking their removal.

Discussion and Conclusion

Our research demonstrates that the introduction and spread of agroecological practices in the Uluguru Mountains (and the surrounding lowland) is possible, and that for farmers who adopt the practices this can lead to improvements in their livelihoods, through increased production and lower input costs. We also find evidence of beneficial impacts for reduced harm to the natural environment. These findings confirm those of others detailed in section 2, that agroecological practice can increase production whilst reducing environmental impact.

However, our analysis reveals that there are critical institutional barriers that will need to be overcome. The success of the farmers in the Ulugurus is partly connected to the accessibility of water for irrigation of higher-value crops, and fairly equal and homogenous social relations which have facilitated access to land and water sharing arrangements. Yet the water use of the farmers is contested and is currently considered illegal. This fundamentally threatens the longer-term sustainability of livelihood gain.

The specific context of resource and market availability underpins the successful adoption of agroecological practice. Hence, we cannot conclude that these practices would work as well in other contexts, but one of the significant benefits of agroecology adoption for small scale farmers is the low cost of inputs

Such practices are knowledge intensive, and so will require inputs of time. Again, in the context of the Ulugurus, high levels of social trust and co-operation underpin the spread of agroecological practice. This appears to be similar to evidence from Cuba on the spread of low-input agroecological systems (Rosset et al. 2011).

We argue that the potential of agroecology requires further experimentation, and it would be a relatively low risk strategy to adopt this approach into national policy. Tanzanian agricultural history is littered with examples of failed ‘modernisation’, and yet the small-scale farmer has continued to feed the nation. A national agricultural policy centred on increasing the application of agroecology practice could have a significant impact on improving agricultural production and protecting and enhancing natural resource use.

With the growing demands for 'climate smart agriculture' and 'sustainable intensification', Tanzania could be a world leader in addressing these agendas through the creative adoption of agroecological practice, which shows the potential to actually improve the livelihoods of small scale farmers and tackle critical environmental challenges. Current mainstream second green revolution approaches will almost certainly fail to achieve these goals.

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