Norwegian University of Life Sciences

Master's Thesis 2020 30 ECTS
BIOVIT

THE ROLE OF DEMONSTRATION FARMS IN AGROECOLOGICAL TRANSITIONS - NEXUS FOR SCALING UP AND SCALING OUT AGROECOLOGY

Edd Colbert
MSc Agroecology Double Degree

THE ROLE OF DEMONSTRATION FARMS IN AGROECOLOGICAL TRANSITIONS:

NEXUS FOR SCALING UP AND SCALING OUT AGROECOLOGY

Thesis for MSc Agroecology Double Degree at Norwegian University Of Life Sciences (NMBU) & Institut Superior d'Agriculture Rhône-Alpes (ISARA)

Written by Edd Colbert
July 2020

Thesis supervision provided by Charles Andrew Francis (NMBU) and Hélène Brives (ISARA)

Abstract

Adoption of agroecological farming practices remains low, despite increasing evidence for their socioeconomic and ecological potential. This is regretful, especially in Sub Saharan Africa (SSA) where there is a critical need for supporting farmers to become more resilient to the myriad challenges they face. However, while it is crucial that agricultural extension services support the scaling out of contextualised agroecological practices, it is also critical that agroecological principles are scaled up to create enabling market and policy contexts for food system transformation. Demonstration (demo) farms are increasingly being recognized as platforms for supporting the former process, yet this research asserts that these centres can also support agroecological transitions beyond the farm gate. This research therefore aims to explore the role of demo farms in agroecological transitions and further to highlight important design considerations that may enhance the abilities of these centres to support agroecology at field, farm, market and policy levels. A comparative case study analysis of six demo farms in Kenya was conducted using the Agroecology Criteria Tool to highlight how these centres are already supporting agroecological transitions. The results of these case studies are integrated with farmers' perspectives gained during a participatory demo farm design workshop to further understand how such centres might be (re)designed to better enable support for agroecological transitions. Consequently, this research presents important considerations for the (re)design of demo farms as nexus for scaling agroecology up and out, in order to support sustainable food system transformation in SSA and beyond.

Keywords

Demonstration farm, Agroecology, Scaling out, Scaling up, Kenya, Co-design

Acknowledgements

I extend the deepest respect and gratitude to the farmers who I have met through the course of this research and in particular those who participated in the farm design workshop. My respect stems from having witnessed first-hand the multitude of challenges farmers in Kenya face to achieve their desired goals. One afternoon I helped a farmer to harvest some maize cobs before the start of the rains. Within a $25m^2$ plot we encountered damage caused by fall-army worms, stemborers, aflatoxin, weevils and weaver birds. All the while a swarm of locusts flew above the field luckily avoiding our patch while commuting to a warmer region. It was in this moment I truly learnt what it means to cultivate empathy with the people with whom you are working. Simultaneously I could appreciate the attractiveness of agrichemicals!

I also wish to share my appreciation for the people I met at demo farms in Kenya who work to help farmers improve their livelihoods while protecting the ecosystem on which they depend. I am equally inspired by those working at Sistema.bio for their dedication to improving the lives of farmers. In particular I wish to extend immense gratitude to Mutuma Muriuki, who has continually inspired and challenged me throughout our work together at Sistema.bio. Equal thanks go to Max Affre, Esther Altofer, Oscar Ominde, Paul Murithii, the Meru and Kiambu field teams, and Alex Eaton for their support in integrating this thesis into my work for Sistema.bio.

I feel fortunate to have received support and guidance from Hélène Brives and Charles 'Chuck' Francis as my supervisors from ISARA and NMBU. Their generous insights and encouragement, provided across multiple time zones, have meant even more to me during this process given the challenges presented by the COVID19 pandemic. I am also grateful to Matthias Geck at Biovision Foundation for Ecological Development for his continued enthusiasm and support for my endeavor of adapting the Agroecology Criteria Tool for farm level use. Thanks also goes to Jules Pretty for an early inspiring conversation about the design of this thesis.

This thesis marks the end of a two year process in which I first travelled from Colombia to Norway to start studying at NMBU. From there I travelled to Wageningen in the Netherlands for an Erasmus placement. After a short stint in Kenya on my summer break I moved to Lyon for the final semester of courses at ISARA before finally returning to Kenya to complete my thesis. I have met innumerable inspiring people during these two years and am grateful for the friendships I have made with students and professors alike. Last but absolutely not least I want to thank my partner Hayley and also my parents for the incredible moral support they have provided throughout the two years of my degree. From proof-reading my work to listening to lengthy rants about soil and plants, they have enabled me to remain focused and confident throughout this research. Thank you.

Funding

Partial funding was provided for this research from Småforskmidler Biovit.

Contents

List of Tables

List of Figures

Acronyms

ACT – Agroecology Criteria Tool
ATC – Agricultural Training Centre
CSHEP - Community Sustainable Agriculture & Healthy Environment Program
FAO – Food and Agricultural Organisation
FFS – Farmer Field Schools
FPEAK – Fresh Produce Exporters Association of Kenya
G-BIAC – Grow Biointensive Agricultural Centre
GHG – Green House Gas
HIV/AIDS - Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome
HLPE – High Level Panel of Experts
IPES-Food – International Panel of Experts On Sustainable Food Systems
IPM – Integrated Pest Management
KALRO – Kenya Agricultural & Livestock Research Organisation
KES – Kenyan Shillings
KIOF – Kenya Institue of Organic Farming
LPC – Laikipia Permaculture Centre
LPCT – Laikipia Permaculture Centre Trust
MOA – Ministry of Agriculture
NGO – Non-goververnmental Organisation
PAR – Participatory Action Research
PDC – Permaculture Design Course
PELUM – Participatory Ecological Land Use Mangement
PTC - Practical Training
SSA – Sub Saharan Africa
TAPE – Tool for Agroecological Performance Evaluation

1.0 Introduction

Agroecology is increasingly being proven as a viable approach to sustainable agriculture that generates profitability for farmers while improving quality of life for people and the planet (Pretty 2006, Khadse & Rosset 2017, Chappel et al. 2018, Van de Ploeg et al. 2019). The positive socioeconomic and ecological impacts agroecology can bring to food systems is especially true in sub-Saharan Africa (SSA) (Tittonell et al. 2012, Blanchard et al. 2013, Félix et al. 2019, Sourisseau et al. 2019). Throughout this region's diverse cultures and ecosystems farmers are utilizing a wide range of traditional and novel agroecological farming practices to support climate change adaptation and resilience (Debray et al. 2018, Sinclair et al. 2019, Malézieux et al. 2019). However, widespread adoption of sustainable farming practices remains limited (Debray et al. 2018, Mier y Terán et al. 2018, Takahashi et al. 2020).

Demonstration farms (henceforth demo farms) have been identified as important tools for enabling agroecological transitions at the field and farm level (Nicholls & Altieri 2018, IPES-Food 2018). These centres are a common method of agricultural extension (Mbure & Sullivan 2017, Ingram et al. 2018) whose focus has traditionally been on providing farmers with training and advice regarding practices or inputs (Pappa et al. 2018). As such, their role in agricultural development has been limited to scaling *out* field level resource efficiency or input substitution measures. Yet rather than encouraging a homogenous expansion of specific practices or technology, agroecology demands that such interventions must be contextualized to the needs of local agroecosystems using agroecological principles (Ferguson et al. 2019, Gaitán-Cremaschi et al. 2020). Moreover, the scaling *up* of agroecological principles must also occur to create enabling market and policy environments for sustainable and just food systems to be realized (Francis et al. 2013, Gliessman 2016, Rosset & Altieri 2017, Mier y Terán et al. 2018, IPES-Food 2018). Indeed, in SSA there is great need for enabling policies to stimulate territorial agroecological development (Sourisseau et al. 2019).

A number of agroecological demo farms or 'lighthouses' have been developed across the world that support both scaling up and scaling out efforts (Nicholls & Altieri 2018). Although these centres appear to have begun in Latin America (Nicholls & Altieri 2018), at least ten Agroecology Training Schools have emerged in Africa (Rosset et al. 2019). These centres deliver more than just demonstrations with activities related to training on ecological practices, supporting market development, mobilizing farmer organisations, and influencing national and regional policies (La Via Campesina s.a.).

Calls are being made for the development of "agroecological centres of excellence" in sub-Saharan Africa (Biovision Foundation for Ecological Development[1] & IPES-Food 2020:7). While this term is

[1] Henceforth referred to as 'Biovision'

used to describe formal education institutions, it could also be used to describe extension facilities such as demo farms, as is done by the Shashe Agroecology School (Mudzingwa 2013). However, considerations for how demo farms could be (re)designed to support agroecology are yet to be explored.

The purpose of this research is therefore to initiate discussion around the role of demo farms in agroecological transitions by exploring how demo farms are already supporting agroecology. The paper begins with a review of recent literature on two topics. First, methods for assessing agroecological transitions are reviewed to select an appropriate method for assessing how demo farms are already supporting agroecology. Second, existing literature on demo farm design considerations is reviewed in order to develop a framework for analysing design features that may support or hinder agroecological transitions. Following this, key knowledge gaps in the literature are highlighted before describing the objectives and methods of the research. Next, the extent to which demo farms in central Kenya[2] are already promoting agroecology is discussed based on the results of six case studies. Farmers' perspectives about how agroecological demos farms should be designed are then discussed based on insights gathered from a participatory farm design workshop in Kenya. Finally, concluding reflections are offered regarding considerations for how demo farms might be (re)designed as nexus for the scaling up and scaling out of agroecology.

2.0 Literature Review

2.1 How to assess demo farm support for agroecological transitions?

In order to assess the degree to which demo farms are supporting agroecological transitions it is necessary to use a method that enables identification of concrete activities that are supporting specific elements of agroecology at the different levels of food system transformation. The aim is not to evaluate the success or impact of such activities, but rather to identify how demo farms are already contributing to agroecological transitions. As such, it is desirable for such a methodology to be light weight to allow rapid assessments and easy evaluation of results. Furthermore, the use of a method that is accessible to a wide range of actors (including demo farm staff) is desirable to allow non-scientific users to compare agroecosystems or training programs over time. Hence a methodology that reflects the following three desired characteristics were searched for: multidimensionality, a focus on identification of agroecological activities rather than evaluating performance, and ease-of-use. A brief review of methods found in the literature on agroecological transitions is presented here.

Trabelsi et al. (2016) reviewed a range of methods for assessing the sustainability of farming systems yet found none to be satisfactory as tools for assessing and supporting agroecological transitions. In

[2] The choice of Kenya as a location is explained in the methodology section.

response, the authors propose a dynamic modelling tool for measuring the performance of agroecological transitions at the farm level based on indicators related to "environment, crop protection, health, society, and the economy" (Trabelsi et al. 2016:153). The advantages of this method compared to those that came before are limited however given the authors' insistence that the main challenge faced by farmers is "the reduction of agricultural inputs… while maintaining long-term productivity" (Trabelsi et al. 2016:153). Furthermore, the tool's complexity requires expert knowledge and hence is unlikely accessible for many farmers. Other methods recently proposed suffer from similar limitations (e.g. Padel et al. 2020, Tittonel 2020). Lovell et al. (2010) go one step further by proposing a framework for evaluating agroecosystems at the farm and landscape level however the tool's focus on the environmental performance of agricultural practices still negates changes at market and policy levels.

Ruiz-Almeida and Rivera-Ferre (2019) propose a methodology for assessing the sustainability of national food systems using food sovereignty as a conceptual framework. Although a useful approach, its focus is at the macro level and hence is not appropriate for use at the farm level. Duru et al. (2015) proposed an integrative design methodology for developing local agroecological transitions in a participatory manner. This approach is action-oriented and has been developed to help farming stakeholders create informed plans for transitions. It moves beyond simple considerations of agroecological practices by supporting stakeholders to consider necessary governance structures and rules to enable local and territorial transitions. Such a tool is useful in terms of establishing contextualised baselines for transition to emerge from and be measured against. However, use of this methodology is intended to be facilitated by "Participatory-Design Facilitator-Scientists" over a series of workshops, who are also responsible for identifying stakeholders (Duru et al. 2015:13).

Audouin et al. (2019) build on the work of Duru et al. by developing a participatory action research (PAR) methodology for designing and managing agroecological transitions at the territorial level. Again, a scientist-facilitator is assumed to initiate this method, however the ultimate aim is to transfer responsibility and management of the process to local actors. The methodologies of Duru et al. (2015) and Andouin et al. (2019) are useful, yet their function goes beyond identification of supporting activities for agroecological transitions.

Two comprehensive methods of assessing the agroecological performance of agroecosystems and/or projects are currently being tested. Levard et al.'s (2019) *Mémento pour l'évaluation de l'Agroécologie* contains agronomic, environmental social, economic and governance indicators for agroecosystem assessments and is designed for use by field practitioners, not just researchers. However, the criteria used for assessing how interventions are impacting market and governance structures are somewhat limited (e.g. there is no reference to inclusive interactions between farmers and market actors or policy makers). FAO's (2019) Tool for Agroecological Performance Evaluation (TAPE) builds on a number of existing frameworks for assessing sustainable food systems to provide a detailed, multidimensional method for assessing agroecological transitions. However, TAPE's high level of detail as well as technical knowledge and time requirements render it less accessible to stakeholders whose primary occupation is not research.

The Agroecology Criteria Tool (ACT) is another method for assessing support for agroecological transitions (Biovision & IPES-Food 2020). The tool integrates the five levels of food system change proposed by Gliessman (2016) with FAO's ten elements of agroecology (2018) and thirteen agroecological principles proposed by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE 2019). Eleven elements are distilled from this integration. Each element contains criteria for identifying *how* agroecological transitions are being supported rather than evaluating performance as TAPE does. Furthermore, the criteria used are more comprehensive than Levard et al. (2019) while remaining succinct enough for rapid assessments. However, ACT was designed for assessing agricultural research for development (Ag4RD) and investment projects (e.g. Biovision & IPES-Food 2020). Nonetheless, with slight modification, ACT could be an easy-to-use tool that demo farms (as well as farmers) could use to assess how their activities are contributing to agroecological transitions at the farm, field, market and policy levels.

Each of these methods were designed for specific research objectives, none of which overlap entirely with the topic of this research either due to limited scope, limited ease of use, or because of a focus on performance rather than identifying supportive activities. ACT allows for the rapid identification and assessment of supporting activities and with slight modification is appropriate for use at the (demo) farm level. An adapted version of this tool is therefore used to assess how demo farms are already supporting agroecological transitions and is explained in more detail in the methods section.

2.2 Design Considerations for Successful Demo Farms

Despite demo farms being a universal method of agricultural extension, they have received far less attention in academic literature than other aspects of agricultural extension (Ingram et al. 2018). Nonetheless, there has been an increase in academic publications and grey literature on this topic in the last decade with a focus on how best to design demo farms to increase learning and adoption of agricultural practices and technologies. This literature is henceforth reviewed in order to establish a framework for analysing design features that may support or hinder agroecological transitions based on the following categories: motivation, location, education, operations, and participation.

2.2.1 Motivation

According to the literature, it is important for the motivation behind demo farms to be clearly defined prior to implementation. Motivation here refers to the ultimate purpose of the demo farm as well as the objectives by which this purpose can be pursued. Important considerations in defining motivation include alignment between purpose and objectives, relevance of objectives for the target farming community, and clarity in the communication of this motivation with all stakeholders.

The purpose of demo farms can vary significantly. For example, demo farms may exist for the purpose of increasing the productivity and income of farmers (Ingram et al. 2018), for business expansion and marketing (Lixia et al. 2015), or to fulfil development project targets. Burton (2020) argues that they may also be used for political purposes, as examples exist in which demo farms have been used as colonial tools for land-grabbing and dictating colonial modes of agriculture. The objectives of demo farms typically relate to the dissemination or experimentation of novel farming practices, knowledge, or equipment (Pappa et al. 2018). However, demo farms may also aim to create a shift in values or rules related to farming (Ingram et al. 2018, Cooreman et al. 2018). Mbure & Sullivan (2017:19) argue that demo farms should be a means to helping farmers “appreciate the value of experimentation and evidence-based decision-making in adopting new farming practices”.

While the objectives of demo farms are highly varied, they are generally defined through a top-down approach (Ingram et al. 2018). Mbure & Sullivan (2017) argue that insufficient engagement with farmers in this process means objectives often fail to be met. Demo farms should be motivated by the interests of target farmers and, therefore, extension providers should seek to understand the communities with which they work to ensure demonstrations are relevant for local contexts (Burton 2020, Adamsone-Fiskovica et al. 2018).

Whatever the nature of a demo farm, its motivation should be clearly understood by all stakeholders involved (Pappa et al. 2018, Adamsone-Fiskovica et al. 2018). Lixia et al. (2015) highlight how a lack of clarity in purpose can lead to confusion amongst stakeholders, ultimately undermining the effectiveness of a site. Most importantly, by identifying the motivation for an agricultural intervention it may become clear whether or not a demo farm is the right tool for the job (Mbure & Sullivan 2017).

2.2.2 Location

In order for a demo farm to achieve its purpose and objectives it must be situated in a suitable location. The land on which the demo farm is situated will ultimately determine the feasibility of the desired change. The reviewed literature suggests the following criteria for land suitability: ownership, accessibility, physical condition, and available infrastructure.

Demo farms may be established on institutional property (e.g. land owned by government extension services, NGOs, or the private sector) or alternatively on farmers' own land or community owned plots. The research at hand focuses on the former which are henceforth referred to as *demo farms* while the latter are regarded as *on-farm demonstrations.* In some cases, a hybrid model may be chosen. This is the case in Zimbabwe where, "mother" demo farm locations are used to train farmers who then manage "baby" demo farms in their communities (Mbure & Sullivan 2017:15). Multiple on-farm demonstrations may be established as part of a network to enable validation of technologies across diverse agroecosystems (Pappa et al. 2018, Mbure & Sullivan 2017).

Adekoya (2007) found that farmer distance from demo farms is inversely correlated with both awareness and adoption of agricultural innovations. Demonstration activities should hence be located on land that is accessible to a wide range of farmers, and hence using multiple sites is likely to increase accessibility (Adamsone-Fiskovica et al. 2018, Mbure & Sullivan 2017, Pappa et al. 2018).

For demonstrations to be convincing it is necessary that they take place on land of a similar condition to that which the participating farmers are familiar (Adamsone-Fiskovica et al. 2018, Mbure & Sullivan 2017, Ingram et al. 2018, Pappa et al. 2018, Burton 2020). In the case of on-farm demonstrations, this is a matter of selecting a farm that reflects a typical farm for the area in terms of size, soil, equipment, practices, financial status, crops, livestock and access to water (Pappa et al. 2018). In the case of demo farms there is a risk that project funding may make it attractive to design a 'model farm' meeting the exact specifications the organisation desires for optimal demonstration results. However, this is likely to lead farmers to feel the results are unattainable on their own farms (Mbure & Sullivan 2017, Burton 2020). Selecting less favourable land may be advantageous if the demonstration activity is able to restore the land to its productive capacity (Adamsone-Fiskovica et al. 2018, Mbure & Sullivan, 2017).

Finally, selected locations should have the necessary facilities available for demonstration activities to take place, including, toilets and spaces for learning activities (Pappa et al. 2018). Demo farms have an advantage here as, assuming funding is available, such infrastructure can be easily constructed, while on-farm demonstrations may require that the site is altered (Adamsone-Fiskovica et al. 2018).

2.2.3 Education

A third area of consideration stressed in the literature refers to *how* demonstration activities should be carried out to meet the farm's purpose and objectives. Four inter-related factors are highlighted in the literature, namely: the intended outcomes of demonstrations, the object of the demonstration, feasibility for adoption by farmers, and the pedagogic approach.

Pappa et al. (2018) suggest demonstrations may result in two outcomes. One is that farmers have an increased awareness of the advantages of a technology or practice, for example profitability (Burton 2020). The other is that the capacity of farmers to obtain the advantageous results themselves is enhanced (Pappa et al. 2018), what Compagnone et al. (2018) refer to as the development of embodied knowledge. These outcomes relate to two commonly referenced values of demo farms namely, 'seeing is believing' and 'learning by doing' (Kiptot & Franzel 2015, Mbure & Sullivan 2017, Ingram et al. 2018, Pappa et al. 2018). The practical and visual aspects of these centres are therefore central to their function. Hence, it is crucial that demo farms provide space for farmers to interact with demonstrations rather than simply observe them (Ingram et al. 2018, Adamsone-Fiskovica et al. 2018).

Demonstrations may relate to single or multiple related objects or practices, or whole farm approaches (Mbure & Sullivan 2017, Pappa et al. 2018). Mbure & Sullivan (2017) emphasise that single practice demos should be kept simple to allow farmers to easily attribute results to the promoted intervention. This can be done with trial strips or plots in single or multiple fields (Pappa et al. 2018).

The success of demonstrations is in part determined by the ability of farmers to replicate interventions on their own farm. It is therefore important to ensure farmers do not face limiting financial or non-financial barriers to adoption (Mbure & Sullivan 2017, Burton 2020). This includes ensuring that farmers are supported beyond demonstration activity (Mbure & Sullivan 2017, Adamsone-Fiskovica et al. 2018). Lacombe et al. (2018) add that continued engagement is not only important for supporting adoption but can also generate insights about how farmers adapt technologies to suit their own contexts.

Demo farms should employ a diversity of approaches to cater for different learning styles and preferences (Mbure & Sullivan, 2017, Ingram et al. 2018, Adamsone-Fiskovica et al. 2018). Moreover, suitable pedagogic methods are required to build the capacity of farmers to problem-solve in addition to learning new skills related to input substitution (Rosset & Altieri 1997, Ingram et al. 2018, Nicholls & Altieri 2018). This could include developing farmers' competencies to redesign and optimize their systems as a whole to achieve their goals (Meynard et al. 2012, Compagnone et al. 2018). Focusing on agroecological principles rather than specific practices can better enable farmers to grasp the complexity required for such problem solving (Nicholls & Altieri 2018). A commonly referenced pedagogic approach for developing such competencies is multi-loop learning. This approach combines incremental skills acquisition with deeper transformational learning about assumptions, rules, and values that determine the way farmers farm and the way in which institutional structures influence their capabilities (Duru et al. 2015, Ingram et al. 2018, Cooreman et al. 2018).

2.2.4 Operations

Another important, yet less frequently discussed design consideration for demo farms regards how they are managed to ensure continued sustainability. Key operational elements include finances, event management, and monitoring of the farm's effectiveness.

Mbure & Sullivan (2017) emphasise that determining how a demo farm will be managed after establishment is an important aspect of ensuring the sustainability of any design. This is particularly true from a financial perspective meaning that farm staff should ensure budgets are developed and approved well in advance of seasonal activities (Mbure & Sullivan 2017).

Publicity of demonstration activities is crucial to ensure farmers are aware of learning opportunities (Adamsone-Fiskovica et al. 2018). It is equally important to consider the timing of these events in line with when farmers may be engaging in similar activities in their own farms (Pappa et al. 2018).

Data collection and storage is critical for evaluating the effectiveness of the demo farm activities (Mbure & Sullivan 2017). Cooreman et al. (2018) suggest embedding adoption and diffusion as outcomes in on-farm demonstration projects to understand not only *what* is being learned but also *how* this learning is happening. Data that can be collected may include records of events, agronomic data about demonstrations, climatic data, and results in terms of yields and margins (Mbure & Sullivan 2017). Staff and farmers can be trained to conduct research collaboratively to embed participatory research methods into demo farm operations (Mbure & Sullivan 2017, Ingram et al. 2018).

2.2.5 Participation

A common theme in the literature which underpins each of the factors already discussed is the participation of farmers. The motivation (purpose and objectives), location, educational approach, and operations of demo farms all benefit from farmer participation. Participation in the literature refers to general involvement, incorporation of farmers' knowledge, and working with farmers as trainers.

Some authors suggest the success of demo farms requires the voluntary involvement of farmers throughout the design, planning, and implementation phases of development (Adamsone-Fiskovica et al. 2018, Mbure & Sullivan 2017, Ingram et al. 2018). However, the exact level of involvement is not well defined. Pappa et al. (2018) suggest that demonstration activities must be aligned with appropriate times in the growing season to enable farmers to participate and put what they have learnt straight into practice. Specific attention should be given to women's participation as they are less likely to have time to engage due to culturally gendered activities (Mbure & Sullivan 2017). Such considerations can be made more explicit through collaborative principles or tools, e.g. shared calendars (Ingram et al. 2018).

Adamsone-Fiskovica et al. (2018) highlight that demo farms should be welcoming of farmers' own knowledge. Ingram et al. (2018) further suggest that demo farms best function as forums for connecting different types of knowledge. This requires moving away from knowledge *transfer* models, toward viewing knowledge as a product of social learning processes (Cooreman et al. 2018). This demands that farmers are recognised as knowledge providers and co-designers, while researchers and advisors are to be seen as mediators and facilitators, as well as co-designers (Leeuwis & Ban 2004, Ingram et al. 2018, Lacombe et al. 2018, Pappa et al. 2018, Takahashi et al. 2020).

There is also value in involving farmers as trainers as they can cultivate greater trust with other farmers than can be achieved with institutional staff (Pappa et al. 2018). However, the effectiveness of farmer trainers can be highly variable depending on the competence of the demonstrating farmer and the level of support they receive (Pappa et al. 2018, Cooreman et al. 2018, Takahashi et al. 2020). Nonetheless, Ingram et al. (2018) argue that it is through the inclusion of multiple actors that more questions can be asked, constructive conflicts can arise, reflection can be practiced, and multi-loop learning can be achieved at demo farms. Whichever the chosen form of participation, expectations must be clearly communicated between all parties involved (Pappa et al. 2018).

3.0 Knowledge Gaps & Research Objectives

While there may be similarities between 'conventional' demo farms and their agroecological counterparts, there remain two important gaps in the literature relating to their differences. First, the way in which demo farms can support agroecology at multiple levels is yet to be explore. Second, there is a lack of detail about what exactly is meant by farm participation in the context of demo farm design. Additionally, there is a tendency for research to focus on normative considerations as opposed to tested truths. These issues are expanded upon here before defining the objectives of this research.

The role that demo farms can play in promoting agroecological transitions across the food system is yet to be properly identified. At the farm level, the research highlights the role of demo farms for transferring knowledge about inputs and practice, but there is limited research on how demo farms could support agroecosystem redesign. Similarly, examples of how demo farms could support farmers and other stakeholders to enable transformation in the market and supply chain are not forthcoming. Furthermore, while demo farms have been used to raise awareness of national agri-environmental schemes amongst farmers in Europe (Smallshire et al. 2004), it is unclear whether such farms engage in two-way dialogue regarding policy development. There is therefore a need to understand the role demo farms can play in supporting agroecological transitions across the food system.

The literature highlights the need for farmer participation for demo farm success. However, the motivation for participation is not expanded upon, nor are the intended outcomes. Pretty (1995) suggests participatory approaches to agricultural development include a spectrum of motivations from coerced or passive stakeholder presence, to more active forms of empowerment and emancipation. Related to these motivations are a variety of desired outcomes including institutional legitimization, cost-savings, research validity, collective decision making, or local ownership of transformational development processes (Pretty 1995, White 1996, Leeuwis & Ban 2004, Lacombe et al. 2018). Participation is equally valued by proponents of agroecology as a central requirement for sustainable agricultural (Altieri & Nicholls 2005, Warner 2008, Méndez et al. 2016, FAO 2018, HLPE 2019). However, agroecology in its tripartite definition (Wezel et al. 2009) also falls victim to this critique due to continued ambiguity about what exactly is meant by participation. As a science, methods such as PAR are proposed as critical for agroecology (Méndez et al 2016, Méndez et al 2017), yet the extent of participation in such processes is often unclear (Bentley 1994, Bacon et al 2005). As a set of agricultural practices, the emphasis on knowledge co-creation (Milgroom et al. 2016) implies involvement and collective decision making but not necessarily emancipation (Leeuwis & Ban 2004). As a social movement, the promotion of collective decision-making at the community, market, and government levels (HLPE 2019, FAO 2018) is open to interpretation and hence at risk of manipulation. It is therefore necessary to understand what types of participation are likely to best support agroecological transitions.

Finally, while the literature provides a useful framework for considering how to develop demo farms, the research is largely reliant on normative considerations as opposed to empirical evidence of what works[3]. In reality various challenges may demand compromise and hence empirical data is needed to understand how these recommendation may support or hinder support for agroecological transitions.

This research has two primary objectives that build on these knowledge gaps as follows:

The first is to explore the role of demo farms in agroecological transitions, based on empirical evidence. A comparative case-study analysis of six demo farms in Kenya is undertaken to explore how they are already supporting agroecology. The Agroecology Criteria Tool (ACT) is used to assess the agroecological status of these centres. As it is the first time ACT has been used at the farm level an ancillary objective is to evaluate the suitability of ACT for this purpose (see appendix D for evaluation).

[3] Mbure & Sullivan (2017) is an exception here given their use of case studies.

Second, this research aims to highlight important design considerations that may enhance the ability of demo farms to support agroecology at field, farm, market and policy levels. Each of the case studies investigate to what extent the characteristics identified in the literature for successful demo farm design are expressed by each farm. In doing so the research seeks to identify how the motivation, location, educational approach, operations and use of farmer participation on demo farms might affect their support for agroecological transitions. Given the importance of farmer participation in particular, a co-design workshop was facilitated with a group of farmers for the design of a demo farm in Kenya. This workshop sought to gain insights into how demo farm objectives can be aligned to farmers' needs and goals, at which levels of transitions farmers might expect demo farms to support them, and the role of exogenous and local knowledge at demo farms. Finally, this workshop explores how farmers might design their own demo farm.

4.0 Methodology

4.1 Choice of location: Kenya

This research began as an action research project conducted by the author while working as a consultant for Sistema.bio, an international agricultural social enterprise that produces and sells biodigester technology to farmers. The company rents an acre of land in Meru, Kenya for a field office and wished to develop the site as a demo farm show-casing biodigester technology within a wider context of ecological farming practices. Research was conducted to see how demo farms are already promoting agroecology in Kenya leading to the development of the case studies in this research. Recognizing the value of farmer participation, a participatory design workshop was also facilitated by the author at the site in February 2020. The purpose of the workshop was to generate design ideas for the demo farm based on local farming systems and the challenges farmers face. Unfortunately, the demo farm project was put on hold due to land issues and COVID19. However, the results from the research provide useful insights for how demo farms may be designed to support agroecological transitions.

4.2 Case studies

Case studies of six demo farms were developed through semi-structured interviews and direct field observations carried out between January and March 2020. The interviews included questions related to design considerations from the literature review and about how each farm was supporting agroecological transitions. The Agroecology Criteria Tool (ACT) was used as a basis for the latter questions (described below). Data was collected during guided tours with senior staff members which lasted from two and four hours. Data was stored in excel and used for a systematic comparative analysis.

4.3 Agroecology Criteria Tool (ACT)

ACT was used to assess the extent to which demo farms are supporting agroecological transitions. Table 1 presents the theoretical framework of ACT while a full list of the criteria used for assessment can be found in appendix B.

Table 1 Theoretical foundations of the ACT framework. The table shows how the ACT's elements were created from the integration of Gliessman's five levels of food system change (2016), FAO's ten elements of agroecology (2018), and HLPE's thirteen agroecological principles (2019). Dotted lines highlight overlap between rows.

5 Levels of Food System Transformation (Gliessman 2016)	*13 Agroecological Principles (HLPE 2019)*	*10 Elements of Agroecology (FAO 2018)*	*ACT Elements*
Level 1: Increase efficiency of industrial and conventional practices	2. Input reduction	Efficiency	1.1 Efficiency
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	1. Recycling	Recycling	2.1 Recycling
	4. Animal health	-	2.2 Regulation/balance
Level 3: Redesign whole agroecosystems	5. Biodiversity 7. Economic diversification	Diversity	3.1 Diversity
		Resilience	3.3 Resilience
	5. Biodiversity 6. Synergy (managing interactions) 3. Soil health	Synergies	3.2 Synergies
Level 4: Re-establish connections between growers and eaters; develop alternative food networks	8. Co-creation of knowledge (embracing local knowledge and global science)	Co-creation and sharing of knowledge	4.3 Co-creation and sharing of knowledge
	11. Connectivity	Circular and solidarity economy	4.2 Circular and solidarity economy
	9. Social values and diets	Culture and food traditions	4.1 Culture and food traditions
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	10. Fairness	Human and social values	5.1 Human and social values
	12. Land and natural resource governance 13. Participation	Responsible governance	5.2 Responsible governance

ACT criteria were used as a basis for questions during demo farm visits. However, some of the criteria were partially adapted for use at the farm level. Originally some criteria required Ag4RD programs to use specific frameworks or were oriented strictly toward policy development. However, such specificities do not account for the varying ways in which farms support these criteria and hence required broadening. For example, a farm was considered as supporting agroecosystem resilience without specifying a framework, or as engaging with social issues such as youth employment based on actions other than just policy development. Binary (yes/no) answers were obtained through conversations between the researcher and interviewees to determine if a demo farm met each criteria. Qualitative descriptions about how the criteria were met were also recorded. Percentage scores indicating the extent of support for each element (E) were calculated by dividing the number of criteria a farm met (C_M) by the total number of criteria (C_T) for a given element as follows:

$$E = \frac{C_M}{C_T} \cdot 100$$

Percentage scores indicating the farms' support for each level (L) were calculated by dividing the sum of the total element scores for each level (E_T) by the total number of elements (E_N) for a given level:

$$L = \frac{E_T}{E_N} \cdot 100$$

Given the binary nature of ACT's criteria, these scores offer an indication of which agroecological elements are being engaged with at each farm but do not differentiate the quality, variety, or impact of the approaches taken by the farms. The results should not be used to judge one farm over another, but rather to give an impression of which agroecological elements each demo farm is engaged with.

4.4 Participatory Farm Design Workshop

Farmers were invited to the workshop by Sistema.bio's field staff. The inclusion of client and non-client farmers was chosen to a) represent a broad range of farm systems, and b) to allow for insights regarding farms that did not use biodigester technology. A total of 43 participants took part in the workshop of whom 33 were farmers and 10 were staff members. 39% of farmers and 25% of staff were women. Farmers came from a range of different localities near to the demo farm site and were provided refreshments and reimbursed for travel expenses as a courtesy for their time and knowledge. Farmers were viewed as co-designers and knowledge providers. The workshop was facilitated by the author of this research with local language support from an assistant. Participating staff members held a dual role of active participants and facilitators for smaller group work. Participants were engaged in interactive group activities, a full description of which are included in appendix A.

4.5 Limitations of methods

Additional demo farms were to be visited[4] however this was not possible due to travel restrictions. Furthermore, had travel restrictions allowed, the addition of participant observation during demo farm activity may have provided insights about participants' perceptions of these centres to balance potential

[4] E.g. Baringo Agricultural Marketing Services Cooperative Society (BAMSCOS), Drylands Natural Resource Centre (DNRC), International Center for Insect Physiology and Ecology (ICIPE), Kwetu Training Centre for Sustainable Development, and Manor House Agricultural Centre (MHAC)

bias in interviews with demo farm staff. The unequal representation of women and men in the workshop was another limiting factor (39% of the farmers were women). An equal balance would have been preferable, not least because a number of men were observed dominating many discussions except in one group, comprised of female farmers and two male staff, where women were more actively involved.

5.0 Results & Discussion of Case Studies

Six demo farms, listed in Table 2, were visited to gain insights into how such centres are supporting agroecological transitions. Three centres are run by NGOs, one by an agribusiness and two either directly or indirectly by the Kenyan government. The latter two demo farms also host demo events from agribusiness partners. Although a far greater diversity and number of demo farms exist in Kenya, the selected cases shed light on how demo farms can, and already are, supporting agroecological transitions.

Table 2 List of demo farms visited

Name of demo farm	*Ownership*
Kenya Institute of Organic Farming (KIOF)	NGO
Kenya Agriculture & Livestock Research Organization Practical Training Centre (KALRO PTC)	Quango / Private
Grow Biointensive Agriculture Centre (G-BIAC)	NGO
Laikipia Permaculture Centre (LPC)	NGO
Kaguru Agricultural Training Centre (Kaguru ATC)	Government / Private
Real IPM	Private

This section highlights key insights from these case studies in two parts. In the first half, the way in which these demo farms are currently supporting agroecological transitions is discussed. Quantitative results indicating the extent to which the demo farms are supporting agroecology at the five levels of food system transformation are visualised on a radar chart (Figure 1). The results are then presented at a finer level of detail to visualize the extent to which each demo farm is supporting the eleven agroecological elements contained in ACT (Figure 2). The five levels and eleven elements are presented in a clockwise fashion. Plots closest to the outer ring (i.e. 100%) indicate a demo farm is engaged in more activities that support a particular level or element than those closest to the centre (i.e. 0%). Following these two diagrams, results are presented of how each farm meet the various criteria that underpin each element (Table 3-11).

In the second half of this section, results from the case study are used to reflect on how the design considerations featured in the literature review are supporting or hindering support for agroecological transition (i.e. motivation, location, education, operations, and participation). Full case studies are provided in appendix C.

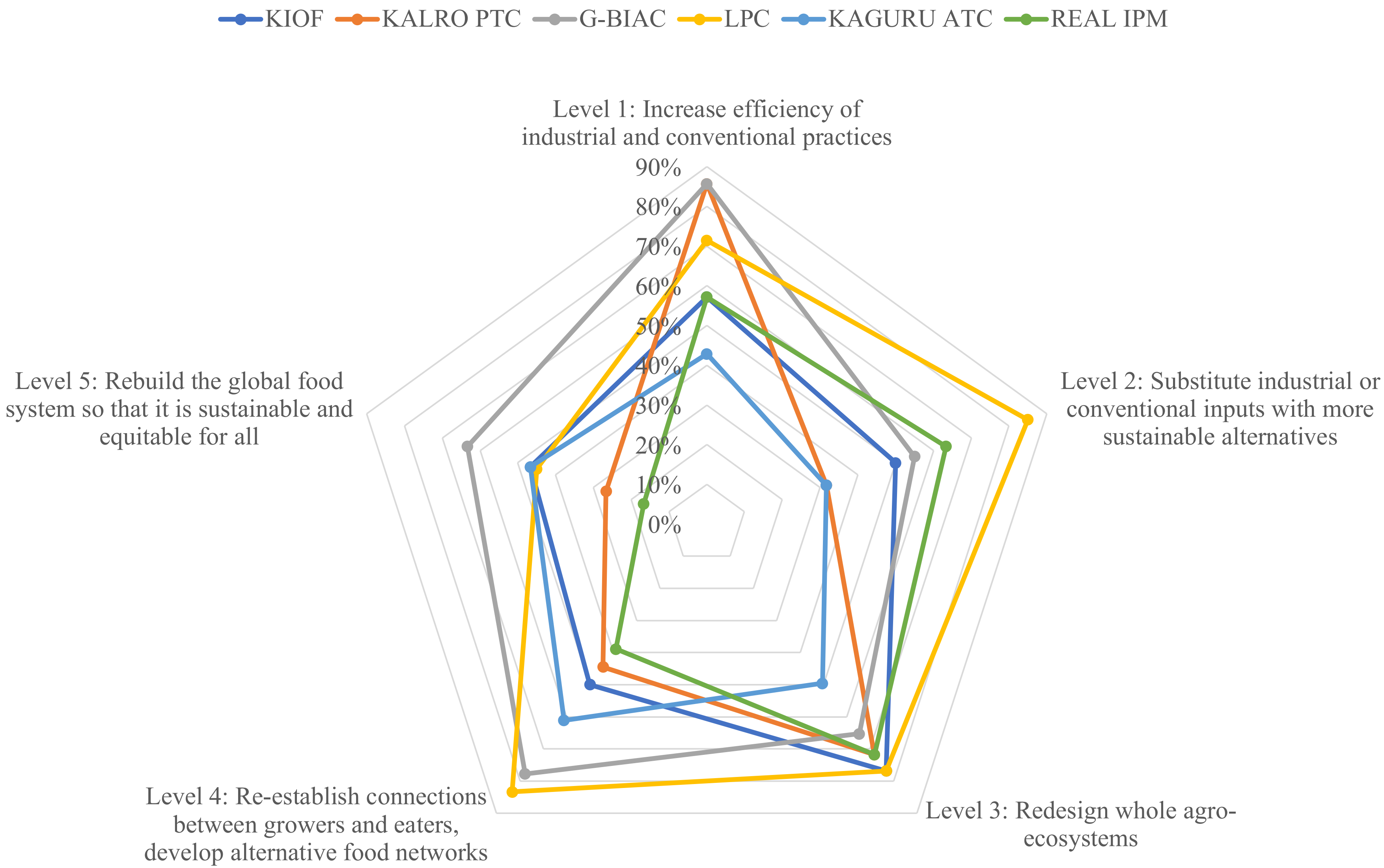

Figure 1 Extent to which six demo farms in Kenya are supporting agroecological transitions at each level. Percentage values derived from the ACT

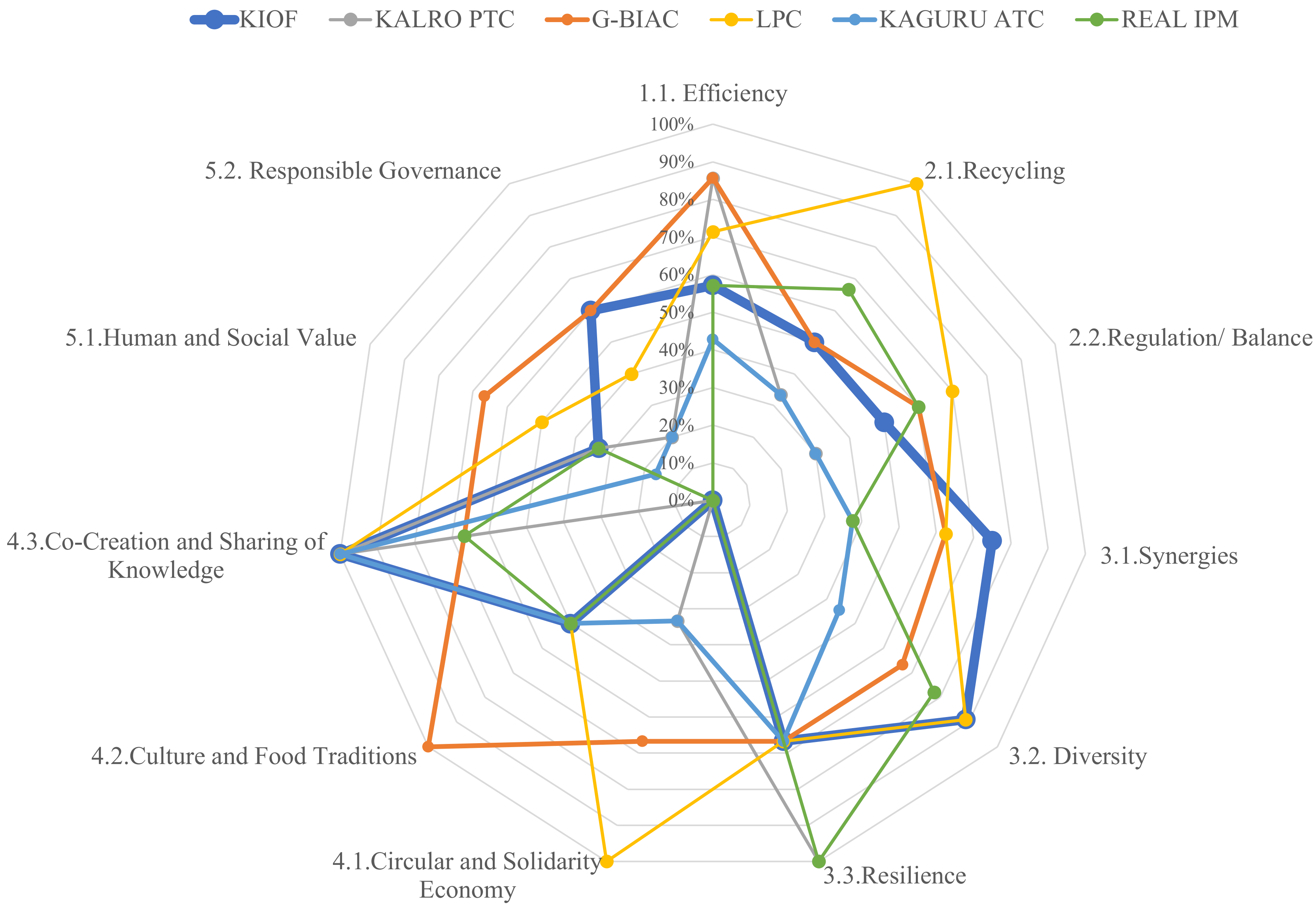

Figure 2 Extent to which six demo farms in Kenya are supporting the eleven agroecological elements of ACT

5.1 To what extent are Kenyan demo farms supporting agroecological transitions?

All six demo farms are supporting agroecological transitions at the five levels of food system transformation (Gliessman 2016) and hence provide examples of nexus for the dual processes of scaling up and out agroecology (Figure 1). However, the extent and method of support varies greatly between centres. This is explained by differences in engagement with the eleven ACT elements (Figure 2) which are in turn explained by variation in how the farms are supporting various criteria of ACT (tables 3-11). Qualitative results from the case studies are hence presented to demonstrate how criteria are being fulfilled by the demo farms in order to understand how support for each element is being cultivated.

Level 1: Increase efficiency of industrial and conventional practices

Support for Level 1 is highly varied from 43% (Kaguru ATC) to 86% (G-BIAC and KALRO PTC) (Figure 1). As this level related to only one element in ACT (1.1. Efficiency) the same results are found in Figure 2. The variation in results in explained by the different criteria met by the farms.

Element 1.1 Efficiency

Each of the demo farms visited reported a number of ways in which they encouraged farmers to be more resource efficient (Table 3). However, while all of the farms supported reductions in water and agrichemicals, variation is observed in how other resource efficiency is promoted.

Water use efficiency is promoted through various practices related to water harvesting, soil conservation, and efficient methods of irrigation. All farms encourage either the reduction or elimination of chemical pesticide and fertilizer use. Where reduction is encouraged, several approaches to Integrated Pest Management (IPM) are employed, although varying levels of detail were provided for these measures. Fertilizer reduction is promoted by two centres who train farmers in well-timed spot applications of crop-appropriate fertilizers, and another who support farmers through transitions to become organic.

KIOF is the only centre delivering training on animal feed efficiency, while none offer advice on veterinary drug use. Energy use reduction is demonstrated by two centres either through the use of a biodigester or solar equipment. Seed use efficiency is promoted by three centres via training on plant spacing, seed storage, and nursery management. Training on grafting is included in the latter criteria as a means of efficient use of plant material. Four demo farms promote waste reduction either through processing (drying and other value addition activity), improved storage, or recycling of local resources. Two centres promote the use of resource efficient crop varieties.

Table 3 Results from case studies showing how the demo farms meet the ACT criteria for Element 1.1 'Efficiency'.

Criteria:	*1.1.1. Reduced water consumption*	*1.1.2 Reduced application of pesticides and veterinary drugs*	*1.1.3 Reduced synthetic fertilizer application and use of animal feed*	*1.1.4 Reduced energy use*	*1.1.5 Reduced seed use*	*1.1.6 Reduced waste*	*1.1.7 Improved plant variety and animal breed*
KIOF	Drip irrigation, water storage, water retentive soil practices	Scouting for pests and other IPM methods. No synthetic pesticide used	Production of home grown animal feed for pigs and chickens	-	-	Solar drying, hale baling.	-
KALRO PTC	Timing of water application to maximise water uptake, educating on risks of overwatering, drip irrigation	IPM measures: exclusion, disease resistant varieties, scouting, crop protection plans, economic damage thresholds, mechanical removal, use of weaker chemicals followed by stronger chemical as last resort	Soil testing, spot applications, correct seed use, educating about correct use of fertilizers	-	Training on seed selection & harvesting, creation of local seed banks, training on graft selection	Value addition through sun drying, juicing and puree making	Distribution of *Fusarium* resistant *Musa* spp. varieties.
G-BIAC	Rainwater harvesting in storage tanks, ponds, and trenches	No spraying at the farm, focus on soil building and crop diversification	No chemicals used on site. Reduction strategy trained with farmers.	-	Cross planting, Indigenous seed bank centre, cool store for roots, lath house for seed curing, seed harvesting, and preservation training	Solar drying, cow dung ash and *Tephrosia Vogelii* powder used for storage	Growing some KALRO improved *Ipomoea batatas*, despite preference for indigenous varieties in terms of performance and taste
KAGURU ATC	Rainwater harvesting, planting holes, conservation tillage, soil cover	Timing of spraying, safe and effective use, IPM training	Selective use for crop needs at different stages of the life cycle	-	-	-	-
LPC	Rainwater harvesting, boreholes, mulching	Assist with two transition process towards organic farming	No chemicals used on site	Solar lighting, biogas heating, solar boiler	-	Reusing glass bottles for processing cactus wine, kitchen waste weighed before composting or disposing, charcoal cool box used for produce	-
REAL IPM	Drip irrigation, rainwater harvesting	IPM training: 1) Cultural: intercropping 2) Physical: scouting, trapping & cleaning feet 3) Biological Products (sprays and nat. enemies) 4) Chemical sprays as last resort	DAP only used as a starting fertilizer in the vertical urban farming bags, vermiliqiud and compost used throughout farm	Biogas	Cross planting, nursery training to increase seed efficiency	-	-

Level 2: Substitute industrial or conventional inputs with more sustainable alternatives

Support for Level 2 is similarly varied between farms. However, farms that scored high for Level 1 did not necessarily score high for Level 2 (Figure 1). Again, variation is explained by the different criteria met in relation to Element 2.1 (Recycling) and 2.2 (Regulation/Balance) (Tables 4 and 5). It is important to note that in addition to containing two rather than one elements, Level 2 contains more than double the number of criteria featured in Level 1.

Element 2.1 Recycling

Recycled soil inputs are used at all sites, while the recycling of other resources is less common (Table 4). Compost is promoted at each demo farm. Using manure as a soil amendment is promoted by five centres while bioslurry[5] is promoted by one. A variety of other recycled soil amendments are demonstrated including bone ash, wood ash, vermicompost, and fertilizer teas made from plant extracts. KALRO PTC and LPC promote the use of green manures. The other centres do not work with green manures as they report that the farmers they trained do not have sufficient land to do so.

Recycling of waste-water is demonstrated at LPC and Real IPM through the use of filter beds. The recycling of biomass for energy generation is practiced by two demo farms using biodigesters but is not a focus at the other centres. Two centres bury organic matter to create fertility trenches[6] to support climate mitigation. Vermiculture is practiced by three demo farms. Real IPM also promote recycling organic waste for insect cultivation. Other recycling practices demonstrated include harvesting weeds for mulch material (KIOF) or animal feed (LPC), using on-farm timber production for construction (KIOF), and compost toilets for recycling human waste (LPC).

Element 2.2 Regulation/Balance

Although only three demo farms are strictly organic, all six demonstrate substitution methods for enhancing regulation and balance within agroecosystems (Table 5). Chemical pesticide substitution is mainly achieved through biological (plant based) pesticides[7] (five farms) and physical traps (three farms). *Mucuna pruriens* is used as a cover crop by G-BIAC for reducing weeds. Weed fallows incorporating *Tagetes Minuta* are practiced by LPC for disrupting soil borne pests. Real IPM is the only centre promoting the introduction of natural enemies (the centre breeds and sells natural enemies). However, some farms also viewed cultural methods (e.g. rotations & scouting) as substitution methods.

---

[5] Bioslurry is the name given to the effluent produced by biodigester technology after methane extraction.

[6] Fertility trenches are a form of double dug bed in which large carbon rich material (leaves, twigs, branches) are incorporated into the sub-soil as a means to store carbon and improve water retention in dry areas.

[7] Plant species used for making biopesticides are mentioned in the case studies provided in the appendix C.

Soil ecosystem regulation and balance is promoted through reduced or zero tillage practices at five farms. G-BIAC demonstrate the practice of ratoon cropping[8] with *Sorghum bicolour*, however no other farms demonstrate perennial crop substitutions for annual crops. Only two farms report using green manures, however a number of leguminous and non-leguminous cover crops are used for improving soil moisture retention and preventing soil erosion on terraces. KIOF report using weed fallows for the soil protection during non-productive periods.

Domesticated bees are kept for pollination and honey at three demo farms. Training on animal welfare is limited to non-existent. The majority of the farms feature zero-grazing or enclosed livestock systems, with only LPC demonstrating free range poultry and rabbit rearing. KIOF provide farmers with advice on herbal medicine for livestock. Real IPM provide their cattle with mattresses to sleep on as well as training farmers in how to produce nutritious fodder mixes and how to use biological tick control.

Table 4 Results from case studies showing how the demo farms meet the ACT criteria for Element 2.1 'Recycling'.

Criteria	*2.1.1 Alternative soil inputs*	*2.1.2 Green manure*	*2.1.3 Recycling of wastewater*	*2.1.4 Use of biomass residues for energy generation*	*2.2.5 Climate mitigation through alternative practices*	*2.1.6 Other practices that enhance recycling of biomass and organic matter waste*
KIOF	Compost and manure	-	-	-	Fertility trenches	Chop & drop weeds for mulch, woodland timber used for construction
KALRO PTC	Compost and manure	Legumes planted in orchards	-	-	-	-
G-BIAC	Compost, manure, bone ash, fertilizer teas from plant extracts, vermicompost	-	-	-	-	Vermiculture
KAGURU ATC	Compost, manure, leaf compost, wood ash	-	-	-	-	-
LPC	Compost, manure, vermicompost	Beans when necessary	Wastewater filtered through reedbed (with charcoal, sand & gravel) into *Musa* spp. plots	Biogas from biodigester	Fertility trenches	Compost toilet
REAL IPM	Compost, vermicompost, bioslurry, cocopeat	-	Wastewater recycled via charcoal filter into *Colocasia esculenta* plots	Biogas from biodigester	-	Using crop residues and weeds for animal feed, insect cultivation, vermiculture

[8] Ratoon cropping refers to the practice of cutting an annual grain crop back to its root base after harvesting in order for the plant to regrow and produce additional yields in later seasons.

Table 5 Results from case studies showing how the demo farms meet the ACT criteria for Element 2.2 Regulation/Balance.

Criteria:	*2.2.1 Biological pest management*	*2.2.2 Cover crops for pest management*	*2.2.3 Other pest management (non-chemical)*	*2.2.4 Cover crops for improved soil conditions*	*2.2.5 Perennial crops*	*2.2.6 Reduced tillage*	*2.2.7 Adoption of organic and low-input farming*	*2.2.8 Domesticated pollinators*	*2.2.9 Improved animal welfare and health*
KIOF	-	-	Biopesticides made from fermented plant teas. Physical traps. Ash for seed storage. Scarecrows sprayed with deodorant. Early planting	Short gap between season so only simple weed fallow	-	Reduced tillage. Raised beds with paths	Yes	Bees kept for pollination and honey	Herbal medicine used, e.g. *Aloe vera* for worms and skin wounds
KALRO PTC	-	-	Tagetes Minuta spray used	*Mucuna pruriens* used in orchards to prevent water loss.	-	Disc tillage and/or zero tillage.	-	-	-
G-BIAC	-	*Mucuna pruriens* in dry season to prevent weeds	Biopesticides made from fermented plant teas, ash and plant powders use for seed storage	*Lablab purpureus* grown in dry season	Ratoon cropping of *Sorghum bicolor* for two years	Double-dig beds then zero tillage for five years.	Yes	-	-
KAGURU ATC	-	-	Pheromone traps, *Azadirachta indica* biopesticide (purchased)	Fodder crops grown on terraces and slopes	-	Conservation tillage, direct sowing	-	-	-
LPC	-	*Tagetes Minuta* and weed fallow when needed	Biopesticides made from fermented plant teas	*Ipomoea batatas* grown on contours	-	Double-dig beds then zero tillage for five years	Yes	Bees kept for pollination and honey	Free range rabbits and chickens
REAL IPM	Breeding and use of natural enemies.	-	Intercropping, rotations, scouting, cleaning boots, pheromone traps	Fodder legumes grown on bare soil, *Ipomoea batatas* grown on terraces.	-	-	-	Bees kept for pollination and honey	Animals provided with mattresses. Animal welfare training provided: how to make nutritious feed and use of biological tick control

Level 3: Redesign whole agroecosystems

When viewing Figure 1 it appears that support for Level 3 (Redesign Whole Agroecosystems) is the least varied compared to the other levels. However, although support at this level is above 50% at each farm, the way the farms offer support is not uniform. This can be seen when looking at Figure 2 as each farm contributes to supporting the elements of Level 3 (Diversity, Synergies and Resilience) idiosyncratically. Further this does not imply that the farms are necessarily assisting farmers with redesigning entire agroecosystems (although in the case of KIOF, G-BIAC, and LPC this is often true), but rather that the content of their demos and training relate to specific criteria related to each of these elements (Tables 6, 7 and 8).

Element 3.1 Synergies

Agroforestry techniques is demonstrated at each of the demo farms[9], with five centres providing specific training on this topic (Table 6). Agroforestry techniques include alley cropping, dispersed planting, hedgerows and windbreaks, contour planting, and designated wooded areas.

Other non-crop plants are intentionally planted at three farms to demonstrate different ecosystem functions, namely: production of plant fertilizers (*Tithonia Diversifolia)*, pest repellants (*Tagetes Minute* and *Tephrosia Vogelii*), pollinator attraction (*Tagetes patula*), and water purification (*Eichhornia crassipes* and an unidentified species of reed).

Five of the demo farms integrate crop and livestock production. A form of intensive rotational grazing is demonstrated at KIOF and G-BIAC whereby goats are tethered to new patches of grass each day to minimize overgrazing. More extensive rotational grazing methods are taught by LPC to nomadic pastoralist groups. G-BIAC's demo farm feature multifunctional rain ponds used for *Eichhornia crassipes* production and fish farming.

Landscape planning to enhance ecosystem services is demonstrated at three farms. Contour terracing (bench and *Fanya chini[10])* is used to reduce soil erosion on the sloping land of Kaguru ATC, LPC, and Real IPM and in the latter case terrace trenches are used to grow *Maranta arundinacea*. KIOF use fertility trenches and zai pits[11] to create microclimates for soil moisture retention in dry areas. Woodland conservation areas are featured at three centres.

---

[9] Tree species planted at each farm are mentioned in the case studies provided in the appendix C.

[10] 'Fanya chini' is Kiswahili for 'do/make it down' and refers to a type of terracing in which soil is placed on lower side of the contour line as opposed to 'Fanya juu' terraces (do/make it up) where the soil is placed on the upper side.

[11] Zai pits are a dry-land farming technique in which farmers create large sunken planting holes (filled with compost or manure) before the onset of the rainy season to enable greater water retention and yields.

Table 6 Results from case studies showing how the demo farms meet the ACT criteria for Element 3.1 Synergies

Criteria:	*3.1.1 Non-crop plants*	*3.1.2 Agroforestry*	*3.1.3 Rotational / regenerative grazing*	*3.1.4 Integrated crop-livestock systems*	*3.1.5 Other selective integrations at farm level to optimize ecological synergies*	*3.1.6 IPM by habitat manipulation*	*3.1.7 Other landscape planning & synchronized landscape activity leading to improved agricultural ecosystem services*	*3.1.8 Climate mitigation through redesigned system*
KIOF	*Tagetes Minuta* (pest repellant), *Tithonia Diversifolia* (green fertilizer)	Woodland lot for timber and fruit, alley cropping and dispersed planting, hedgerows used as windbreaks	Tethered goats moved daily	Crop residues fed to goats, chickens, and rabbits in zero grazing units whose manure is returned to the fields	-	Hedgerows and woodland areas for natural enemies	Fertility trenches, zai pits, hedgerows, woodland area	-
KALRO PTC	-	Agroforestry training provided in partnership with World Agroforestry Centre	-	-	-	Conservation areas designated on farms used as pest traps	Staff promote at least 10% green cover on farms	-
G-BIAC	*Eichhornia crassipes* (water purification), *Tithonia Diversifolia* (green fertilizer), *Tagetes patula* (pollinator attractant)	Alley cropping, dispersed planting and windbreaks	Tethered goats moved daily	Crop residues fed to goats, chickens, and rabbits in zero grazing units whose manure is returned to the fields	Rain ponds for irrigation also house tilapia and mudfish.	-	-	-
KAGURU ATC	-	*Grevillea Robusta* on terrace lines. Grafting training provided to farmers	-	Crop residues fed to cattle, goats, poultry and pigs in zero grazing units whose manure is returned to the fields.	-	-	Bench terraces and planting holes	-
LPC	Reeds (water purification), *Tagetes Minuta* and *Tephrosia vogelii* (pest repellants)	Alley cropping, hedgerow windbreaks, contour planting, and wooded areas	Rotational grazing trained in community groups	Crop residues fed to poultry and rabbits whose manure is then composted	-	*Tephrosia vogelii* hedgerow used to prevent moles and squirrels	Wilderness conservation area, terraces	-
REAL IPM	-	Not a training topic. However, farm does have a number of trees dispersed in the demo plots	-	Crop residues fed to cattle and chickens in zero grazing units whose manure is returned to the fields	-	-	Fanya chini terraces, *Colocasia esculenta* trenches, windbreaks, year round flowering trees	-

Element 3.2 Diversity

All six farms demonstrate and promote the use of indigenous crops (e.g. *Amaranthus* spp, *Cleome gynandra*, *Solanum nigrum*, and *Vigna unguiculate)* to diversify crop production (Table 7). However only half the farms are involved in improving these varieties through propagation and distribution.

Crop rotations of three or more crops are practiced at all farms[12], however KIOF also practices a two-crop rotation between *Zea mays* and *Fabaceae* spp. Intercropping is practiced at four farms although it is included in the training given by five. Four centres also demonstrate spatial diversity through the use of permanent vegetable beds with strips of alternating crops. Crop and livestock diversification are linked to training on dietary diversification at five centres.

At the landscape level, five farms practice a multi-habitat approach to demonstrate the integration of woodland or conservation areas for wider biodiversity conservation. This includes Kaguru ATC who work to protect local monkeys even though they damage crops. Two farms demonstrate the integration of ponds for biodiversity and irrigation purposes. Specific attention to supporting pollinators through the integration of flowering non-crop plants and trees is demonstrated by five farms.

Element 3.3 Resilience

All six demo farms reported to be increasing the resilience of farmers to drought and flooding via soil and water conservation practices (Table 8). Additionally, KIOF and G-BIAC promote the use of drought-tolerant fruit trees and Kaguru ATC promotes the use of *Sorghum bicolour* as a drought tolerant crop. Two centres help increase farmer resilience to changes in pest and disease damage caused by climate change either by plant testing for resistance (KALRO PTC) or by offering a text message service that alerts farmers to outbreaks based on local climate indicators (Real IPM). Livelihood resilience is a focus for all six farms either through product diversification, increasing farm productivity, value addition, or non-agricultural skills training

Level 4: Re-establish connections between growers & eaters; develop alternative food network

Support for Level 4 varies amongst the demo farms (Figure 1). Although varying levels of support for Element 4.1 and 4.2 are expressed, all of the demo farms reflect strong support for Element 4.3 (Figure 2 and Table 9). This is testament to the farms' recognition of the importance of interactive pedagogies that bring together exogenous and local knowledge. Such a result is encouraging and reflects the role of demo farms as a bridge between different sources of knowledge (Ingram et al. 2018).

[12] Details of the specific rotation systems used are mentioned in the case studies provided in appendix C.

Table 7 Results from case studies showing how the demo farms meet the ACT criteria for Element 3.2 Diversity

Criteria:	*3.2.1 Improving local seed/breed diversity*	*3.2.2 Integrating locally adapted crops/races*	*3.2.3 Two-Crop rotation*	*3.2.4 Three+ Crop rotation*	*3.2.5 Spatially diversified farms*	*3.2.6 Biodiversity*	*3.2.7 Natural pollinators*	*3.2.8 Multi-habitat approach*	*3.2.9 Diversification of diets and consumption*
KIOF	-	Indigenous vegetables and kinyeji chickens[13]	To crop rotation	Four crop rotation	Intercropping, strip beds with alternating crops	Woodland areas. Hedgerows.	Flowering plants amongst crops	Food production and natural habitat protection, large ponds for water storage	Crop and livestock diversification and inclusion of indigenous vegetables
KALRO PTC	Provide indigenous vegetable seeds	Indigenous vegetables	-	Three crop rotation	Intercropping promoted through training	Designated conservation areas	Flowering plants in conservati on areas	Food production and natural habitat protection	Inclusion of indigenous vegetables
G-BIAC	Growing drought resistant beans. Indigenous seed bank holds climate adapted crops	Indigenous vegetables and kinyeji chickens	-	Three crop rotation	Intercropping, strip beds with alternating crops, relay cropping, companion planting	-	Flowering plants amongst crops	Ponds and water channels throughout the farm.	Crop and livestock diversification and inclusion of indigenous vegetables
KAGURU ATC	-	Indigenous vegetables	-	Three and four crop rotations	-	Designated conservation areas. Local monkey's protected	-	Food production and natural habitat protection	-
LPC	Propagating *Aloe secundiflora* for community groups	*Aloe Secundiflora*, *Opuntia* cactus. Indigenous vegetables and kinyeji chickens	-	Five crop rotation	Intercropping, strip beds with alternating crops	Designated conservation areas. Food forests also provide food and shelter to birds	Flowering trees and plants amongst crops.	Food production and natural habitat protection (for bee production)	Crop and livestock diversification and inclusion of indigenous vegetables. Conducting research on nutritional value of cactus products
REAL IPM	-	Indigenous vegetables	-	Three crop rotation	Companion cropping in vertical farming and strip beds with alternating crops	Designated conservation areas. Training to sensitise farmers to protect biodiversity	Flowering trees.	Food production and natural habitat protection	Crop diversification and inclusion of indigenous vegetables. Nutrition training provided to staff

[13] *Kinyeji* is a Kiswahili word meaning traditional or indigenous and is a term commonly used to describe traditional breeds of chicken kept in Kenya

Table 8 Results from case studies showing how the demo farms meet the ACT criteria for Element 3.3 Resilience

Criteria:	*3.3.1 Systemic resilience of agroecosystems to extreme weather events and other disturbances*	*3.3.2 Systemic resilience and adaptive capacity to changing environmental conditions due to climate change*	*3.3.3 Livelihood resilience*
KIOF	Dry-land farming techniques, planting drought tolerant fruit trees	-	Value addition. Diversified crop and livestock production.
KALRO PTC	Water harvesting (collaboration with Real IPM)	Plant testing for disease and pest resistance	Increasing production capacities.
G-BIAC	Planting drought tolerant fruit trees	-	Non-agricultural skills training
KAGURU ATC	Planting drought tolerant crops, conservation agriculture techniques	-	Increasing production capacities.
LPC	Soil and water conservation structures, mulching	-	Diversification from subsistence into production of cosmetics and marketing food
REAL IPM	Terraces, windbreaks	Text message service alerts farmers about pests and diseases outbreaks	Crop diversification

Element 4.1 Circular and solidarity economy

Four demo farms worked to connect farmers with traditional or organic markets. Kaguru ATC trains farmers to conduct market surveys and supported them to adapt their farms to local market demands. KALRO PTC helps farmers formalize trading relationships. Training in value addition is provided by G-BIAC and LPC. The only centre with a specific focus on encouraging regional produce demand is LPC with its sales of locally made products.

Element 4.2 Culture and food traditions

Four centres worked on supporting healthy, diversified, and culturally appropriate food traditions and diets by either highlighting the dietary benefits of diversifying crop and livestock production or via specific training on nutrition. Two farms specifically worked to support farmers to choose the food they wanted to grow. This was done either through participatory farm design activities (LPC) or through the development of a local version of Biointensive farming – an approach that traditionally does not discourages livestock farming (G-BIAC).

Element 4.3 Co-creation and sharing of knowledge

Every farm made efforts to connect farms to share knowledge either through farmer exchanges, group training, or farmer testimonial videos. All but one centre engaged in participatory approaches to knowledge generation either through farmer field schools or two-way knowledge exchange between trainers and participants.

Table 9 Results from case studies showing how the demo farms meet the ACT criteria for Elements 4.1, 4.2, and 4.3

Element:	**4.1.Circular and Solidarity Economy**			**4.2.Culture and Food Traditions**		**4.3.Co-Creation and Sharing of Knowledge**		
Criteria:	*4.1.1 Business support for re-establishing the connection between producers & consumers*	*4.1.2 Supporting regional value generation*	*4.1.3 Encourage & sensitize for seasonal & regional demand*	*4.2.1 Support healthy, diversified, and culturally appropriate food traditions and diets*	*4.2.2 Support the right to adequate and culturally appropriate food*	*4.3.1 Connecting farmers to share knowledge*	*4.3.2 Promote participatory and multi-stakeholder approaches in knowledge generation*	*4.3.3 Promote formal and non-formal "production and food" education*
KIOF	-	-	-	Growing locally appropriate crops and livestock linked to nutrition training	-	Farmer exchanges. Farmer learning groups	Two-way knowledge exchange between trainers and participants	Education provided to farmers and agricultural students
KALRO PTC	Offer support for region-specific market linkages and formalise links to sellers and legal contractors		-	-	-	Farmer exchanges	Farmer field schools	Education provided to farmers
G-BIAC	Connect farmers to organic farmers market	Solar dehydrators	-	Training on nutrition linked to cooking and farming courses	African adaptation of biointensive farming - originally a western concept that excluded animal production	Inter and intra community swaps between new and old trainee farmers	-	Education provided to farmers and agricultural students
KAGURU ATC	Farmers are trained to adapt production to market requirements. Support offered to connect farmers and vendors	-	-	Promotion of indigenous vegetables and diversified production linked to nutrition advice	-	Farmer exchanges done in partnership with the local government ward offices	Farmer field Schools	Education provided to farmers
LPC	Connect farmers to organic farmers market and local retailers	Value addition of honey, *Opuntia* cactus, and *Aloe vera,* solar drying herbs	Local sales of *Opuntia* cactus products	-	Participatory design to help people grow the food they want	Farmer exchanges	Two-way knowledge exchange between trainers and participants	Education provided to farmers and other participants
REAL IPM	-	-	-	Nutrition training for staff, and encouraging an increase in urban farming to improve urban diets	-	Farmer exchanges between demo plots in communities. Sharing farmer testimony videos	-	Education provided to farmers

Level 5: Rebuild the global food system so that it is sustainable and equitable for all

Support for Level 5 varied amongst demo farms but generally received the least attention (Figure 1). Nonetheless, the results highlight different ways in which demo farms are encouraging the promotion of Human and Social Value (Table 10) and Responsible Governance (Table 11) in the food system.

Element 5.1 Human and Social value

Four demo farms work to empower women, for example by working with women's groups, raising awareness of gender issues on industrial farms, or through a specific empowerment program for young women. LPC and G-BIAC also highlight the importance of training husbands and wives together to ensure gender equality in knowledge acquisition and decision making.

KIOF provide training to people living with HIV/AIDS to improve access to nutritious food. Training is provided to rural youth at KALRO PTC and Kaguru ATC, while Real IPM provide over 200 jobs to young people at their centre. Farmer organizational capacity building is provided at half of the farms either through registration of legal entities, or leadership and finance training.

None of the centres work on policy development for inclusive food systems that promote equity and dignity. G-BIAC is the only centre that reported working to improve access to food by evaluating their work to measure whether or not community training programs increase household food security. It is also the only demo farm that reported to be involved with promoting policies related to food sovereignty, which is does as a member of Participatory Ecological Land Use Management (PELUM).

Element 5.2 Responsible Governance

The demo farms visited have limited involvement with agroecological policy development (Table 11). KIOF is engaged with lobbying the Kenyan Ministry of Agricultural (MOA) to establish policy on organic farming and improving the connection between organic farmers and consumers. KIOF is also pushing for policies that recognize the role of agriculture in dealing with global changes and reward farmers who are enhancing biodiversity.

LPC has worked to promote seed sovereignty through PELUM's seed declaration and G-BIAC is engaged in policy advocacy on agroecology as a member of the same organisation. LPC also engages local government officials in on-site demonstrations to promote agroecological farming practices. G-BIAC supports indigenous seed networks but do not engage with policy development related to natural resource management.

KALRO PTC is a stakeholder in the MOA's policy development on linking agricultural to biodiversity conservation but no further comments were made regarding specific details. Although Kaguru ATC does not promote organic farming on-site it is involved in proposing organic farming policies to the local government and is also working to establish a food safety committee to support reductions in chemical pesticide use.

Table 10 Results from case studies showing how the demo farms meet the ACT criteria for Element 5.1 Human & Social Values

Criteria:	*5.1.1 Gender and vulnerable group approach*	*5.1.2 Strengthen organisational capacities*	*5.1.3 Equity, Dignity, Inclusion*	*5.1.4 Support right to food (sufficient, access, adequate)*	*5.1.5 Promote food sovereignty*	*5.1.6 Creating decent jobs for rural youth based on agriculture*
KIOF	Work to help those living with HIV/AIDS	Assistance with registration of self-help groups and formation of farmer committees	-	-	-	-
KALRO PTC	"Gender in agriculture" sensitisation training provided to industrial farmers	-	-	-	-	Provide training to rural youth for IPM related services and plant propagation
G-BIAC	Girls Empowerment residential training program onsite (1.5 years), wife and husbands trained together to empower women on their own farms	Leadership training. Establish farmer cooperatives	-	Baseline assessment and post-intervention study conducted to assess impact of training on food security	Through membership in PELUM	-
KAGURU ATC	-	-	-	-	-	Training rural youth
LPC	Work with women's groups and with mixed groups to promote gender equity	Legal registration of farmer organisations. Finance training	-	-	-	Young people employed as farm managers in community projects
REAL IPM	Work with women's groups	-	-	-	-	Employing >200 young people on the farm

Table 11 Results from case studies showing how the demo farms meet the ACT criteria for Element 5.2 Responsible Governance

Criteria:	*5.2.1 Policy development (PD) on producer-consumer links*	*5.2.2 Inclusive policy making*	*5.2.3 Establishment of equitable governance and rights over natural resources*	*5.2.4 PD on the links between agroecology and global changes*	*5.2.5 PD that reward agricultural management that enhances biodiversity and the provision of ecosystem services*
KIOF	Encourage farmers to form links with public institutions for selling food, and lobbying MOA for organic farming policy	-	-	Lobbying for organic agriculture policies that relate to climate change	Lobbying for organic agriculture policies that relate to biodiversity conservation
KALRO PTC	-	-	-	-	Stakeholder in MOA policy development.
G-BIAC	-	-	Seed saving and distribution as resistance against Kenyan laws preventing indigenous seed networks.	Engaged in policy advocacy as member of PELUM	Engaged in policy advocacy as member of PELUM
KAGURU ATC	-	-	-	-	Proposing policy to local government to form food safety committee to reduce chemical use to a safe and effective level, and also advocate for organic farming for health reasons
LPC	-	-	PELUM seed declaration 2019	Engage local governments to promote ecological farming	-
REAL IPM	-	-	-	-	-

5.2 Which factors are supporting or hindering support for agroecological transitions?

Five design considerations for successful demo farms were identified in the literature review (i.e. motivation, location, education, operations, and participation). However, it is unclear how such considerations may be nuanced to enable support for agroecology. Indeed, expressions of these considerations could hinder support. Therefore, the farms were analyzed to see how their design enabled or hindered their ability to support agroecological transitions.

5.2.1 Motivation

The purposes of the demo farms visited (Table 12) appear to fall into two categories. The purpose of first group reflects traditional notions of extension by aiming to transfer agricultural knowledge and skills to farmers. Such extension may relate to broad agricultural topics (as in the case of KALRO PTC and Kaguru ATC), or more specifically to ecological practices (e.g. KIOF and Real IPM). The second group see such extension efforts as a means to achieving higher social purposes (e.g. poverty eradication or community resilience). The objectives of the farms are broadly to support farmers through training activities and hence there is overlap between the purpose and objectives for the first group.

Both types of purpose likely support agroecological scaling out efforts. This is demonstrated by the way in which these centres are supporting various efficiency, substitution, and redesign efforts as well as encouraging the co-creation of knowledge (Figure 2). However, the two farms whose purpose is to create wider social change appeared to be more engaged with advancing change at the market level than those focusing on extension efforts. Although the sample size is limited, the results suggest that defining the purpose of demo farms beyond simple extension may promote agroecology in a more holistic sense. It is important to note that additional motivations are likely present where products are showcased by private partners, as is the case at KALRO PTC and Kaguru ATC (hybrid seed demos were on central display at both centres at the time of visiting). Hence, depending on the nature of the product, private motives may support or hinder agroecological transitions.

Table 12 Ownership, purpose and objectives of each demo farm

	Ownership	*Purpose*	*Objectives*
KIOF	NGO	To convince farmers to adopt ecological farming practices	Train farmers and provide formal youth education
KALRO PTC	GOV	To transfer knowledge, skills and technology developed about tree and field crops by KALRO and their partners directly to farmers	Provide practical training to farmers
G-BIAC	NGO	To eradicate extreme poverty amongst farmers	Help farmers understand the logic of organic farming
LPC	NGO	To empower people to create sustainable and resilient communities	Delivering training programs and community development activities, and promote the principals of permaculture
KAGURU ATC	GOV	To provide agricultural training and demonstrations to farmers	None specified
REAL IPM	Business	To educate farmers on safe methods of farming biological control	Provide clear explanations of various agricultural practices and allow farmers to observe the effectiveness of products and practices with their own eyes.

5.2.2 Location

All of the demo farms use community demo plots which confirms the value of hybrid ‘mother-baby’ systems for adapting practices to local agroecosystems (Table 13). This integrated approach is likely supportive of ensuring scaling out efforts are contextualized rather than simply multiplied. It likely also increases accessibility given the varying ability of farmers to reach the central farms.

None of the demo farms reflect a typical agroecosystem for their area given the presence of institutional and training facilities. However, their acreage generally corresponded with the size of the farmers engaged with. Where farms promote a particular agricultural approach (LPC and G-BIAC), their layouts reflect realistic systems for farmers to replicate. Accessibility is generally good, except at LPC and Real IPM. However, only Real IPM reports this as an issue.

Aside from the use of ‘mother-baby’ systems no further insights were derived about how location may support or hinder agroecological transitions. However, although demo farm distribution is not mentioned in the literature, the presence of three centres in Kiambu suggest there may be value in mapping demo farms in Kenya. This could highlight areas that are underserved and help to limit competition or confusion between extension providers.

5.2.3 Education

The intended outcomes of training activities (Table 14) is closely aligned to the purpose of each demo farm (Table 12). Farms whose purpose is related to agricultural extension generally see training as a means for farmers to acquire new skills and knowledge in an incremental manner. KIOF is an exception where, similar to LPC and G-BIAC, the intended outcome of training is to empower farmers and communities to increase farm resilience. The intentions behind the demos of the latter group are likely to encourage the development of embodied knowledge through multiloop learning as opposed to the single-loop learning promoted by the other groups.

Topics covered by training are determined by a range of actors at each centre reflecting the way in which set curricula is adapted to the needs of farmers and community groups. A diversity of pedagogic methods is employed by each farm, although only two use specific frameworks for teaching. Practical training is central to the work conducted by each centre and is combined with theoretical education. All of the centres confirm the importance of ‘seeing is believing’ and ‘learning by doing’ as principles for effective demonstrations further showing the value of visual and practical training.

Demo farm staff are generally viewed as performing hybrid roles as facilitators and experts. Agribusiness representatives also provide training at KALRO PTC and Kaguru ATC. Participants are viewed as active participants but are also engaged as trainers at three centres.

Table 13 Characteristics related to location of each demo farm

	County	*Accessibility*	*Acres*	*Other sites*	*Infrastructure*	*Similarity to local farms*
KIOF	Kiambu	Connected to highway by good roads	10	Community demo plots	Student residence, classrooms, crop fields, woodlot, rain ponds, livestock shelters, offices	Not typical of local farms given infrastructure and layout, however agroecosystem elements are typical of the area
KALRO PTC	Kiambu	Connected to highway by good roads	40	On-farm demos for technology validation	Offices, research facilities, nursery, crop fields, protected floriculture unit, orchards, classrooms	Not typical of local farms given infrastructure and layout. Farm also showcases private demo plots for seeds and other inputs
G-BIAC	Kiambu	Connected to highway by good roads	1.75	Community demo plots and development programs	Offices, student residence, kitchen and dining facilities, computer suite for computer skills training, textiles training room, seed bank, library	Not typical of local farms given infrastructure, however the farm is designed as a replicable system to inspire similar Biointensive garden designs
LPC	Laikipia	Connected to main road via 17km dirt road	5	Community development programs	Offices, staff and guest accommodation, food processing facilities, kitchen and restaurant, shop, seed bank	Not typical of local farms given infrastructure, however the farm is designed as a replicable system to inspire similar permaculture designs
KAGURU ATC	Meru	Connected to highway by good roads	67	Community demo plots	Offices, teaching facilities, accommodation, indoor and outdoor event spaces, polytunnels, orchards, crop fields, livestock enclosures	Not typical local farms given infrastructure and layout. Farm also showcases private demo plots for seeds and other inputs.
REAL IPM	Kiambu	No public transport access, but connected to main road by long dirt roads	2.5	Community demo plots	Offices, training facilities, staff residence, natural enemy breeding facilities, nursery, kitchen and dining facilities, urban agriculture demo plots, crop fields, polytunnels, zero grazing cattle shed, insect breeding unit	Not typical of local farms given infrastructure

Table 14 Details of the educational approach taken at each demo farm

	Intended outcomes of training activity	*Who determines training content?*	*Pedagogic Methods*	*Role of staff*	*Role of participants*
KIOF	Farmer/community empowerment to increase farm resilience	KIOF, Communities, Farmers groups	Demonstrations, single day training, week-long community training, action planning, farm mapping, residential courses, farm exchanges and lectures	Facilitators Guides	Active participants Farmer trainers *(farm exchanges)*
KALRO PTC	Incremental skills and knowledge acquisition	KALRO, Agribusiness partners, Farmer groups	Demonstrations, week-long residential courses, roadshows, farm exchanges, and farmer field schools	Facilitators Experts Researchers	Active participants Farmer trainers *(on-farm demos)*
G-BIAC	Farmer/community empowerment to increase farm resilience	G-BIAC, Communities, Farmers groups	Participatory Action Learning, residential courses, demonstrations, lectures, discussions	Scientific knowledge providers Facilitators	Indigenous knowledge providers and recipients Farmer trainers *(community projects)*
LPC	Farmer/community empowerment to increase farm resilience	LPC, Visiting experts, Communities	Permaculture Design Courses, workshops, farm tours, discussions, question and answer sessions, farmer field schools, and farm exchanges	Experts Facilitators	Active participants
KAGURU ATC	Incremental skills and knowledge acquisition	Kaguru ATC, Agribusiness partners, Farmer groups	Farm tours, active discussions, question and answer sessions, farmer field schools, and farm exchanges	Expert trainers Facilitators	Active participants
REAL IPM	Incremental skills and knowledge acquisition	Real IPM, Farmer groups	Group training, 1:1 consultancy	Facilitators Experts	Active participants Knowledge recipients engaged in a two-way educational process

5.2.4 Operations

All of the centres charged farmers for either some or all of their services (Table 15). Only two of the demo farms offered extension services to farmers for free, both of whom received external funding. Training costs are reported as a barrier for many farmers by G-BIAC and Real IPM. The reason for charging however is related to a general trend of declining funding from donors (KIOF and Real IPM) and the government (KALRO PTC and Kaguru ATC). All of the centres lamented the lack of government financial support for agricultural extension.

Both of the centres who receive funding from the government expressed that private sector funding through partnerships is necessary to ‘fill the void’ left by government cuts to extension services. Staff at Kaguru ATC reported that private funding is received for showcasing specific agricultural inputs. Staff also reported that private businesses had previously brought contaminated plant material to Kaguru ATC which caused soil contamination, and on another occasion had been caught applying unlabeled chemicals to crops to enhance the results of demo plots. Although anecdotal, such issues highlight potential conflict that may arise when engaging with private partners.

Farmers are engaged in training via external actors (e.g. community groups or extension agents) or websites and online platforms. Staff at G-BIAC highlight the need for frequent refresher courses because farmers felt confused by conflicting extension information from different providers.

Table 15 Operational characteristics of each demo farm

	Fee for training or free?	*Funding for training?*	*How is training organised?*	*Operational challenges*
KIOF	Fee	No - previously funded by NGO	Farmers are engaged through church groups and farmers' groups	Lack of government support for ecological agriculture, cost of courses is a barrier for many farmers, and student retention has declined in recent years
KALRO PTC	Fee	Yes - government and private partnerships	Via extension field offices, social media, private partners.	Reliant on conditional private funding due to government cuts
G-BIAC	Free for certain groups (funded) Fee for non-funded groups	Yes - community projects are funded by partner organisations	Community groups are identified by field workers	Lack of government support for ecological agriculture, and farmers are often confused by conflicting agricultural extension advise from different providers
LPC	Fee for demo farm visits and training Free for community projects	Yes - community projects are funded by partner organisations	Website, social media, partner networks	Lack of government support for ecological agriculture
KAGURU ATC	Fee for demo farm visits and training Free for agribusiness events	Yes - government and private partnerships	Via field extension agents	Reliant on conditional private funding due to government cuts, and in the past private companies have introduced infected plant material and tried to use unlabelled products
REAL IPM	Fee for demo farm visits and training	No - previously funded by NGO	Website, social media, farmer to farmer interactions	Lack of government support for ecological agriculture, and cost of courses is a barrier for many farmers

5.2.5 Participation

All of the demo farms employed forms of farmer participation. However, the outcomes of participation varied between farms. Knowledge co-creation is reported as a main outcome from participation at four demo farms. Participation is also used to enable active learning at these centres. KIOF and G-BIAC used participation to empower farmers as local trainers, while KALRO PTC sought the assistance of demo farmers for validating technology in the field. Similar to the organizational purpose of G-BIAC and LPC, these centres saw participation as a means to empower participants to take ownership of their own development. G-BIAC also saw farmer participation as a necessary component of the seed networks they had established. None of the centres involved farmers in the design of the farms, but farmers do shape the content of training activities by requesting bespoke training or by staff adapting predesigned training to their needs. Farmers' knowledge is welcomed at all of the farms.

5.3 Case study discussion

The six demo farms are engaged in a number of activities supporting elements of agroecology at the field, farm, market, and policy levels. Through unique approaches, these farms offer inspiration for how demo farms can function as nexus for the dual processes of scaling agroecology out and up. This result challenges the common notion that demo farms solely engage in agricultural extension (Pappa et al. 2018). Instead, demo farms may be (re)designed as platforms for engaging a diversity of stakeholders in activities that address all levels of food system transformation.

Despite the efforts of these farms, their support for agroecology still largely focuses on scaling out practices. A similar emphasis is reflected in Kenya's agricultural research institutes where 70% of projects are recently found to be limited to increasing agricultural efficiency, 13% to input substitution and 13% to redesign (Biovision & IPES-Food 2020). Even so, variation in these measures suggest there is room for development. In particular, many of the farms could do more to support recycling and agroecosystem regulation.

Centres such as LPC, G-BIAC, and Kaguru ATC offer ideas for how other centres could increase support for agroecological transitions at the market and policy levels. For example, demo farms could act as platforms for training on value addition and marketing or for facilitating connections between farmers, sellers, and consumers. Similarly, demo farms could demonstrate the impact of agroecology to policy makers and other influential actors. The latter is of particular importance in Kenya where "low awareness of alternatives to the (new) Green Revolution model [has] emerged as the greatest barrier to supporting and implementing more agroecological projects" (Biovision & IPES-Food 2020:5). Although not practiced at the centres, there may be value in demo farms demonstrating to one another to create dialogue about different agriculture approaches to limit the confusion experienced by farmers confronted with conflicting extension advice.

It is important to note that none of the farms provide a perfect image of what an agroecological demo farm should be like. Each farm's activities reflect the context in which they operate and the needs of the farmers with which they engage (e.g. KIOF and G-BIAC cater for farmers engaged in dry-land farming). This insight is a reminder of the importance of contextualising scaling efforts (Ferguson et al. 2019, Gaitán-Cremaschi et al. 2020). Achieving such contextualisation may require trade-offs in terms of which agroecological elements are given the most attention at a demo farm. Indeed, it may be undesirable or even unnecessary for a demo farm to "score" 100% using ACT. For example, Real IPM were the only farm to promote biological pest management, yet this may be redundant14 for other centres where wider IPM strategies are promoted.

The design considerations that emerged from the literature offer further insights regarding how agroecological demo farms might be designed. Agroecological demo farms may find more success if driven by motivations that seek to empower farmers to develop resilience and embodied knowledge. The use of multiple locations through 'mother-baby' hybrid models including community owned demo plots is likely to enhance the contextual validity of extension efforts while also increasing accessibility for farmers. Engaging farmers in visual ('seeing is believing') and practical ('learning by doing') educational activities is likely to improve adoption of sustainable practices. Similarly, other stakeholders (e.g. policy makers) may benefit from practical demonstrations as a means for building empathy with farmers. Funding is a major operational challenge especially within a context of government cuts to extension services. Therefore, thought should be given to how to sustain agroecological demo farms, e.g. through appropriate partnerships or fees. Demo farms can encourage knowledge co-creation by facilitating learning in groups, or through farmer led activities such as exchanges and field schools. Viewing extension staff both as facilitators and experts and farmers as active participants and knowledge providers will allow for exogenous knowledge to complement local knowledge as and when requested. However, farmer participation should be oriented toward empowerment rather than manipulation of farmers for technology validation.

A final point of discussion is how the case studies reflects the trend of institutional rather than participatory demo farm design that is suggested in the literature (Mbure & Sullivan 2017, Ingram et al. 2018). Given the emphasis placed on participation, both in the literature on demo farms and agroecology more broadly, this result raises questions about what farmers may expect from demo farms. This question is hence explored in greater detail in the following section.

[14] Redundancy is used here in the ecological sense rather than suggesting obsolescence.

6.0 Results & Discussion of Participatory Farm Design Workshop

A participatory farm design workshop was held to explore what a co-design process for a demo farm might look like, the results of which are intended for Sistema.bio to use for developing a demo farm. The insights gathered offer lessons about how farmers relate to demo farms and generate ideas about how farmers' perspectives can be integrated when designing agroecological demo farms.

6. 1 How can demo farm objectives be best aligned to farmers' needs and goals?

The proposed demo farm was expected to fulfill a number of institutional objectives set by Sistema.bio. The company wanted to create a demo farm that would showcase their biodigester technology within a wider ecosystem of agroecological practices, provide space for conducting research, and function as a commercial farm. However, the company wanted to take a participatory approach to design the farm as a centre for agroecological innovation.

The workshop began by creating dialogue between farmers and Sistema.bio staff to understand why local farmers engage in farming (their purpose). A variety of answers were given relating to individual and societal purposes for farming (Figure 3). Some answers related to the provision of food at the household or community level. Others related to farming as a means for improving socio-economic and ecological living standards.

INDIVIDUAL ⟷ **SOCIETAL**

- "Get food ready at home"
- "Fresh food from the farm"
- "Balanced diet"
- "Feeding the community"

- "Improved lifestyle"
- "Improved income"
- "Save time"
- "Biogas"
- "Improve the environment"
- "Educate kids"

- "Business"

- "Culture"

Figure 3 Farmers' responses to the question 'Why do you farm?'. Answers grouped by how farmers viewed farming as a means (business or culture) or as an end (food provision or lifestyle improvement)

Some farmers saw farming primarily as a business, while others saw it as part of their culture. Each of the answers not only generated empathy between the workshop stakeholders but also provided insights about what the purpose of the demo farm might be. For example, it may be to enable farmers to provide their communities with fresh food in a way that is profitable, ecologically sensitive, and culturally appropriate. The effectiveness of the demo farm in supporting this purpose could hence be routinely evaluated. For example, training could be checked to see if farmers feel supported to achieve their goals of food provision and improvements to living standards. Additionally, the farm could be assessed to ensure local farming cultures are represented.

6. 2 At which levels of transition might farmers expect demo farms to support them?

In order for the demo farm to empower local farmers to attain their goals it was necessary to understand what challenges farmers faced so that training activities could be developed accordingly. Farmers were asked to discuss challenges in small groups before sharing answers in plenary. Answers related to challenges that occurred on-farm (farm size, infrastructure, knowledge, crops, and livestock) and off-farm (politics, the market, and environmental factors) (fig. 4). Four key challenges, namely water, soil fertility, the market, and knowledge were selected by the group as topics for further discussion in a 'challenge market' activity. Participants were asked to gravitate to their topic of interest to discuss the challenges in detail before generating potential solutions (Table 16).

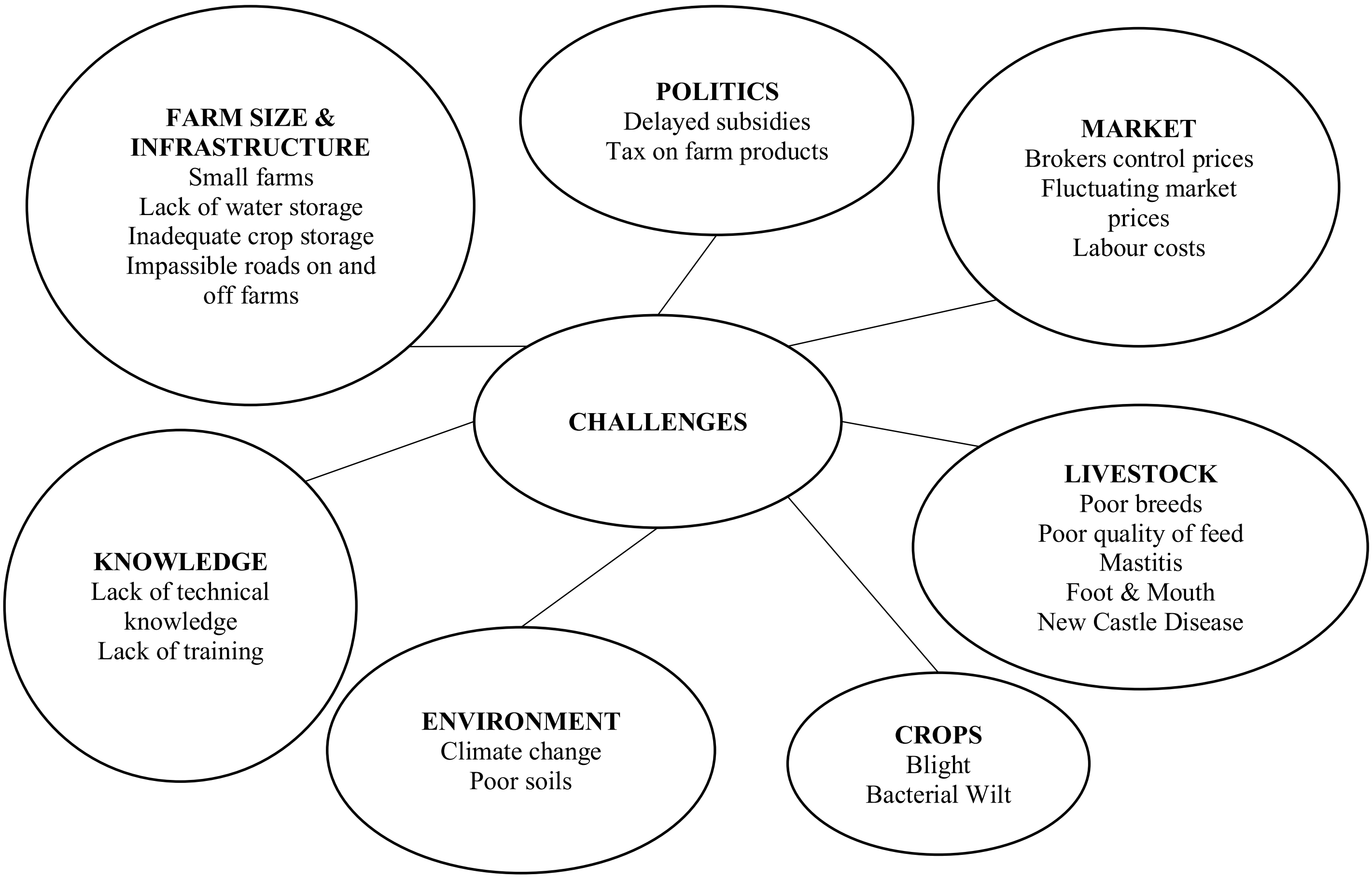

Figure 4 Farmers' responses to the question "what challenges do you face on your farm?"

Table 16 Details of key challenges faced by farmers and proposed solutions generated by breakout group

Theme	Challenges	Proposed solutions
Water	Shortage of water Lack of storage facilities Flooding Contamination Unreliable rains Cost of water maintenance Water rationing Cost of local water projects Land size too small for installing water systems	Trapping runoff water Terraces with good trenches Water harvesting Drip irrigation instead of sprinklers Construction of boreholes Membership in local water projects Construction of damns Buy/Construct tanks (over or underground) Water treatment Planting Trees/afforestation/agroforestry Government subsidies for water maintenance Community self-help groups Find solutions for small farms
Soil fertility	Soils depleted of nutrients Soil acidity Lack of technical knowledge regarding soil testing and acidity Lack of crop rotations Soil borne diseases (e.g. fusarium and bacterial wilt) Hard pans Lack of manure	Organic farming Stop the use of fertilizers that make the soil acidic Long term crop rotations Intercropping Soil sampling No-till farming Avoid burning crop residues Use certified seeds Chiselling to break hard soil Source pigs, cows and poultry Use of manure
Market	Brokers determine the price Markets get flooded with same produce Lack of information on market trends and prices Quality control Labour cost and availability Fewer casual workers People prefer white collar jobs Culture mindset views agriculture poorly	Form cooperatives Diversify production Improve storage facilities Scout for market prices Encourage young people into farming Influence education institutions to promote farming Highlight the benefits of farming Increase mechanization
Knowledge	Fodder management Value addition Finance management Crop rotation and intercropping Cattle breeding Pest & disease management Water harvesting and storage Soil fertility (testing and management)	New demo farms Visit existing demo farms Forums to connect farmers with agronomist and extensionists for training on specific issues Engage research institutions to help with soil testing and other tests Connect farmers with animal nutritionists Develop cottage industry for value addition

Later in the workshop, farmers were asked to write down ideas (as mind maps or lists) about how the demo farm could support them in overcoming their challenges. Farmers expressed desire for the demo farm to provide training in a range of topics related to some of the challenges they had identified as well as offering ideas about how to provide the training. The suggestions demonstrated a desire for support at the first four levels of agroecological transition (Table 17). A number of the proposed solutions to the challenges faced by the farmers were not included (e.g. organizational capacity building, financial management, no-till farming). The lack of suggestions related to Level 5 could suggest the farmers' disinterest in working with a demo farm to engage in changes at this level. Alternatively, the farmers may not feel welcome or able to engage in political activity at the local or national level. Further, it may reflect a common perception of demo farms as platforms for extension services only. Therefore, if demo farms are to be (re)designed as nexus for scaling agroecology *up* and *out* work may be required to reframe what farmers expectations of them.

Table 17 List of topics and methods of training suggested by farmers organised by associated level of agroecological change

Level 1: Increase efficiency of industrial and conventional practices	*1.1 Efficiency* Safe and efficient use of chemical fertilizers Using bioslurry as a feed supplement for poultry Animal feed production (e.g. making and using silage) Drip irrigation & small scale irrigation systems Vegetable nurseries How to select seeds for particular climate zones Fruit tree management and harvesting Grafting Monocropping Urban farming Green houses Intensive animal rearing (zero-grazing) Dairy production technology Livestock breed selection for climate zones
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	*2.1 Recycling* Use of biodigesters for biogas and bioslurry production Use of bioslurry as a fertilizer *2.2 Regulation/Balance* Pest & disease management (e.g. how to make biological pesticides, including from bioslurry) Weed management Organic farming techniques Livestock management Cover crops for soil erosion on terraces
Level 3: Redesign whole agroecosystems	*3.1 Synergies* Incorporating insect repelling plants in the farm (e.g. *Tagetes Minuta*) Windbreaks Contour planting *3.2 Diversity* Farm layout design Intercropping Crop rotations Dairy farming (in particular zero grazing cattle husbandry) Rabbit farming Aquaculture *3.3 Resilience* -
Level 4: Re-establish connections between growers and eaters; develop alternative food networks	*4.1 Circular and solidarity economy* Connect farms to market information Dairy value addition (e.g. yoghurt) Vegetable value addition (e.g. drying) *4.2 Culture and food traditions* - *4.3 Co-creation and sharing of knowledge* Farm exchanges Farmer led demonstrations and research Group and individual training Involve farmers in demo farm design and development

6.3 How can exogenous & local knowledge support agroecological transitions at demo farms?

The way in which farmers' challenges were discussed demonstrated the value of embracing the collective knowledge and creativity of farmers for developing solutions, while also highlighting key areas where exogenous knowledge may be required. The solutions the farmers proposed to help with knowledge gaps (Table 16) and the training methods they suggested for co-creating knowledge (Table 17) demonstrate an appreciation of both farmer and non-farmer knowledge sources.

A number of training methods were suggested for the demo farm, including regular practical workshops and training courses, refresher courses, specific training for farmer groups, demo plots for new crop varieties, and demo days for multiple topics. Additionally, farmers requested access to experimental plots to test new practices over long periods of time. This highlights how demo farms can de-risk innovation and encourage experimentation among farmers.

Participants also suggested training approaches that could take place away from the demo farm, including 1:1 training with farmers on their own land, group visits to successful farmers' farms, exchange programs with other learning institutions, phone call extension services, and farmer exchanges. It was also suggested that the centre could be a source of information about market prices and trends for farmers.

These insights suggest that exogenous knowledge may complement local knowledge when requested, but that participatory extension methods should play a central role in agroecological demo farm activities. Indeed, farmers expressed gratitude for the ability to connect with different farmers during the workshop as they felt they had gained new and immediately implementable solutions for many of the challenges they had shared.

Farmers also suggested that they should be involved in the ongoing development of the demo farm, illustrating a desire and willingness for participation to ensure the centre continued to be aligned with their needs. Farmers also requested to be involved as demonstrators and experimenters at the demo farm or during farm exchange visits. No suggestions were given regarding the role of demo farm staff, although the involvement of vets and other specialists was suggested.

6.4 Given the opportunity, how would farmers design a demo farm?

Farmers were split into six groups and given A1 printed maps of the proposed site. Land boundaries and existing physical structures (including buildings, a zero grazing unit and a biodigester) were indicated on the map. The groups used these maps to create designs of how they would arrange the demo farm (Figure 5). The designs are analysed below to understand how they reflect agroecological activity at the farm level (i.e. Elements 1.1 to 3.3).

Element 1.1 Efficiency

Water use efficiency is addressed by three designs through the inclusion of water storage tanks. However, given water shortages in the region, farmers were especially interested in being able to increase water availability, particularly during the dry months. Methods for reducing fodder wastage are suggested on four maps through silage and feed storage facilities. Aside from the preexistence of a biodigester, no specific design features relate to reducing energy use. No clear design features relate to reducing the use of agricultural chemicals. Similarly, seed use efficiency and the inclusion of resource efficient crops and livestock are not reflected in the designs.

Element 2.1 Recycling

Two farm designs include areas for compost production, but no other alternative soil amendments are included. Green manures are not featured although leguminous fodder crops are. None of the designs feature wastewater recycling elements or energy generation technologies that utilized biomass residues aside from the preexisting biodigester.

Element 2.2 Regulation/Balance

No features are given related to biological pest control. Fodder crops (e.g. *Pennisetum purpureum, Ipomoea batatas* and *Calliandra calothyrsus*) are included as cover crops on contour lines for enhancing soil stability. The use of perennial varieties of annual crops or reduced tillage practices are not highlighted in the designs. Similarly, it is unclear whether the designs are intended to represent strictly organic or low-input agroecosystems. An apiary is included in one design for honey production and pollination services. No specific features relate to improved animal welfare.

Element 3.1 Synergies

None of the designs feature interplanting of crops and trees. However, three of the designs feature trees as windbreaks, while two maps include the use of a marginal land for woodland. Two groups incorporate flower and non-crop shrub strips along the driveway. All of the designs represent mixed crop-livestock systems and include areas for fodder crop production. The inclusion of animals may have been influenced by the presence of a biodigester and cow shed, however, all of the farmers attending the workshop also kept animals. Rotational or regenerative grazing are not suggested. Fishponds are illustrated in three maps, either on high ground next to the cattle shed or at the lowest point of the farm. No features are found regarding habitats manipulation for IPM measures. Wider landscape planning is not indicated, likely due to the specific focus on the target farmland.

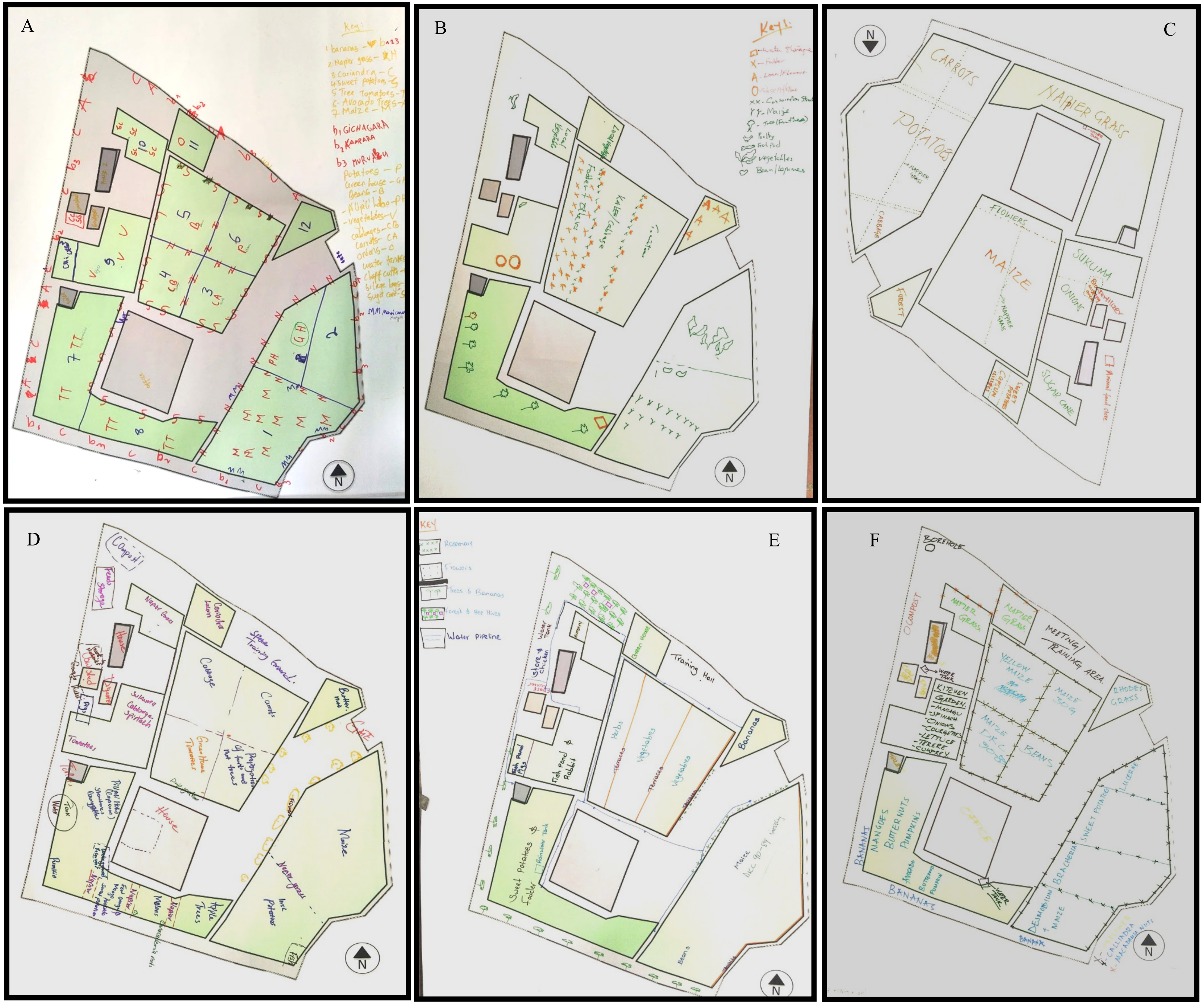

Figure 5. A-F. Hand-drawn demo farm designs produced by workshop participants. Key features described below:

Map A: Distinct areas for vegetables, grain, fodder and fruit trees. Multifunctional windbreaks placed around farm and single terrace in central plot. Plots delineated by fodder crops. (Purple numbers indicate plots).

Map B: Distinct areas for vegetables, grain, fodder and fruit trees. Three terraces in central plot.

Map C (inverted for readability): Distinct areas for vegetables, grain, and fodder. Plots delineated by fodder crops. Single terrace in central plot. Flower margin on main plot. Woodland on marginal land.

Map D: Distinct areas for vegetables, grain, fodder and fruit trees. Green house and fishpond. Some plots delineated by fodder crops. Single terrace in central plot and multiple terraces on southern side. Flower strips along drive. Compost area. Training area.

Map E: Distinct areas for vegetables, herbs, grain and fodder. Three terraces in main plot. Greenhouse and fishpond. Woodland on marginal land with apiary. Flower strips along drive. Training area.

Map F: Distinct areas for vegetables, grain, fodder and fruit trees. Single terrace in main plot. Plots delineated by fodder crops. Kitchen garden with indigenous vegetables. Compost area. Training area.

Element 3.2 Diversity

Participants shared a diversity of crops and livestock that they farm (see appendix E for full list) and suggested that many of these be included as components of the demo farm. The farm designs designate specific areas for crops typically grown for subsistence and market sales reflecting the dual purpose of many of the farmers' own systems. The arrangement of crops varied between intercropping and monocropping systems. Zea mays (an important staple crop featured on all the maps) was typically grown as a monoculture although buffer strips were suggested around plots in some of the maps. One group specified demo plots for improved varieties of Zea mays suited to the local climate and another indicated similar plots for improved varieties of Musaceae spp. Indigenous vegetables were included as part of diversified kitchen garden plots on two designs alongside other subsistence crops, suggesting a strategy for dietary diversification. Crop rotations were implied on four of the designs through clear segregation of different plots for market vegetables. The inclusion of flowering non-crop plants on three farms was suggested for attracting pollinators or for green fertilizer in the case of Tithonia Diversifolia. A multi-habitat approach is represented on the two maps that include a woodland. No other features are presented for wider biodiversity conservation.

Element 3.3 Resilience

All of the designs included terraces using contour lines indicated by straight lines along the North East – South West axis. Farmers' stated that this feature was included to prevent soil erosion and hence increase the farm's resilience to extreme weather events. No specific design features were included to increase resilience to wider issues related to climate change. Each of the designs reflect the farmers' interest in diversifying crop and livestock production as a strategy to increase livelihood resilience.

6.5 Participatory workshop discussion

Understanding why farmers engage in agriculture can enable demo farms to be better support farmers in overcoming their challenges to achieve their goals. Solutions can also be obtained through dialogue between farmers and non-farming peers and can be used to define specific training activities. This highlights the complementarity of local and exogenous sources of knowledge and creativity.

As individual farmers may not be able or willing to risk experimenting with novel farming strategies, demo farms can serve to de-risk innovation and experimentation. Performing this function could allow farmers to filter new practices and technologies once they've been validated against their expectations on the demo farm. Lead farmers (early adopter types) could offer further validation and/or adaptation at community demo plots to encourage wider diffusion. Similarly, demo farms could provide more focused support with regards to transitions at the market and policy levels. Demo farms could act as hubs for connecting farmers with each other and with markets actors to encourage market diversification and support for ecological produce. As individual farmers may be unwilling or unable to engage in effective dialogue with policy makers demo farms could work with farmers to develop and advocate for inclusive policy recommendations. However, for such ambitions to be realised it is necessary to create dialogue with farmers and other stakeholders to update expectations about the role of demo farms.

Finally, engaging local farmers as co-designers can highlight specific elements to feature on a demo farm leading to the creation of farms that showcase the agroecological potential of familiar agroecosystems. Such processes may highlight the presence of existing agroecological practices (e.g. terraces to prevent soil erosions). Equally this process may uncover areas where farmers' perspectives about how to tackle specific challenges required support from exogenous knowledge. For example, although farmers in the workshop expressed interest in reducing pesticide use, there are limited examples of design features that would enable this, e.g. push-pull farming (Murage et al. 2012).

The results of the workshop offer inspiration for how future demo farms could be (re)designed as nexus for the dual process of scaling agroecology not only out but also up. The results further highlight how involving farmers as co-designers (Lacombe et al. 2018) could lead to the development of demo farms that are better aligned to the needs of farmers. Farmer participation in this sense aims to create greater accountability in terms of what a demo farm does, how its effectiveness is monitored, and how knowledge, innovation and agroecological transitions are co-created.

7.0 Concluding reflections

Adoption of agroecological farming practices remains low, despite increasing evidence for their socioeconomic and ecological potential. This is regretful, especially in SSA where there is critical need for supporting farmers to become more resilient to the myriad challenges they face. Limited adoption is in part due to extension efforts being focused on conventional farming practices over the past few decades. Therefore, this paper argues that there is a need for developing demo farms as agroecological centres of excellence to support the scaling out of contextualised agroecological knowledge and practices. However, there is also need for scaling up agroecological principles to create enabling markets and policy contexts. It is hence argued that demo farms also have a role to play in this regard.

Recent research on demo farms has largely focused on design considerations to increase the effectiveness of these centres. Five key considerations can be distilled from the literature related to motivation, location, education, operations, and participation of farmers. However, the role of demo farms in agroecological transitions has yet to be fully explored. The results from the case studies presented in this research highlight the various ways in which demo farms are already providing contextualised support for agroecological transitions at the field, farm, market and policy levels. This result challenges the common notion that demo farms are merely a tool for agricultural extension. The case studies also give nuance to the design considerations found in the literature and in doing so reveal important insights into how demo farms might be (re)designed to enhance support for agroecology.

An important function of demo farms in scaling out agroecology is the de-risking of agricultural innovation. This is demonstrated in the case studies by the use of 'mother-baby' systems that enable farmers to learn experientially about new practices and technology on both centralised demo farms and community owned demo plots. However, further de-risking could also be enabled by allowing farmers to design and maintain experimental plots at demo farms, as suggested by farmers who participated in the demo farm design workshop. Such de-risking is no doubt increasingly important as farmers move from incremental efficiency and substitution practices toward more complex redesign measures that may require greater support (Wezel et al. 2014). Furthermore, de-risking activities may serve to expand farmers' imaginations about what is possible on their own farms.

The demo farms featured in the case studies demonstrate different means for enabling supportive market and policy contexts. For example, demo farms could offer training in value addition or marketing, or exist as a hub for connecting producers, traders and consumers of food to encourage sustainable diets. Such activities were also requested by farmers during the demo farm design workshop. With regards to policy, demo farms could play an active role in policy development by demonstrating agroecological practices and principles to policy makers. This opportunity could be further leveraged to connect farmers with policy makers. Cooperatives and farmer associations may be well positioned for managing demo farms given their existing role in connecting farmers to these levels of the food system. However, reconceptualising the traditionally held view of demo farms will necessitate dialogue with farming stakeholders to realign expectations. Furthermore, demo farms must be joined by other institutions working to create supportive market and policy contexts. This is even more critical in Kenya, given that each of the demo farms visited lamented the lack of government support for agricultural extension.

It is critical that scaling efforts are contextualised to the needs of local farming communities and agroecosystems (Ferguson et al. 2019, Gaitán-Cremaschi et al. 2020). Indeed, it may be unfeasible or even undesirable for any single demo farm to become a one-stop-shop for all things agroecological. By understanding the goals and challenges of local farming communities it is likely that demo farms will be more successful. Therefore, it is recommended that farmers are involved as co-designers in the design and ongoing development of demo farms. Farmer participation is furthermore crucial for ensuring agroecological demo farms work to empower farmers to overcome their challenges by developing embodied knowledge (Compagnone et al. 2018). Such knowledge may originate locally or exogenously but is likely best supported by pedagogies and experimentation that combine both.

Finally, two tensions may arise in the development of agroecological demo farms. First, there is a need for supporting incremental skills acquisition while also building farmers' competencies to redesign and optimize their farms as a whole (Rosset & Altieri 1997, Meynard et al. 2012, Ingram et al. 2018, Nicholls & Altieri 2018). However, educational approaches that enable multi-loop learning are likely able to integrate these needs (Duru et al. 2015, Ingram et al. 2018, Cooreman et al. 2018). Second, is the issue of product endorsement. While certain technologies may prove useful in certain contexts it is necessary that farmers are supported to understand their function within the wider agroecosystem. Doing so will allow farmers to assess whether such functions can be achieved in other ways on their farm, rather than being influenced by agricultural salespeople. Nonetheless, given the context of declining funding for agricultural extension (particularly in Kenya) such partnerships may be necessary for the economic sustainability of demo farms.

To conclude, this research highlights the important role demo farms can play as nexus for scaling agroecology up and out not only in SSA, but also around the globe.

References

Adamsone-Fiskovica, A., Grivins, M., Sumane, S., Tisenkopfs, T., Kilis, E. 2018. SWOT analysis and requirements for demo farms. Final report. INNOFRUIT project. Institute of Horticulture: Baltic Studies Centre

Adekoya, A. 2007. Effect of distance from demonstration sites on farmers' adoption of technologies. In Journal of Food, Agricultural & Environment 5:1, 307-309

Altieri, M. & Nicholls, C. 2005. Agroecology and the search for a truly sustainable agriculture: 1st edition. United Nations Environment Programme: Mexico

Audouin, E., Bergez, J. & Therond, O. 2019. Participatory Methodology for Designing an Agroecological Transition at Local Level. In Bergez, J., Audouin, E., & Therond, O. (eds) Agroecological Transitions: from theory to practice in local participatory design. Springer International Publishing: New York, USA

Bacon, C., Méndez, V., Brown, M. 2005. Participatory Action-Research and Support for Community Development and Conservation: Examples from Shade Coffee Landscapes of El Salvador and Nicaragua. Center for Agroecology and Sustainable Food Systems (CASFS), University of California: Santa Cruz, California, USA

Bentley, J. 1994. Facts, fantasies, and failures of farmer participatory research. Agriculture and Human Values 11, 140–150.

Biovision Foundation for Ecological Development & IPES-Food. 2020. Money Flows: What is holding back investment in agroecological research for Africa? Biovision Foundation for Ecological Development & International Panel of Experts on Sustainable Food Systems

Blanchard, M., Vayssières, J., Dugué P. and Vall, E. 2013. Local technical knowledge and efficiency of organic fertilizer production in South Mali: Diversity of practices. Agroecology and Sustainable Food Systems 37:6, 672-699

Chappel, M., Bernhart, A., Bachmann, L., Gonçalves, A., Seck, S., Nandul, P., & Cristo dos Santos, A. 2018. Agroecology as a pathway towards sustainable food systems. Aachen: MISEREOR IHR Hilfswerk

Compagnone, C., Lamine, C., & Dupré, L. 2018. The production and circulation of agricultural knowledge as interrogated by agroecology. In Revue d'anthropologie des connaissances 12:2, 111-183

Cooreman, H., Vandenabeele, J., Debruyne, L., Ingram, J., Chiswell, H., Koutsouris, A., Pappa, E., & Marchand, F. 2018. A conceptual framework to investigate the role of peer learning processes at on-farm demonstrations in the light of sustainable agriculture. In International Journal of Agricultural Extension 91-103

Debray, V., Wezel, A., Lambert-Derkimba, A., Roesch, K., Lieblein, G., & Francis, C. 2018. Agroecological practices for climate change adaptation in semiarid and subhumid Africa. In Agroecology and Sustainable Food Systems 43:4, 429-456

Dumont, A., Gasselin, P., & Baret, P. 2020. Transitions in agriculture: Three frameworks highlighting coexistence between a new agroecological configuration and an old, organic and conventional configuration of vegetable production in Wallonia (Belgium). In Geoforum 108, 98–109

Duru, M., Therond, O., & Fares, M. 2015. Designing agroecological transitions: a review. In Agronomy for Sustainable Development 35, 1237-1257

Kiptot, E. & Franzel, S. 2015. Farmer-to-farmer extension: opportunities for enhancing performance of volunteer farmer trainers in Kenya. In Development in Practice 25:4, 503-517

FAO. 2018. The 10 Elements of Agroecology: guiding the transition to sustainable food and agricultural systems. Rome: FAO

FAO. 2019. TAPE Tool for Agroecology Performance Evaluation 2019 – Process of development and guidelines for application. Test version. Rome

Félix, G.F., Scholberg, J.M.S., Clermont-Dauphin, C., Cournac, L., & Tittonell, P. 2018. Enhancing agroecosystem productivity with woody perennials in semi-arid West Africa. A meta-analysis. In Agronomy for Sustainable Development 38:6

Ferguson, B., Maya, M., Giraldo, O., Mier y Terán, M., Cacho, G., Morales, H., & Rosset, P. 2019. Special issue editorial: What do we mean by agroecological scaling? In Agroecology and Sustainable Food Systems 43:7-8, 722-723

Francis, C., Lieblein, G., Gliessman, S. Breland, T., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Wiedenhoeft, M., Simmons, S., Allen, P., Altieri, M., Flora, C., & Poincelot, R. 2003 Agroecology: The Ecology of Food Systems. In Journal of Sustainable Agriculture 22:3, 99-118

Gaitán-Cremaschi, D., Klerkx, L., Duncan, J., Trienekens, J., Huenchuleo, C., Dogliotti, S., Contesse, M., Benitez-Altuna, F., & Rossing, W. 2020. Sustainability transition pathways through ecological intensification: an assessment of vegetable food systems in Chile. In International Journal of Agricultural Sustainability 18:2, 131-150

Gliessman, S. 2016. Transforming food systems with agroecology. In Agroecology and Sustainable Food Systems 40:3, 187-189

HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome

Ingram, J., Chiswell, H., Mills, J., Debruyne, L., Cooreman, H., Koutsouris, A., Pappa, E., & Marchand, F. 2018. Enabling learning in demonstration farms: a literature review. In International Journal of Agricultural Extension, 29-42

IPES-Food. 2018. Breaking away from industrial food and farming systems: Seven case studies of agroecological transition.

Khadse, A. & Rosset, P. 2017. Scaling up agroecological approaches. Chapter 17 in Poyyamoli, G. (eds.) Agroecology, Ecosystems, and Sustainability in the Tropics. Delhi: Studera Press

La Via Campesina. [Sine Anno]. La Via Campesina Agroecology Training Schools and Processes. Accessed on 9/6/20. Retrieved 9th July 2020 from: https://viacampesina.org/en/schools/

Lacombe, C., Couix, N., Hazard, L. 2018. Designing agroecological farming systems with farmers: a review. In Agricultural Systems 165, 208-220

Leeuwis, C & Ban, A.w 2004. Communication for Rural Innovation: Rethinking Agricultural Extension. 3rd Edition. Oxford: Blackwell Science. Oxford : Blackwell Publishing Ltd

Lovell, S., DeSantis, S., Nathan, C., Olson, M., Méndez, E., Kominami, H., Erickson, D., Morris, K. & Morris, W. 2010. Integrating agroecology and landscape multifunctionality in Vermont: An evolving framework to evaluate the design of agroecosystems. In Agricultural Systems, 103:5, 327–341

Malézieux, E., Rapidel, B., Goebel, F. & Tixier, P. 2019. From natural regulation processes to technical innovation, what agroecological solutions for the countries of the global south? In Côte, F., Poirier-Magona, E., Perret, S., Roudier, P., Rapidel, B., Thirion, M (eds) The Agroecological Transition of Agricultural Systems in the Global South, eds. 179-197. Versailles, France: Ed Quae.

Mbure, G. & Sullivan, C. 2017. Improving the Management of Agriculture Demonstration Sites in Food Security Programs: A Practitioner's Guide. World Vision: Washington. Accessed on 13/11/19. Available from: https://www.wvi.org/food-assistance/publication/improving-management-agriculture-demonstration-sites-food-security

Méndez, V., Bacon, C., Cohen, R., & Gliessman, S. 2016. Agroecology: a transdisciplinary, participatory and action-oriented approach. CRC Press/Taylor & Francis

Méndez, V., Caswel, M., Gliessman, S., & Cohen, R. 2017. Integrating Agroecology and Participatory Action Research (PAR): Lessons from Central America. In Sustainability 9:5, 705

Meynard, J., Dedieu, B., & Bos, A. 2012. Re-design and co-design of farming systems: an overview of methods and practices. Chapter 18 In Darnhofer, I. Gibbon, D., & Dedieu, B. (eds.) Farming Systems Research into the 21st Century: The New Dynamic. Dordrecht: Spring Science

Mier y Terán, M., Cacho, T., Giraldo, O., Aldasoro, M., Morales, H., Ferguson, B., Rosset, P., Khadse, A., & Campos, C. 2018. Bringing agroecology to scale: key drivers and emblematic cases. In Agroecology and Sustainable Food Systems 42:6, 637-665

Milgroom, J., Bruil, J., & Leeuwis, C. 2016. Editorial: co-creation in the practice, science and movement of agroecology. In Farming Matters 3, 6-8

Murage, A., Obare, G., Chianu, J., Amudavi, D., Midega, C., Pickette, J., Khan, Z. 2012. The Effectiveness of Dissemination Pathways on Adoption of "Push-Pull" Technology in Western Kenya. In Quarterly Journal of International Agriculture 51:1, 51-71

Padel, S., Levidow, L., & Pearce, B. (2019). UK farmers' transition pathways towards agroecological farm redesign: evaluating explanatory models. In Agroecology and Sustainable Food Systems 44:2, 139-163

Pappa, E., Koutsouris, A., Ingram, J., Debruyne, L., Cooreman, H., & Marchand, F. 2018. Structural aspects of on-farm demonstrations: key considerations in the planning and design process. In International Journal of Agricultural Extension 6:3, 79-90

Pretty, J. 1995. Participatory Learning for Sustainable Agriculture. In World Development 23, 1247-1263

Pretty, J. 2006. Agroecological Approaches to Agricultural Development. World Bank, Washington, DC.

Rosset, P. & Altieri, M. 1997. Agroecology versus input substitution: A fundamental contradiction of sustainable agriculture. In Society & Natural Resources: An International Journal 10:3, 283-295

Rosset, P. & Altieri, M. 2017. Agroecology: Science and politics. Manitoba, Canada: Fernwood Publishing.

Rosset, P., Val, V. Barbosa, L., & McCune, N. 2019. Agroecology and La Via Campesina II: Peasant Agroecology Schools and the Formation of a Sociohistorical and Political Subject. In Agroecology and Sustainable Food Systems 43, 895-914

Ruiz-Almeida, A. & Rivera-Ferre, M. 2019. Internationally-Based Indicators to Measure Agri-Food Systems Sustainability Using Food Sovereignty as a Conceptual Framework. In Food Security 11, 1321-1337

Sinclair, F., Wezel, A., Mbow, C., Chomba, S., Robiglio, V., & Harrison, R. 2019. The Contribution of Agroecological Approaches to Realizing Climate-Resilient Agriculture. Global Commission on Adaptation: Rotterdam and Washington, DC.

Smallshire, D., Robertson, P., & Thompson, P. 2004. Policy into practice: the development and delivery of agri-environment schemes and supporting advice in England. In International Journal of Avian Science 146:2, 250-258

Sourisseau, J., Bélières, J., Marzin, J., Salgado, P., & Maraux, F. 2019. The Drivers of Agroecology in Sub-Saharan Africa: An Illustration from the Malagasy Highlands. In Côte, F., Poirier-Magona, E., Perret, S., Roudier, P., Rapidel, B., Thirion, M (eds.) The Agroecological Transition of Agricultural Systems in the Global South, 179-197. Versailles, France: Ed Quae.

Takahashi, K., Muraoka, R., Otsuka, K. 2020. Technology adoption, impact, and extension in developing countries' agriculture: a review of recent literature. In Agricultural Economics 51: 31-45

Tittonell, P., Scopel, E., Andrieu, N., Posthumus, H., Mapfumo, P., Corbeels, M., & Mtambanengwe, F. 2012. Agroecology-based aggradation-conservation agriculture (ABACO): Targeting innovations to combat soil degradation and food insecurity in semi-arid Africa. In Field Crops Research, 132, 168-174

Tittonel, P. 2014. Ecological intensification of agriculture — sustainable by nature. In Current Opinion in Environmental Sustainability 8, 53-61

Tittonel, P. 2020. Assessing resilience and adaptability in agroecological transitions. In Agricultural Systems 184

Trabelsi, M., Mandart, E., Le Grusse, P., & Bord, J. 2016. How to measure the agroecological performance of farming in order to assist with the transition process. In Environmental science and pollution research international 23:1, 139–156

Van der Ploeg, J., Barjolle, D., Bruil, J., Brunori, G., Madureira, L., Dessein, J., Drag, Z., Fink-Kessler, A., Gasselin, P., Gonzalez de Molina, M., Gorlach, K., Jürgens, K., Kinsella, J., Kirwan, J., Knickel, K., Lucas, V., Marsden, T., Maye, D., Migliorini, P., Milone, P., Noe, E., Nowak, P., Parrot, N., Peeters, A., Rossi, A., Schermer, M., Ventura, F., Visser, M., & Wezel, A. 2019. The economic potential of agroecology: Empirical evidence from Europe. In Journal of Rural Studies 71, 46-61

Warner, K. 2008. Agroecology as participatory science: Emerging Alternatives to Technology Transfer Extension Practice. In Science, Technology and Human Values 33:6, 754-777

Wezel, A., Bellon, S., Doré, T. Francis, C., Vallod, D., & David, C. 2009. Agroecology as a Science, a Movement and a Practice. In Sustainable Agriculture 2, 503-515

Wezel, A., Casagrande, M., Celette, F., Vian, J., Ferrer, A. & Peigné, J. 2014 Agroecological practices for sustainable agriculture. A review. In Agronomy for Sustainable Development 34, 1–20

White, S. 1996. Depoliticising Development: The Uses and Abuses of Participation. In Development in Practice 6:1, 142-155.

Wijeratna, A. 2018. Agroecology: scaling-up, scaling-out. Johannesburg: Actionaid

Appendices

A. Participatory Demo Farm Workshop Program

Activity 1: Welcome & Warm-up

Two facilitators welcomed participants and provided a brief introduction to Sistema.bio and the demo farm project. The workshop program was provided, first in English then in Kiswahili. Participants were then asked to stand up and walk around the room 'as if they were at the market'. They were asked to meet and greet other participants by asking each other their names, where they were from, and what they were most proud of on their farm.

Activity 2: Circle discussions (Purpose, crops, livestock, and challenges)

Participants were asked the following questions to discuss in groups before sharing in plenary:

1. What is the main purpose of your farm / why do you farm?
2. What crops and livestock do you have on your farm?
3. What challenges do you face on your farm?

For each question the participants were given around ten minutes to answer and ten minutes for plenary, at which point the group's ideas were noted on a flipchart.

Activity 3: The challenge market

Participants voted for four challenges that they wished to discuss in more detail. They then moved to the challenge 'market stall' that they felt most drawn to. Here the farmers discussed the challenges in more detail before suggesting solutions to tackle the problems.

Activity 4: Guided Farm Tour

An interactive tour of demo farm site was provided. Questions and answers were provided in English, Kiswahili and Kimeru.

Activity 5: Mind Mapping (what could be included in the design of this demo farm?)

Participants worked in small groups to create a mind-map of ideas for what they felt should be included at the demo farm. Prompts were given to include ideas of crops, livestock, tools and technology, infrastructure, types of training to be provided, challenges to be addressed, agricultural practices to be demonstrated, ways in which the farm should interact with farmers, and any other ideas they had. A one hour lunch break was taken after this activity.

Activity 6: Demo Farm Design (how would you design this demo farm?)

Participants worked in small teams to translate their ideas from the mind-maps into actual farm designs on A1 printed maps. It was recommended that they consider soil, water, plants (crops, trees and other plants), livestock, pests and disease, technology, infrastructure, and any other farming components. After completing the activity, the farm maps were hung alongside the mind-maps.

Activity 7: Closing Reflections

Participants and facilitators sat once more in a circle and were invited to share what they had learnt from the day and how they felt about the workshop process.

B. ACT Framework

Level 1: Increase efficiency of industrial and conventional practices		
1.1. Efficiency	1.1.1.	**Reduced water consumption:** reduction of water use while maintaining/increasing yield through improved practices
	1.1.2.	**Reduced application of pesticides and veterinary drugs:** reduced application of herbicides, fungicides, insecticides, fumigants, or use of veterinary drugs. This subcategory includes general integrated pest management (IPM) programs or references to general pest/livestock disease research in case no other specific practices are mentioned (including research aiming to reduce pesticide use or plant incorporated protectants)
	1.1.3.	**Reduced synthetic fertilizer application and use of animal fed:** reduced application of synthetic fertilizer or nitrogen leakage, more efficient use of animal feed
	1.1.4.	**Reduced energy use:** reducing fuel consumption in farming by improved technology, equipment or through renewable, low-carbon energy sources that can be used on farm (Biofuels are rated separately)
	1.1.5.	**Reduced seed use:** improved or efficient storage and use of planting materials, that result in better crop growth and reduced early mortality
	1.1.6.	**Reduced waste:** reduction of losses at harvesting, processing, storage or post-harvest through improved technologies and equipment
	1.1.7.	**Improved plant variety and animal breed: i**mproved variety or breed that reduces the use of external inputs of at least two of the following categories: water, pesticide, fertilizer, seed and/or drug
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives		
2.1. Recycling	2.1.1.	**Alternative soil inputs:** substituting synthetic fertilizers through alternate amendments
	2.1.2.	**Green manure:** cover crops or other plants that are left in the field to decompose, reducing dependence on synthetic fertilizers and increasing nitrogen fixation, or improving nutrient availability
	2.1.3.	**Recycling of wastewater:** recycling of wastewater for agricultural use, agricultural water reuse
	2.1.4.	**Use of biomass residues for energy generation:** energy derived from biomass residues: primary waste from harvesting residues, secondary waste from processing industries (e.g. using agro-forestry products), or from post-consumer residues and waste. This category includes energy generation from organic waste and residues only
	2.1.5.	**Climate mitigation through alternative practices:** adoption of practices that mitigate climate emissions by sequestering soil carbon or reducing greenhouse gas emissions. This category includes only "Gliessman level 2" type of practices where the agroecosystem is not altered from its more simplified form
	2.1.6.	Other practices that enhance recycling of biomass and organic matter: other recycling of biomass residues and waste
2.2. Regulation / Balance	2.2.1.	**Biological pest management:** pest management through biological control methods that import, enhance, or conserve pest enemies/antagonists (including predators, parasitoids, pathogens, and competitor)
	2.2.2.	**Cover crops for pest management:** planting cover crops specifically for weed control or pest reduction. This category includes cover crops grown primarily for pest management
	2.2.3.	**Other pest management:** non-chemical pest management practices that treat pest problems rather than preventing their occurrence, or biochemical pesticides that control pests by non-toxic mechanisms (naturally occurring substance). This category excludes biological pest management and crop cover
	2.2.4.	**Cover crops for improved soil conditions:** planting cover crops specifically to reduce erosion, run-off, increase soil organic matter, improve soil drainage, soil structure, alleviate soil compaction, improve overall soil condition
	2.2.5.	**Perennial crops:** adoption of perennial plant species in place of annual crops
	2.2.6.	**Reduced tillage:** adoption of conservation tillage or no-till practices. This category includes general or other reduced tillage practices that are not considered in previous categories already
	2.2.7.	**Adoption of organic and low-input farming:** general organic or low-input systems if not considered in other categories already
	2.2.8.	**Domesticated pollinators:** improved pollination through the temporary introduction of domesticated pollinators or introduction of exotic domesticated species
	2.2.9.	**Improved animal welfare and health:** improved livestock health, and further efforts to support livestock wellbeing
	2.2.10.	**Other "Gliessman Level 2" systems:** systems that integrate less toxic/harmful inputs through practices to reduce negative impacts which are not yet captured by any other subcategory

Level 3: Redesign whole agroecosystems		
3.1. Synergies	3.1.1.	**Non-crop plants:** incorporating non-crop plants in agroecological systems for ecological functions such as conservation, water quality, or pest management. This category does not include integration of trees
	3.1.2.	**Agroforestry:** diversified farming system integrating crop production and trees
	3.1.3.	**Rotational/regenerative grazing:** improved grazing methods/management to improve soil quality and forage yield
	3.1.4.	**Integrated crop-livestock systems:** diversified farming system including both crops and livestock
	3.1.5.	**Other selective combinations/integrations at the farm level to optimize (ecological) synergies:** between and among plants, livestock, aquatic animals, trees, soils, water and other components on farms that optimize ecological functions and ecosystem service delivery
	3.1.6.	**Integrated pest management by habitat manipulation:** landscape planning (focused on habitat) or habitat management as systemic precondition for biological pest control
	3.1.7.	**Other landscape planning and synchronized landscape activity leading to improved agricultural ecosystem services**: consideration and coordination of activities incl. land-use, land cover or other components) at the landscape level that optimize ecosystem services that benefits agricultural production. Habitat conservation around agricultural lands, landscape-scale management interventions
	3.1.8.	**Climate mitigation through redesigned system** (increasing C stock, reducing GHG emission): identifying or adopting practices that can mitigate climate change by sequestering soil carbon or reducing greenhouse gas emissions. This category includes only "level 3" type of system where the agroecosystem is fundamentally redesigned
3.2. Diversity	3.2.1.	**Improving local seed/breed diversity:** supporting the development and promotion of local, regional, organic seeds/breeds, including classical breeding
	3.2.2.	**Integrating locally adapted crops/races:** incorporating native or locally/regionally adapted crops and animals
	3.2.3.	**Two-Crop rotation:** supporting a simple crop rotation with just two crops or where the number of crops included is unclear, but excluding cases where the second crop is specified to be a cover crop
	3.2.4.	**Three+ Crop rotation:** supporting a more complex crop rotation system with at least three crops
	3.2.5.	**Spatially diversified farms:** introducing diversity over space by multi-, poly-, or inter-cropping
	3.2.6.	**Biodiversity:** specific attention to protect, or enhance functional agro-biodiversity
	3.2.7.	**Natural pollinators:** specific attention to protect, or enhance local and natural pollinators (and their habitats)
	3.2.8.	**Multi-habitat approach:** increase land-use diversity or diversity at the landscape scale
	3.2.9.	**Diversification of diets and consumption:** promotion of diversified locally produced healthy diet through a diversified food production system (at the landscape/territorial level), macro-and micronutrients, other bioactive components
3.3. Resilience	3.3.1.	**Systemic resilience of agroecosystems to extreme weather events and other disturbances**: promotion of the resilience of agroecosystems to specific disturbances (windfall, storm, heavy rain, winter freeze, floods, draught, wildfire), including developing framework to assess resilience of food systems and measuring the impact of management on the recovery of one or more ecosystem services in response to that disturbance
	3.3.2.	**Systemic resilience and adaptive capacity to changing environmental conditions due to climate change:** research promoting resilience of agroecosystems to future conditions (salinity, average temperatures, new emerging pests and diseases), development of adapted system to future conditions
	3.3.3.	**Livelihood resilience:** diversified income, production and access to market to be resilient against stress and shocks (economic, weather, ...). The project should measure the impact of livelihood strategies (based on the agricultural sector) on the capacity of farmers to respond to a disturbance and recover from it

Level 4: Re-establish connections between growers and eaters; develop alternative food networks		
4.1.Circular and Solidarity Economy	4.1.1.	**Business support for re-establishing the connection between producers and consumers:** assisting in the development of local food systems, short value chains and webs, developing trading relationships with local growers
	4.1.2.	**Supporting regional value generation:** embedding food systems into local economies, connecting local producers with other value-adding activities at the local or regional level, including post-harvesting, processing, packaging
	4.1.3	Encourage and sensitize for seasonal and regional demand: action supporting a stronger seasonal and regional demand
4.2.Culture and Food Traditions	4.2.1.	**Support healthy, diversified and culturally appropriate food tradition and diet:** build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets, support and protect cultural identity and values tied to food systems
	4.2.2	**Support the right to adequate and culturally appropriate food:** support the ability of people to make decisions over the quality and type of food they hunt, fish, gather, grow and eat
4.3.Co-Creation and Sharing of Knowledge	4.3.1.	**Connecting farmers to share knowledge:** engage farmers in co-creation and sharing of knowledge, integrate producer's knowledge and management experience to research (through specific participatory research design), support for farmer-researcher networks
	4.3.2.	**Promote participatory and multi-stakeholder approaches in knowledge generation:** integrate farmers and other actors' views in all stage of decision-making, increase participation and exchange between different types of actors
	4.3.3.	**Promote formal and non-formal "production and food" education:** support for farmer-education networks, formal and non-formal education
Level 5: Rebuild the global food system so that it is sustainable and equitable for all		
5.1.Human and Social Value	5.1.1.	**Gender and vulnerable group approach:** developing and informing policies and approaches that empowerment of women or other vulnerable groups (including youth)
	5.1.2.	**Strengthen organisational capacities**: increasing organisational capacities of farmer's communities and other local food system actors
	5.1.3.	**Equity, Dignity, Inclusion**: support fair, dignified and inclusive livelihoods for all actors engaged in food systems, especially small-scale food producers
	5.1.4.	**Support right to food (sufficient, access, adequate):** developing and informing policies and approaches that ensure the right for people to feed themselves in dignity, implying that sufficient food is available, that people have the means to access it, and that it adequately meets the individual's dietary needs
	5.1.5.	**Promote food sovereignty:** developing and informing policies and approaches that allow communities to decide the way food is produced, traded and consumed
	5.1.6.	**Creating decent jobs for rural youth** based on agriculture: developing policies and incentives for decent jobs creation for rural youth
5.2. Responsible Governance	5.2.1.	**Policy development on producer-consumer links:** developing or informing policies to help re-establish the connection between producers and consumers, market regulations allowing for branding of differentiated agroecological products
	5.2.2.	**Inclusive policy making** developing or encouraging inclusive policy making that aim for sustainable and equitable food system
	5.2.3.	**Establishment of equitable governance and rights over natural resources:** developing, informing or encouraging traditional and customary governance models, policies that ensure and protect equitable land tenure system and secured access to natural resources
	5.2.4.	**Policy development on the links between agroecology and global changes:** developing or informing policies on the integration of agroecology and other policy process tackling global changes, such as climate change
	5.2.5.	**Policy development that reward agricultural management that enhances biodiversity and the provision of ecosystem services:** developing, informing and encouraging national level legislation, policies and programmes that protect biodiversity and multifunctional agriculture, subsidies and incentives for ecosystem services

C. Demo Farm Case Studies

The following appendix contains individual case studies of the six demo farms visited for this research. Qualitative results regarding design characteristics of each farm (motivation, location, education, operations, and participation) are presented. This is followed by results of how each farm is supporting agroecological transitions at the five levels of food system transformation (Gliessman 2016).

Percentage values are given to indicate the degree of support each farm is providing for the eleven agroecological elements of the Agroecology Criteria Tool (ACT). This data is plotted on radar charts with plots closest to the outer ring (i.e. 100%) indicating a higher degree of support than those closest to the centre of the diagram (i.e. 0%).

1.0 KENYA INSTITUTE OF ORGANIC FARMING (KIOF)

1.1 Demo farm characteristics

Motivation: KIOF was established in 2000 as a training centre for organic agriculture. Its purpose is to convince farmers to adopt ecological farming practices, which it does through the objectives of training farmers and providing formal youth education. Demos are viewed as a teaching aid that provides evidence of the benefits of organic farming.

Location: The demo farm is located in Thika on 10 acres of semi-arid land. The centre is divided into separate areas for student residence, classrooms, crop growing areas, forestry, and livestock shelters. Part of the land used for hay production doubles up as a football field after harvesting. Given the educational facilities, the site is not typical of local farms, however it contains crops, animals, and systems typical of the area. It is close to a major highway, and while there are not many farmers in the immediate vicinity the county in which the farm is situated is a popular farming area. KIOF also engages farmers through community-designed on-farm demos, which are established in one week while demonstrating various practices.

Education: KIOF use multiple training methods combining theory and practice including demonstrations, single day training, week-long community practical training, residential courses, and lectures. Additionally, they publish educational material and work closely with agricultural programs at some of Kenya's Universities. Farmer exchanges are encouraged between new and old participants involved in on-farm demos. Farmers are given practical homework assignments to encourage adoption and are trained to create action plans based on current and future farm maps. Training staff are viewed as facilitators and guides. Training courses follow a general structure, however farmers are viewed as active participants with staff encouraging knowledge sharing and tailoring activities to meet farmers' needs. In the case of exchange visits farmers are also viewed as trainers. The topics and agricultural practices covered by KIOF are listed in the section describing the centre's support for agroecological transitions.

Operations: KIOF employs a number staff involved in training , marketing and outreach activities. Farmers are engaged through church groups, markets or farmer organisations. Originally the centre's activities were supported by donor funding, allowing KIOF to charge low prices for courses (e.g. KES 200 per person per week). Income is also generated from the courses they provide to university students. However, recently funding has become less available and student retention has also declined. The price of courses for farmers has increased to KES 2000 per person, and a minimum of 20 farmers is required. KIOF recognizes these costs may be prohibitive for many farmers, but currently they have no other options. Staff argue more government funding is needed to support organic farming and that agriculture should be better promoted in high schools and universities.

Participation: KIOF's demo farm was designed by an internal team without participation from local farmers. However, community on-farm demos are co-designed with farmers. Farmer knowledge is acknowledged as an important starting point for training, and staff facilitate knowledge sharing during courses. Farmer exchanges are used to highlight the role of farmers as experts. Feedback is gathered from farmers to help KIOF improve it courses.

1.2 Support for Agroecological Transitions

KIOF's activities support all but one of the eleven agroecological elements defined by ACT, namely *Circular and Solidarity Economy* (Figure 9). The way in which each of these elements is supported is described below.

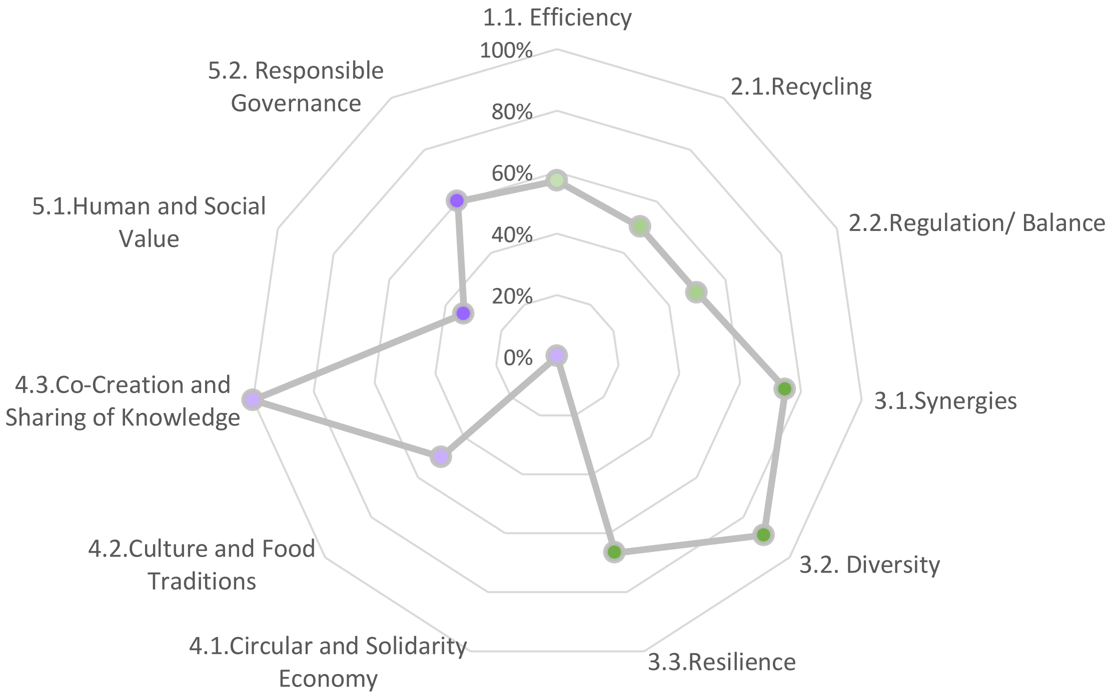

Figure 6 The degree to which KIOF supports the eleven agroecological elements of ACT

Element 1.1 Efficiency – 57%

Training is provided to reduce water consumption through rainwater storage, water retention measures (e.g. soil cover), and drip irrigation. The use of synthetic pesticides and fertilizer is strictly avoided. Training is provided on reducing animal feed inputs, by encouraging farmers to use locally available and homemade resources instead. Herbal medicine is advocated as a means for treating sick animals. Practices to minimize post-harvest losses are encouraged (e.g. hay bailing and solar drying). Seed and energy use efficiency are not promoted, nor is the use of resource efficient crops or livestock.

Element 2.1 Recycling – 50%

Nutrient recycling is encouraged through the use of compost and manure. Green manures are not encouraged due to the limited land generally cultivated by participating farmers. Biomass recycling practices are encouraged for climate mitigation (fertility trenches), soil building (chop and drop weed mulching), and construction (use of on-site woodland timber). Training is not provided on wastewater recycling or energy generation from biomass residues.

Element 2.2 Regulation/Balance – 50%

KIOF advocate an organic and low-input approach to farming. Training is offered in a range of integrated pest management (IPM) methods. The desynchronization of crop and pest lifecycles is encouraged through early planting. Beer traps are used for ground dwelling pests and light traps for nocturnal airborne pests. Scarecrows sprayed with deodorant are used amongst field crops to deter larger pests. Farmers are encouraged to make organic pesticide sprays from *Tagetes minuta*, *Nicotiana tabacum*, *Allium species*, *Azadirachta indica*, *Capcisum annum* and *Aloe vera*. Wood-ash is used in seed storage to prevent losses from insect damage. Natural enemies and cover crops are not part of the IPM training. Animal health is maintained through the use of herbal medicine and nutritious feed. KIOF trains farmers to conduct minimal tillage after establishing double-dug beds. Raised beds are used for vegetable production with permanent paths to minimize compaction. Farmers are encouraged to plant flowering trees and crops to support wild pollinators. Bee keeping courses also focus on the role of honeybees as pollinators. Perennial crops are not promoted in place of annual varieties.

Element 3.1 Synergies – 75%

The use of non-crop plants is encouraged for nutrient cycling (*Tithonia Diversifolia*) and pest management (*Tagetes minuta*). A diversified approach to agroforestry is promoted. Alley cropping of trees is encouraged for provision of nutrients, flowers and food. Example of these trees include *Sesbania Sesban*, *Carica Papaya*, *Persea Americana*, *Croton Megalocarpus*, *Grevillea Robusta*, *Moringa Oleifera*, *Markhamia Lutea*, and *Luceana spp*. KIOF encourage woodland areas on farms to provide a sustainable supply of firewood and timber, as well as to foster biodiversity. Hedgerows are demonstrated at the centre.

KIOF provides training on zero-grazing livestock systems and cut and carry fodder techniques. Crop residues are used as livestock feed, with the ensuing manure being returned to the fields. KIOF train farmers on a form of rotational grazing where goats are tethered to different areas for grazing each day.

The demo farm is segmented into separate areas providing various functions. The woodland houses 14 honeybee hives which serve as pollinators for the field crops. Nearby, two water-harvesting ponds have been dug for irrigation but also provide refuge for beneficial insects. A number of microclimates exist in the fields through soil and water conservation measures such as zai pits, contours, and fertility trenches.

Element 3.2 Diversity – 89%

KIOF train farmers to operate a four-crop rotation in horticultural systems. Farmers are encouraged to plant *Brassicaceae* crops followed by *Fabaceae*, then either *Cucurbitaceae* or *Solanaceae,* and finally root crops (*Amaryllidaceae* and/or *Umbelliferae)*. *Zea mays* is rotated separately with *Fabaceae* crops. Flowering crops are encouraged in the rotation for example legumes, *Tagetes Minuta* and *Helianthus annus*. Examples of intercropping are demonstrated including *Zea mays* and *Fabaceae* spp., *Allium cepa* and *Brassicaceae* crops, and *Passiflora edulis* and *Vigna unguiculata*. Crop diversification is encouraged for household dietary diversity. Inclusion of indigenous African vegetables and livestock breeds is promoted to protect agrobiodiversity. The demo farm showcases goats, chickens and rabbits, and at the time of research there were plans for reintroducing cows and pigs. Landscape heterogeneity is demonstrated for various agroecosystem functions. Seed breeding is not covered by KIOF.

Element 3.3 Resilience – 67%

KIOF aims to increase farm resilience to drought through dry-land farming techniques and the promotion of drought-tolerant varieties of fruit trees. Livelihood resilience is supported through crop and livestock diversification as well as by training farmers in value addition techniques (ripening, drying, storage, grading and packaging). However, resilience and to future environmental conditions caused by climate change are not a focus of KIOF's training.

Element 4.1 Circular and solidarity economy – 0%

KIOF does not offer training or run projects related to market level change.

Element 4.2 Culture and food traditions – 50%

Farmers are supported to grow the food they want, and culturally important crops and livestock are encouraged. KIOF does not work on these elements at the market or policy level.

Element 4.3 Co-creation and sharing of knowledge – 100%
Farmer participation and knowledge co-creation are seen as important aspects of KIOF's training. Farmers are trained in groups based on their needs and goals and inclusion of farmer knowledge is encouraged. Farmer to farmer exchanges encourage connection and knowledge sharing between different communities. Formal training is provided to university students.

Element 5.1 Human and social value – 33%
KIOF trains farmers to self-organise as committees and registered self-help groups in order to strengthen their organizational capacities. KIOF also provides training to people living with HIV/AIDS to empower these groups to produce nutritious food for themselves. Youth training is provided through the formal university linkages. No specific training is given to women's groups. KIOF does not engage with advocacy or policy development related to social issues.

Element 5.2 Responsible Governance – 60%
KIOF are involved in developing policy on organic agriculture in Kenya and are working to raise awareness of the linkage between this form of agriculture and the benefits it provides for climate change and biodiversity conservation. KIOF encourages farmers to form links with public institutions as buyers as local food, however this is not something that has been formalized as a policy demand. KIOF are not involved in developing other policies.

2.0 KENYA AGRICULTURE & LIVESTOCK RESEARCH ORGANIZATION (KALRO) PRACTICAL TRAINING CENTRE (PTC)

2.1 Demo farm Characteristics

Motivation: KALRO is a research institute that was set up by the Kenyan Government. The PTC exists to transfer knowledge and skills developed about tree and field crops by KALRO and their agribusiness partners directly to farmers.

Location: The PTC has been developed on land used by KALRO's Macadamia Research Centre in Thika. The centre spans 40 acres and is located close to a main highway with good road access. Demonstrations take place on many different plots of land, each with their own distinct focus (e.g. field crops, floriculture, tree nursery). The Kenyan Government and staff at the research centre led the conversion of the research centre into the PTC. Private partners such as the Fresh Produce Exporters Association of Kenya (FPEAK) were also involved with the initial design. On-farm demos are used for the purpose of technology validation. PTC staff also provide on-site training for individual farmers.

Education: The objects of KALRO's demonstrations are largely determined by KALRO's current research focus, as well as the products and services showcased at the centre by private partners (e.g. seed and input companies or produce associations). Training is 30% theoretical and 70% practical. Activities largely focus on incremental skills and knowledge acquisition. Staff always begin with what farmers already know and aim to understand the challenges they face before commencing training. KALRO offer one scheduled training event per quarter. However other group or individual training activities are offered based on farmer-demand. Training methods include field demonstrations, weeklong residential courses, road shows, farmer exchanges and farmer field schools (FFS). Training costs 5000 KES per farmer per day. The topics and agricultural practices covered are listed in the section describing the centre's support for agroecological transitions.

KALRO trainers act as facilitators, experts and researchers when engaging with farmers depending on the need of the activity. Industrial and small-scale farmers are viewed as active participants. KALRO also work with 'lead farmers' who host and present on-farm demonstrations as part of FFS. These farmers are provided materials and training over the course of a season to field test and showcase new agricultural products or practices. Lead-farmers are selected for FFS by local extension staff.

Operations: The PTC employs a large number of administrative and field staff who are involved with training and research activities. Staff reach out to farmers to notify them about scheduled events and services via KALRO's field offices around Kenya. Courses are advertised via social media, private partners and extension agents. Farmers also contact KALRO directly.

The cost of training is a major barrier to many farmers accessing the PTC's services. However, the cost has remained high due to continued declining government expenditure on extension services and reduced funding provided by NGOs and development organizations. The PTC reports that it is difficult to find funding for courses designed by KALRO, with NGOs preferring to fund specific activities demanded by farmers. Private companies are reported to be filling the funding gap; however, this is largely conditional upon KALRO endorsing and demonstrating specific products at the PTC. Staff at the PTC report that there is a great need for government financial support for agricultural extension.

Participation: KALRO PTC employs a form of nominal farmer participation to validate technologies in the field through the farmer field schools. However, this method is also used as a platform to allow farmers to co-create and exchange knowledge, hence suggesting that farmer participation has mixed purposes. The fact that courses are demand-driven is also viewed as a form of farmer participation, in the sense that farmers initiate training. However, it is unclear where such ownership is maintained throughout training activities.

2.2 Support for Agroecological Transitions

KALRO PTC's activities support all but one of the eleven agroecological elements defined by ACT, namely *Culture and Food Traditions* (Figure 10). The way in which each of these elements is supported is described below.

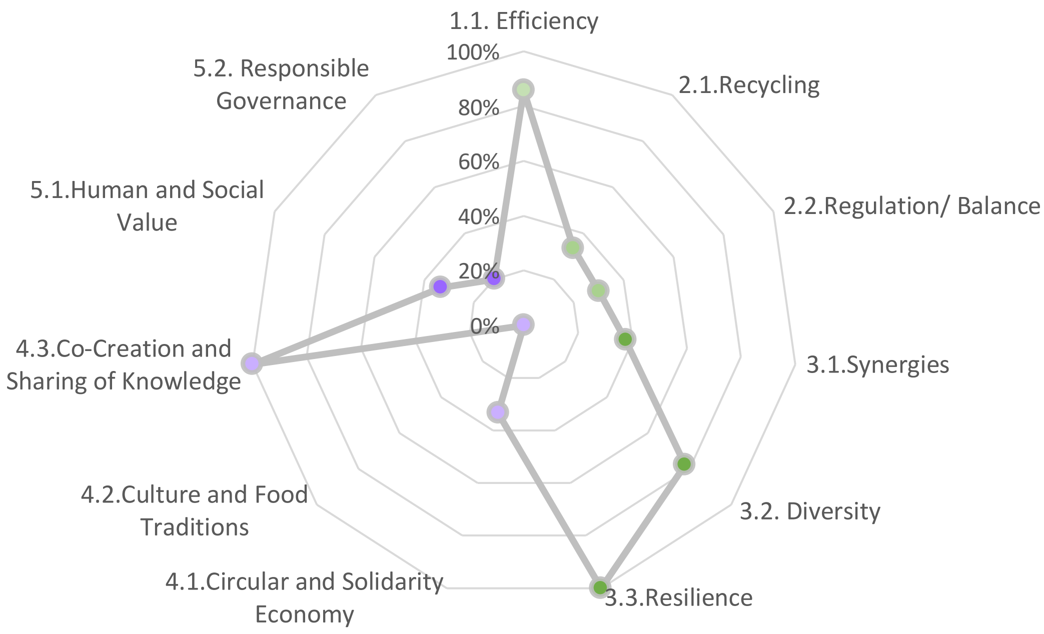

Figure 7 The degree to which KALRO PTC supports the eleven agroecological elements of ACT

Element 1.1 Efficiency – 86%

Water consumption reduction is promoted through training on effective irrigation timing, educating on the risks of overwatering, and drip irrigation.

Pesticide reduction is advocated via training on IPM. This training includes crop protection plans, pest exclusion through greenhouses, use of disease resistant varieties, scouting, economic damage thresholds, and mechanical removal. PTC staff train farmers to use chemical pesticides as a last resort, always starting with the weakest chemicals first. KALRO also develop disease resistant varieties of crops (e.g. *fusarium* resistant *Musa* spp.), which are demonstrated via the PTC to farmers.

Farmers are trained to be more efficient with chemical fertilizer use through soil testing, spot application, and education about choosing the right seeds and fertilizers. Training on seed and plant matter use efficiency focuses on material selection, seed harvesting, development of local seed banks, and grafting. Waste reduction is promoted through value adding activities such as solar drying, juicing and puree making. Advice on energy efficiency and use of veterinary drugs training is not provided.

Element 2.1 Recycling – 33%

Production and use of manure and compost are promoted to farmers to recycle soil nutrients. The use of green manures such as beans are promoted as best practices in orchard systems. Wastewater recycling, use of biomass for energy generation, or other practices that recycle organic matter are not promoted.

Element 2.2 Regulation/Balance – 30%

A biological pesticide made from *Tagetes Minuta* is use in the field crops and advocated to farmers as part of a wider IPM strategy. Cover crops are not promoted as a pest and weed management strategy, although the use of *Mucuna Pruriens* in fruit and nut orchards is promoted to prevent water loss. Training on disc tillage and zero tillage practices are offered to farmers for soil conservation. Replacing annual crops with perennial varieties is not part of the training offered. Strict organic farming is not promoted. Training on introducing domesticated pollinators and animal welfare are not offered given the center's focus on crop production. Staff at the PTC would like to work more with biological pest control (i.e. natural enemies) however they are unable to due to lack of funding for this activity.

Element 3.1 Synergies – 38%

Agroforestry training is provided in partnership with the World Agroforestry Centre in Nairobi. However, farmers in general are advised to maintain at least 10% green cover in the form of hedgerows and woodland on their farm for biodiversity conservation purposes. Specific conservation areas have been designated in field margins at the PTC for biodiversity conservation, but also as pest traps. The PTC does not provided training on the use of non-crop plants aside from trees. Nor does it provide training on crop-livestock integration, sustainable grazing, or other synergetic practices.

Element 3.2 Diversity – 78%

The PTC promotes the development and use of African indigenous vegetables such as *Solanum nigrum* and *Amaranthaceae* spp., as well as traditional staple crops such as *Vigna unguiculata*. They also promote the development of local seed banks. Staff at the PTC described the typical crop rotation they advocate as including *Zea mays*, followed by *Capsicum annuum* and then *Ipomoea batatas*. Fallow periods are also promoted to restore degraded soils and were being demonstrated at the time of visiting the centre. Intercropping is not demonstrated at the centre but is advocated in training programs. The importance of biodiversity protection is highlighted in training and is demonstrated through the PTC's designated conservation areas. These areas are also seen as beneficial for pollinators. Farmers are advised to diversify crop production to for dietary and economic diversification.

Element 3.3 Resilience – 100%

Farmers are trained to increase resilience toward dry weather events through water harvest and storage techniques (a collaboration with local company Real IPM). Resilience to other pest and disease resistant is supported through plant testing. Farmer livelihood resilience is also fostered through the training and is something that the PTC monitors through baselines and post-intervention assessments.

Element 4.1 Circular and solidarity economy – 33%

The PTC offers support for region-specific market linkages by helping farmers formalize links to sellers and legal contractors. The PTC does not work on linking producers with consumers, nor does it work to encourage seasonal or regional demand for produce.

Element 4.2 Culture and food traditions – 0%

This is not an area of focus for the PTC.

Element 4.3 Co-creation and sharing of knowledge – 100%

Formal and non-formal farmer education is provided as the primary activities of the centre. The PTC connects farmers to share knowledge through the farmer exchanges and farmer field schools. It also promotes participatory knowledge generation by documenting indigenous knowledge and scaling farmer practices through research. An example given of this type of knowledge was the burning of green matter in *Mangifera indica* orchards to prevent fruit fly.

Element 5.1 Human and social value – 33%

The PTC provides gender sensitization training to industrial farmers to raise awareness of gender issues in farm labour. They also provide training to rural youth to empower them to become providers of IPM services. The PTC does not engage with strengthening farmer organizations or policy development related to human and social value in farming.

Element 5.2 Responsible Governance – 20%

The KALRO PTC is a stakeholder in the Ministry of Agriculture's policy development linking agricultural management with biodiversity protection. However, the centre does not engage with other policy development.

3.0 GROW BIO-INTENSIVE AGRICULTURE CENTER (G-BIAC)

3.1 Demo farm Characteristics

Motivation: G-BIAC is a Kenyan NGO that runs a demo farm and residential youth training centre as well as organizing community based farmer training programs. The centre was established to eradicate extreme poverty amongst farmers by helping farmers understand the logic of organic farming. Bio-intensive farming is an approach to organic farming that seeks to maximise yields on small plots of land through a range of practices related to soil health and agrobiodiversity. G-BIAC advocate an 'African' version of this approach which supports the inclusion of animals in this approach, whereas the traditional method is vegan.

Location: G-BIAC is based in Juja, near Thika. The 1.75 acre plot is designed to showcase the design and possibilities of using biointensive farming on a small plot and hence is 'typical' of the farms the centre supports to develop. The farm was designed internally by the team in a participatory manner leading to consensus. The surrounding land is dry but thanks to a number of water harvesting techniques, the farm is lush with plants. It accessible by main road and is close to a busy commercial centre. Aside from the demo farm, the centre also has bedrooms for residential students, kitchen and dining facilities for resident and culinary training, a computer suite for computer skills training, a room for textiles training, a seed bank, and a library. In addition to the demo centre, G-BIAC helps farmers develop community based demo plots and has supported the development of satellite centres in other countries.

Education: G-BIAC use a Participatory Action Leaning model within their training programs. Staff at the centre highlighted the importance of 'learning by doing' and hence they combine theoretical and practical training. Training programs are followed up with refresher courses, typically at an individual's own farm. Agricultural training is normally conducted with community groups over a period of 2 to 7 days depending on the farmers' needs. These courses are done either at the centre or at on-farm demos. The centre also runs a residential girls empower programme in which young women learn skills in farming, sewing, computer literacy, baking and cooking. The topics and agricultural practices covered are listed in the section describing the centre's support for agroecological transitions.

The centre's staff take on a role of scientific knowledge providers and facilitators during training. The participating farmers are seen as indigenous knowledge providers engaged in a two way knowledge exchange process. Additionally, individual farmers are elected as 'Community Resource People' to act as lead farmers in communities. Staff note that farmers are not provided any inputs or material objects, just knowledge.

Operations: G-BIAC work with a number of on-site and field staff involved in training and administrative tasks. The centre actively identifies farming communities in need of support. One way of identifying such farmers is based the visual performance of *Zea mays* crops in the area: if the crop is only knee high during the rainy season, the community is approached to offer assistance. A socioeconomic assessment is conducted to establish a baseline regarding for example household food security status. To date over 20,000 farmers have been trained by the organization.

The NGO receives funding from partner organisations in the United Kingdom to provide training to the identified farmer groups for free. Neighboring farmer communities are also able to join demonstration and training events but must pay for access. Staff suggest that there needs to be greater consistency in the training provided by different extension providers in Kenya as farmers are often left confused as to what advice is correct. This is in part why G-BIAC run refresher courses to answer new questions farmers have regarding conflicting advice that's been provided to them. The centre would also like to see agroecology being supported by Kenya's education system and government policies.

Participation: G-BIAC's Participatory Action Learning model aims to create embodied knowledge for farmers to collectively overcome their challenges. Although most of the training follows a standardized curriculum farmers' own knowledge and contexts are valued. Community demo plots are designed with farmer participation. The Indigenous Seed Bank housed at the demo farm is also run in a participatory manner with farmers taking seed and repaying the bank with the following year's seed harvest.

3.2 Support for Agroecological Transitions

G-BIAC's activities support all eleven agroecological elements defined by ACT (Figure 11). The way in which each of these elements is supported is described below.

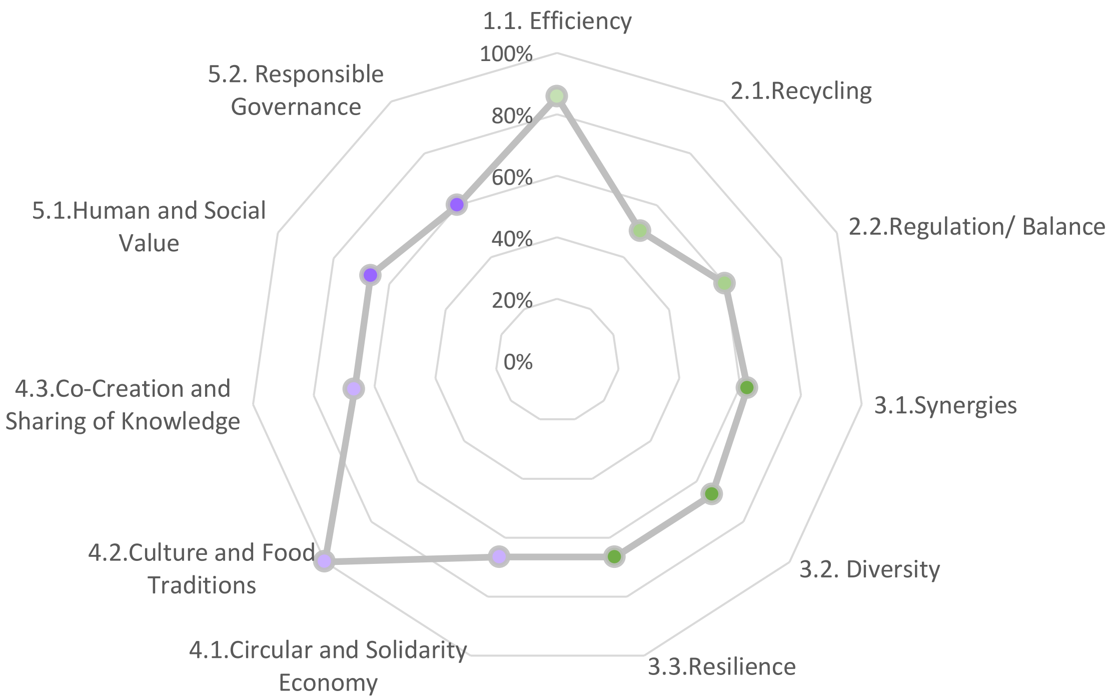

Figure 8 The degree to which G-BIAC supports the eleven agroecological elements of ACT

Element 1.1 Efficiency – 86%

Water use efficiency is part of the farm design training provide by G-BIAC, which focuses on the construction and maintenance of rainwater tanks, fishponds and irrigation channels.

Chemical pesticides and fertilizers are not used on the G-BIAC's demo farm or in training programs. However, farmers are supported to create fertilizer reduction strategies where an immediate shift to organic farming is not appropriate.

Seed use optimization is trained through the use of triangular or cross-spaced sowing. Additionally, the team provide training in seed storage and preservation, seed bank development, and root crop storage to minimize losses. Wastage is minimized through training on solar drying (including construction of passive solar driers), and recipes for organic powders to help with grain storage (e.g. cow dung ash or dried *Tephrosia Vogelii).*

The team have been trialing some improved varieties of *Ipomoea batatas* from KALRO, however, they believe the indigenous variety they use performs much better. Energy use efficiency is not something that is demonstrated or a focus of the training.

Element 2.1 Recycling – 50%

Farmers are trained in the use of a number of organic soil amendments, including compost, bone ash, manure, plant extract teas, and vermicompost. Some crop residues are used as animal feed. Green manures are not advocated. Wastewater recycling and the use of biomass for energy generation are not demonstrated or trained.

Element 2.2 Regulation/Balance – 60%

An organic and low input approach is advocated by G-BIAC. Cover crops are grown for weed suppression (*Mucuna pruriens)* and soil moisture conservation (*Lablab purpureus*) during the dry seasons. However, these crops are not treated as green manures, instead being harvested for food and compost production. On-farm production of a number of organic pesticides are demonstrated to farmers including *Tephrosia Vogelii* powder and extracts, wood ash & liquid soap mixtures, and powders or extracts of *Melia Azedarach*. *Sorghum bicolour* is treated as a perennial crop through the practice of ratoon cropping across four seasons. The use of introduce natural enemies is not practiced by G-BIAC. Domesticated pollinators are not currently a part of the system as the demo farm's previous apiary was lost in a fire. Animal welfare improvements are not a focus of the training provided by G-BIAC.

Element 3.1 Synergies – 63%

G-BIAC grow a number of non-crop plants on their farm for different ecological functions. *Tagetes patula* are grown to attract bees and dragon flies, water hyacinth is used to clean ponds also as biomass for composting, and other crops such as *Tithonia Diversifolia* and *Tephrosia Vogelii are* grown for making green fertilizers and pesticides. The inclusion of trees via agroforestry is also promoted by G-BIAC. At the demo farm a number of species are used for windbreaks and alley cropping. Species at the farm included: *Grevillea Robusta, Ficus elastica, Sesbania Sesban,* and *Mangifera indica.* Agroforestry is also promoted through the community demo plots.

Goats are tethered to posts during the day for grazing and are rotated each day to fresh spots. The manure from the goats, rabbits and chickens is used for compost production. Rabbit urine is also harvested using gutters beneath their enclosures. Some seed crops are used as animal feed. Two fishponds are demonstrated at the farm which house mudfish and tilapia. These ponds are multifunctional as they provide food, nutrients, biomass and irrigation to the land. No landscape scale manipulation is present on the demo farm for the purposes of reforestation, biodiversity protection or pest management.

Element 3.2 Diversity – 67%

G-BIAC advocate for agrobiodiversity in farms and diets, in particular with the use of indigenous seed varieties. The centre maintains drought resistant beans and other climate adapted crops through the Indigenous Seed Bank, amongst a wide range of other open-pollinated seeds that are collected, preserved and distributed to farmers. Farmers are trained to rotate their crops in groups of heavy feeders (e.g. *Zea mays* and other grains*)* to light feeders (e.g. *Ipomoea batatas)* and then to givers (*Fabaceae)*. Another form of temporal diversification is achieved through relay cropping, whereas spatial diversity is maintained through intercropping, companion planting, and highly diversified vegetable gardens. Specific attention is not given to wider biodiversity conservation through habitat protections, however flowers are planted for the purpose of attracting pollinators. Insect repelling plants, such as *Tagetes minuta*, are not demonstrated as the centre aims attract all forms of life to encourage a balanced ecosystem.

Element 3.3 Resilience – 67%
Farmer resilience to extreme dry weather patterns is enhanced through the promotion of drought tolerant fruit trees and other crops. Livelihood resilience is also promoted through diversified production and more specifically through the multiple skills offered to women through the girl's empowerment program. No specific work is done with regards to fostering resilience toward climate induced changes in pest and disease or adaptation to future situations.

Element 4.1 Circular and solidarity economy – 67%
G-BIAC partner with the Community Sustainable Agriculture and Healthy Environment Program (CSHEP) to connect farmers to Organic Markets in Nairobi. However, no specific work is done on sensitize consumers to seasonal or regional diets. They train farmers in value addition and preservation through training in the use of solar driers.

Element 4.2 Culture and food traditions – 100%
G-BIAC support healthy, diversified and culturally appropriate diets by providing training on nutrition, cooking and diversified farming. Moreover, they support the right to culturally appropriate food by a) protecting and distributing farmer developed seeds, and b) training farmers in a locally adapted form of Biointensive farming, originally a Western concept.

Element 4.3 Co-creation and sharing of knowledge – 67%
G-BIAC offer formal education on farming. They also connect farmers to co-create and share knowledge through inter- and intra-community swaps between new and old trainee farmers. Farmer trainers (known as 'Community Resource People') are also elected in communities and are trained at the demo farm before leading development in their communities.

Element 5.1 Human and social value – 67%
G-BIAC pay specific attention to gender in development through their Girl's Empowerment Program. Additionally, their staff make sure that wives and husbands are trained together to ensure both genders are equally empowered with knowledge and work together to implement change on their farms. Farmer organizational capacities are strengthened through group leadership training, the election of community resources persons as leaders, and assistance in forming farmer cooperatives. The right to food is supported through a focus on empowering farmers to grow the food they want to eat, and through careful monitoring to assess how training improves household food security. G-BIAC are a member of Participatory Ecological Land Use Management (PELUM) and La Via Campesina and use these platforms to support policy development related to Food Sovereignty. Although youth training is key to G-BIAC's work it does not currently engage in policy related to youth job creation.

Element 5.2 Responsible Governance – 60%
As a member of PELUM the centre supports policy development that highlights the role of agroecology in combatting climate change and enhancing biodiversity protection. Although not operational at the policy level, G-BIAC support farmers to save a distribute their own seed as a direct means of resistance against Kenyan seed laws that prevent indigenous seed networks. G-BIAC does not specifically work on policy development related to reconnecting producers and consumers or around inclusive policy making.

4.0 LAIKIPIA PERMACULTURE CENTRE (LPC)

4.1 Demo farm Characteristics

Motivation: LPC was established in 2014 and is run by the Laikipia Permaculture Centre Trust (LPCT). The centre acts as a demo farm that exists to create sustainable and resilient communities through training programs and community development activities. A central objective of LPCT is to promote the principals of permaculture.

Location: LPC is located close to Nanyuki, in a semi-arid region north of Mount Kenya. The farm is 5 acres, however only 1 acre is cultivated. The rest of the land is used for biodiversity conservation zones, residential and guest accommodation buildings, food processing facilities, a kitchen and restaurant, and offices. The cultivated part of the land showcases locally grown crops using permaculture techniques, and hence its design is 'typical' of what is intended through the training it provides. The site is reached by travelling along a dirt road 17km from a main road. In addition to the training provided onsite the centre also conducted three year development programs on target community land.

Education: LPC run a number of workshops and courses at the demo farm. The centre runs certified Permaculture Design Courses (PDC) with local and international trainers. Shorter workshops are also held on specific agricultural topics. Farmers are trained in value addition processes as well social and ecological aspects of community development. Courses combine theoretical and practical training and include space for discussion groups. Most of the training is done onsite, however development projects take place on community land also. Most courses and workshops follow set curriculums, however there is space for trainers to adapt to the needs of those being taught. The community development projects are conducted in a participatory manner with the goal being that these communities develop ownership over sustainable projects. LPC make effort to ensure that training is immediately replicable by farmers. Specific topics and agricultural practices are listed in the section describing the centre's support for agroecological transitions.

Training staff are viewed as experts and facilitators, whereas trainees are engaged as active participants. Those seeking training at the centre come from mixed backgrounds, not just from farming communities. The community development projects involve 11 pastoral groups.

Operations: The centre employs a number of administrative and training staff as well as staff involved in food processing activities. Courses are promoted via the LPCT website, social media networks and through various partner organisations. The Ministry of Agriculture has in the past also sent farmers to LPC for training. All of the on-site courses cost money to attend with the price including training, accommodation and food. The centre acknowledge that in some cases the price of courses is prohibitive to some farmers in Kenya. The community work is funded separately by partner organisations and hence is free for those involved.

Staff from LPC suggest that there is a great need for government policy that supports organic methods of farming and also for the development of seed networks. One way they try to support this is by engaging local politicians in training and excursions to bring about a shift in mindset about how farming should be done.

Participation: While the content of many of the courses is predefined by LPC the staff aim to facilitate active participation during training sessions in particular through discussion groups. The community development work is conducted in a participatory manner in order to allow the groups to develop and maintain ownership over sustainable livelihoods projects. Hence these groups design their farms and define their goals and actions themselves with support from LPC staff. The demo farm was designed internally by the LPC staff. In both training formats the intention is for participants to develop embodied knowledge about whole farm system design to enable them to make changes within their own lived contexts.

4.2 Support for Agroecological Transitions

LPC's activities support all eleven agroecological elements defined by ACT (Figure 11). The way in which each of these elements is supported is described below.

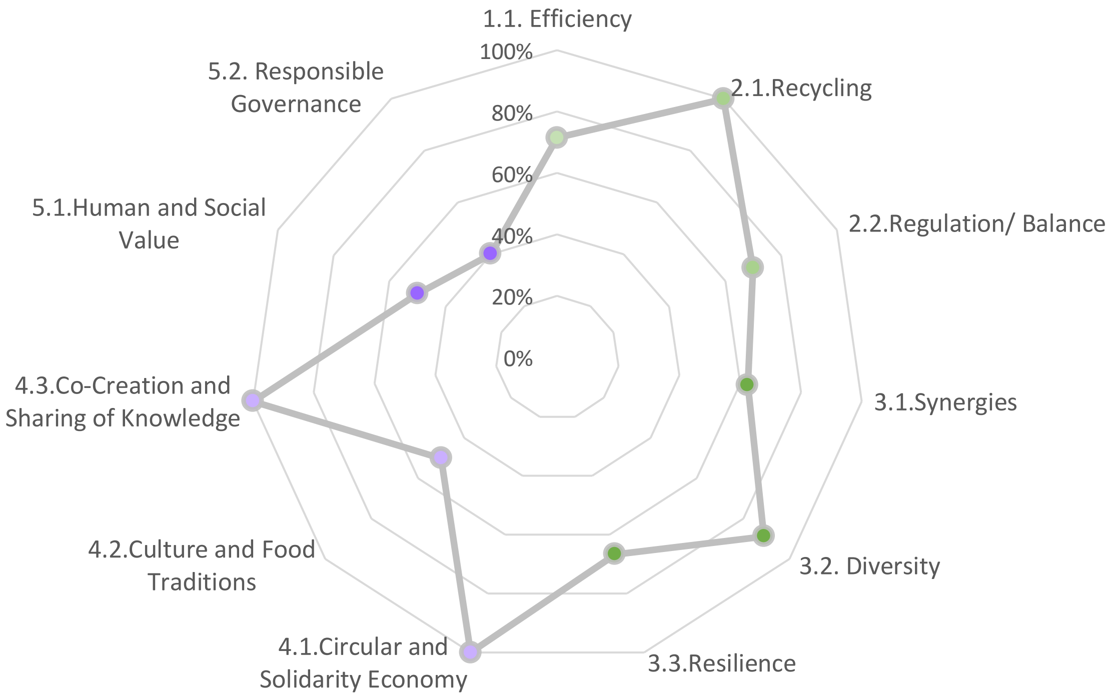

Figure 9 The degree to which LPC supports the eleven agroecological elements of ACT

Element 1.1. Efficiency – 71%

Training on water use efficiency is provided by LPC and focuses on rainwater harvesting, borehole construction, earthworks, and mulching. Reduction in pesticide use is supported through a two-step transition process to organic farming. Chemical fertilizers are not used on the demo site or in any training programs. Energy consumption reduction is demonstrated at the farm through solar systems for lighting and a water boiler, and a biodigester which produces biogas for cooking. Waste reduction is demonstrated through the reuse of glass bottles for packaging value added products and a charcoal cool box is used for storing perishable produce from the farm. Seed use efficiency is not a focus of training activities, nor is the use of improved plant varieties that are resource efficient.

Element 2.1 Recycling – 100%

Vermicompost and compost are used as soil amendments, alongside fermented plant teas. Cow manure is also used, however this is imported from outside of the farm. Beans are used as a green manure where necessary. Wastewater from the kitchen and showers is cleaned via reedbeds with filters made from charcoal, sand, and gravel before being directed into plots of *Musa* spp. Residual biomass is used to create biogas via the biodigester. Carbon is also stored in the ground by burying organic matter into the bottom layer of double dug beds. Human waste is also recycled via compost toilets.

Element 2.2 Regulation/Balance – 70%
Weed and *Tagetes minuta* fallows are used to restore soil vitality when required. A range of biological pesticides are demonstrated including neem spray for mites, *Lycopersicon esculentum* leaf spray for aphids, and *Tagetes Minuta* spray for white fly. *Ipomoea batatas* is used as a cover crop or living mulch to conserve soil moisture. Farmers are trained to construct double dug beds which are then not tilled for a minimum of five years. Honeybees are kept as domesticated pollinators and producers of honey which is sold to local markets. Rabbits and chickens are kept in free range areas providing eggs, meat, and manure for the farm. Perennial varieties of annual crops are not demonstrated.

Element 3.1 Synergies – 63%
Tagetes Minuta and reeds are examples of non-crop plants used for ecological functions on the farm as described above. Similarly, *Tephrosia Vogelii* has been planted to prevent moles from damaging crops. Agroforestry is promoted through alley cropping, hedgerows, dispersed trees, and protected woodland areas. Examples of tree species include: *Moringa* spp, *Sesbania sesban*, *Persea americana*, *Acacia* spp., *Croton megalocarpus*, *Azadirachta indica*, as well as other native wild trees. At the landscape level part of the farm is designated as a wildlife protection area and houses the beehives. Rotational grazing is not something that is demonstrated on the farm, but local pastoral communities are trained in this form of livestock management. Beyond the use of manure on the farm there are no examples of crop-livestock integration.

Element 3.2 Diversity – 89%
LPC is promoting the production of local varieties of *Aloe Secundiflora* for cosmetic products and is propagating these plants for local communities at the demo farm. The locally invasive *Opuntia* cactus species is also being harvested by local communities and then transformed into juices, jams and wines by LPC to be sold locally. The centre demonstrates a crop rotation of *Zea mays*, followed by *Fabaceae*, then *Brassica*ceae, then *Umbelliferae*, and finally *Ipomoea batatas*. Examples of intercropping at the farm include*: Allium porrum* with *Amaranthus* spp. and *Beta vulgaris*, *Brassica*ceae spp. and *Allium* spp., *Coriandrum sativum* and *Allium porrum*, and *Fabaceae* and *Musa* spp.

The demo farm also contains a food forest that as well as providing food crops offers shelter to wild birds. The various agroforestry systems provide nectar for both domestic and wild pollinators. The farm is designed in a way to integrate biodiversity conservation and food production at the whole farm level. With regards to dietary diversification LPC is working with researchers at Jomo Kenyatta University of Agriculture and Technology to research the nutritional value of *Opuntia* food products.

Element 3.3 Resilience – 67%
Farmers are supported to become more resilient to extreme weather patterns through training in the construction of soil and water conservation structures (swales) to manage heavy rain falls and floods as well as drought. Livelihood resilience is also supported through diversification from subsistence farming to production of crops for local markets and cosmetics products. Adaptation to climate induced change such as emerging pest and disease is not a focus of the training provided.

Element 4.1 Circular and solidarity economy – 100%
LPC work to connect farmers with local organic markets and retailers for their fresh produce as well as generating value addition through the production of food and cosmetic products. Examples of value added produce include juice, wine, jam, honey, dried herbs, soap, face cream, shower gel, shampoo and body lotion. LPC is encouraging consumption of regional food by showcasing products at popular food outlets in Nanyuki.

Element 4.2 Culture and food traditions – 50%
LPC encourage farmers to grow the food they want through the participatory design approach to their community development projects. There is not a specific focus however on cultural identity or traditions in the diets promoted.

Element 4.3 Co-creation and sharing of knowledge – 100%

LPC's community work starts with understanding what knowledge farmers have and what goals they want to achieve. A participatory design approach is taken from this point to help communities develop their land to achieve their goals. Exchange visits are organised between communities at different stages to facilitate knowledge sharing between farmers. Formal agricultural training is provided via certified training courses and workshops.

Element 5.1 Human and social value – 50%

Initially LPC had a major focus on working with women's groups, however they have now expanded this focus to also include working with mixed groups to promote gender equity in agricultural development. The centre works to strengthen the organizational capacities of farmer groups by assisting with the writing of constitutions legal registration of groups, capacity building, and sustainable financial planning. Young people are employed as farm managers in community projects and at the demo farm. LPC does not work on policy development with regards to the right to food, food sovereignty or inclusive livelihoods.

Element 5.2 Responsible Governance – 40%

LPCT is a member organization of PELUM and has been involved in the development and promotion of the PELUM seed declaration put forward in 2019. However, LPCT do not generally get involved with policy development but rather engage local government actors directly through demonstrations and training to increase support for ecological farming and its role in addressing climate change.

5.0 KAGURU AGRICULTURAL TRAINING CENTRE (ATC)

5.1 Demo farm Characteristics

Motivation: Kaguru ATC is a government institution that exists to provide training and demonstrations to farmers. It works with a number of partner organisations, both governmental and private, and hence also facilitates the promotion of certain products or practices on behalf of these actors.

Location: The ATC is one of many such government facilities located across Kenya. It is located close to the Embu-Meru highway close to Nkubu. The farm is situated on 67 acres of land, of which 41 acres are cultivated. The farm was designed by the government in the late 1950s. It is on a slope, have bench terraces have been created for soil conservation. The land is split across two areas either side of the highway. On one side there are offices, teaching facilities, residential blocks, and event facilities. On the other side the land is further subdivided into specific areas for: greenhouse production, private partner crop demonstrations, *Macadamia* spp. and *Mangifera indica* orchards, field crop production, and enclosed livestock facilities (pigs, dairy cows, goats and poultry). The cultivated side also contains storage facilities and offices. The ATC also work with sub-county offices to establish community demo plots.

Education: Farmer training is both theoretical and practical. A range of different methods are employed for teaching, including demo farm tours, active discussions, question and answer sessions, farmer field schools, and farm exchanges. There is no specific curriculum offered, instead each training is demand-driven and based on the needs of farmers. The length of training activity varies from single day visits to one or two week residential programs. Specific topics and agricultural practices are listed in the section describing the centre's support for agroecological transitions.

The ATC's training staff act as expert trainers and facilitators, while farmers are viewed as active participants who shape the content of training activity. Representatives from partner organisations also provide demonstrations to farmers and are viewed as knowledge providers or salespeople. School visits are also coordinated and a number of attachment students from Kenya's agricultural universities are engaged in placements.

Operations: The ATC employs a number of training, admin, and field staff. Farmers generally contact the centre directly to request training, however field officers will also recruit farmer groups to attend partner demonstrations. Farmers are charge KES 50 per person per day to visit the centre for training. Additionally, farmers are invited for the centre's 'Farmer Forum Field Days' which showcase a number of different crops, practices or technologies. The biggest hurdle for farmers to access training is the price. The centre used to be entirely government funded but now much of this funding has been cut. Staff at the centre state that the private partnerships are filling this financial void left by the government and that although this funding is necessary for the viability of the centre, it can also affect the neutrality of the advice provided to farmers. Another challenge is that organisations sometimes bring infected plant material or use unauthorized inputs on the farm.

Participation: The training provided by Kaguru ATC is largely demand-driven and hence could be viewed as having a participatory starting point. Additionally, the use of a number of interactive pedagogies empowers farmers as active participants during training sessions. However, much of the training and demonstrations offer farmers incremental skill or knowledge acquisition related to specific product, skills or packages of both.

5.2 Support for Agroecological Transitions

Kaguru ATC's activities support all eleven agroecological elements defined by ACT (Figure 11). The way in which each of these elements is supported is described below.

Element 1.1 Efficiency – 43%
Training is offered in water use efficiency through practices such as rainwater harvesting, conservation tillage, soil coverage, and the use of planting holes. Farmers are encouraged to
reduced pesticide application through training on safe and effective use of pesticides and wider IPM strategies. Fertilizer use efficiency is promoted through training on correct timing of application based on crop requirements. No training is provided on efficiencies related to energy use, seed use, waste reduction or resource efficient breeds or varieties.

Element 2.1 Recycling – 33%
Manure, compost and leaf mold are used as soil amendments for all types of farming, while the use of ash is encouraged specifically in orchards. The centre does not provide training on green manures, wastewater recycling, or the use of biomass for energy generation.

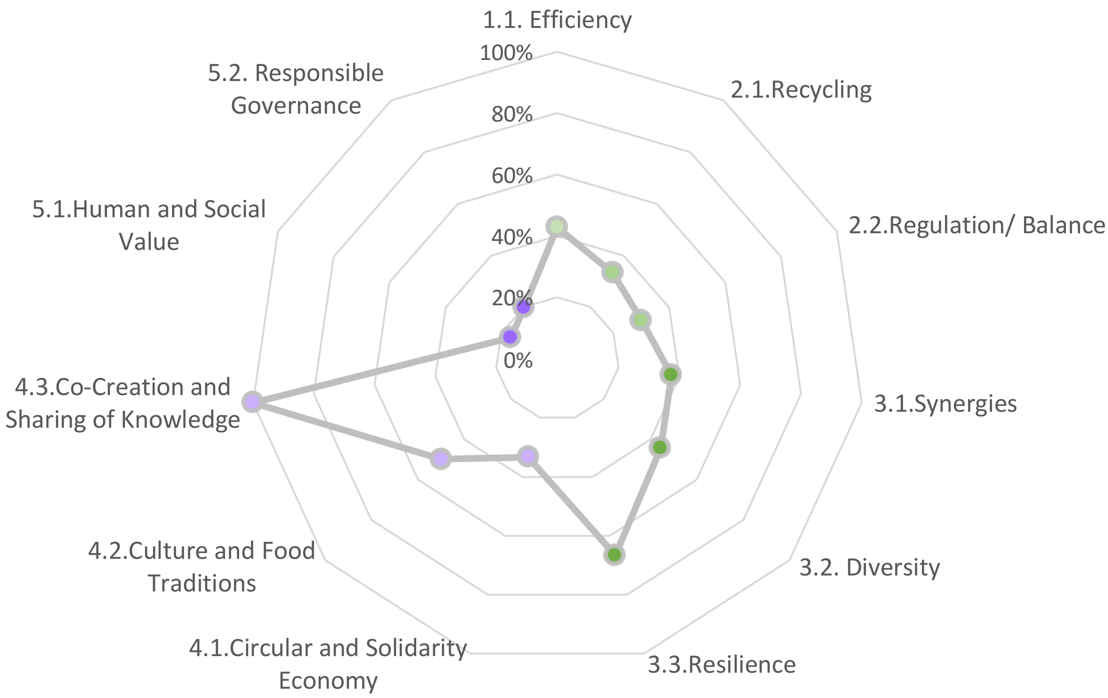

Figure 5 The degree to which Kaguru ATC supports the eleven agroecological elements of ACT

Element 3.1 Synergies – 38%
The ATC demonstrates the agroforestry techniques of contour planting *Grevillea Robusta* on terrace lines for soil conservation. Training related to grafting is also provided. The inclusion of other non-crop plants for their ecological functions is not demonstrated The integration of livestock and crops is promoted on the mixed demo farm, however beyond the exchange of manure and feed there are no further interactions demonstrated between these elements. Rotational grazing is not covered by the training provided by the centre as all animals are kept in zero grazing or indoor housing. Bench terraces have been used for soil conservation however no other landscape manipulation is demonstrated on the farm.

Element 3.2 Diversity – 44%
Indigenous crops such as *Amaranthus* spp, *Cleome gynandra*, *Solanum nigrum*, and *Vigna unguiculate* are promoted to farmers for cultivation. The centre demonstrates two different crop rotations. The first sees *Zea mays* planted followed by *Ipomoea batatas*, then *Zea mays*
again, followed by *Lycopersicon esculentum*, and finally leafy vegetables. The second rotation sees *Fabaceae* planted before *Zea mays* followed by *Lycopersicon esculentum* and then leafy greens. Intercropping is not demonstrated or included in training programs. From a biodiversity perspective, the centre has a designated conservation area to protect a nearby river from run-off and also work to protect local monkeys despite the damage they can cause to crops. Hence the site is engaged in a multi-habitat approach attempting to combine food production and natural habitat protection. No specific efforts are made for protecting or enhancing natural pollinators. Dietary diversification is not a specific focus of training activity.

Element 3.3 Resilience – 67%
Farmers are supported to become resilient to extreme weather patterns through measures that encourage soil conservation and diversifying crop production to include drought resilient crops such as *Sorghum bicolor*. Livelihood resilience is enhanced through training on marketing skills as well as encouraging a general shift from subsistence to market oriented production. No specific attention is given to building resilience toward wider climate induced changes such as pest and disease damage.

Element 4.1 Circular and solidarity economy – 33%
Kaguru ATC assist with developing local trading relationships between farmers and vendors. Farmers are trained to conduct market surveys and are then to adapt their farms to market demand. No specific work is done related to regional value generation or encouraging seasonal or regional demand for produce.

Element 4.2 Culture and food traditions – 50%
The production of indigenous vegetables is promoted to farmers through demonstrations and training programs. No specific work is done to support the right to culturally appropriate food.

Element 4.3 Co-creation and sharing of knowledge – 100%
Kaguru ATC work to connect farmers to share knowledge through farmer exchanges which are conducted in partnership with local government offices. Farmer Field Schools are used as another format for knowledge exchange and generation. As a government entity they provide formal extension services as well.

Element 5.1 Human and social value – 17%
The ATC provide specific training to rural youth. However, no other specific demographic groups are targeted. Farmer group capacity building is not offered nor does the centre does not conduct any work on specific policies related to human and social value in agriculture.

Element 5.2 Responsible Governance – 20%
Kaguru ATC is currently proposing policy to local government bodies to establish a food safety committee to encourage the reduction of chemical use to a safe and effective level. Although the centre does not demonstrate or provide training in organic farming methods it is involved in advocating organic farming for health reasons within local government. The centre is not involved in any other policy development.

6.0 REAL IPM

6.1 Demo farm Characteristics

Motivation: Real IPM is an agribusiness focusing on the products and extension services related to integrated pest management. A major component of the business is natural enemy breeding for biological control agents. The company also sells a range of urban agriculture and irrigation equipment. Real IPM's demo farm exists to educate farmers on safe methods of farming biological control. In order to do this the centre's objectives are to provide clear explanations of various agricultural practices and to also allow farmers to observe the effectiveness of products and practices with their own eyes.

Location: The Real IPM demo farm is located at the company's headquarters near Thika and hence is adjacent to natural enemy breeding facilities, offices and staff buildings. The demo farm is 2.5 acres and is split into four main sections for urban agriculture, terraced horticulture, greenhouse horticulture, and agroforestry. There is also a vermiculture facility and zero grazing cattle shed which are used in demonstrations. The centre is accessible by road and located next to large scale floriculture farms. However, staff report that the centre is difficult to reach for many farmers due to a lack of public transport access and no nearby urban centres. The farm is not typical of local farms given its multifunctionality, however the demonstrations are arranged in ways that are replicable for farmers. The centre was designed by the company's directors with a goal of being able to produce a diverse range of food for staff on site. The centre also develops community plots in rural areas.

Education: Real IPM's training focuses on horticulture and small-scale dairy production. Theoretical and practical training is combined and conducted on-site or at community plots. A minimum of five people is required for group activities, however 1:1 training is provided via consultancy services for large scale farms. Training is demand-driven however the majority of the content and structure is designed by the centre's staff. Training is typically conducted over one to five days. Specific topics and agricultural practices are listed in the section describing the centre's support for agroecological transitions.

Staff trainers are view as facilitators for the training courses, or consultants for the large scale farm services. Trainees are viewed as active participants and knowledge recipients engaged in what staff refer to as a two way process of education.

Operations: Real IPM employ over 200 staff members working in administrative, production, research, and training roles. The majority of these employees are young people. Field officers are also employed and located in more rural areas.

Farmers are engaged in training via the company's website and social media, or through farmer interactions. Training was previously funded by an NGO, however since that funded stopped farmers must pay a fee to access the training services. Money is a barrier for many farmers to access the training, as is the location. Staff suggest that there is a need for more government support for organic farming practices, in particular through more active and better funded extension services.

Participation: Farmers are viewed as active participants during training sessions in the sense that they can ask questions, engage in discussions, and request various content to be provided. However, given that the training is demand-driven many of the farmers arrive already possessing values or desires related to organic farming methods. Therefore, much of the training is focused on incremental skill and knowledge learning about specific products or practices.

6.2 Support for Agroecological Transitions

Real IPM's activities support all but two of the eleven agroecological elements defined by ACT, namely *Circular and Solidarity Economy* and *Responsible Governance* (Figure 14). The way in which each of these elements is supported is described below.

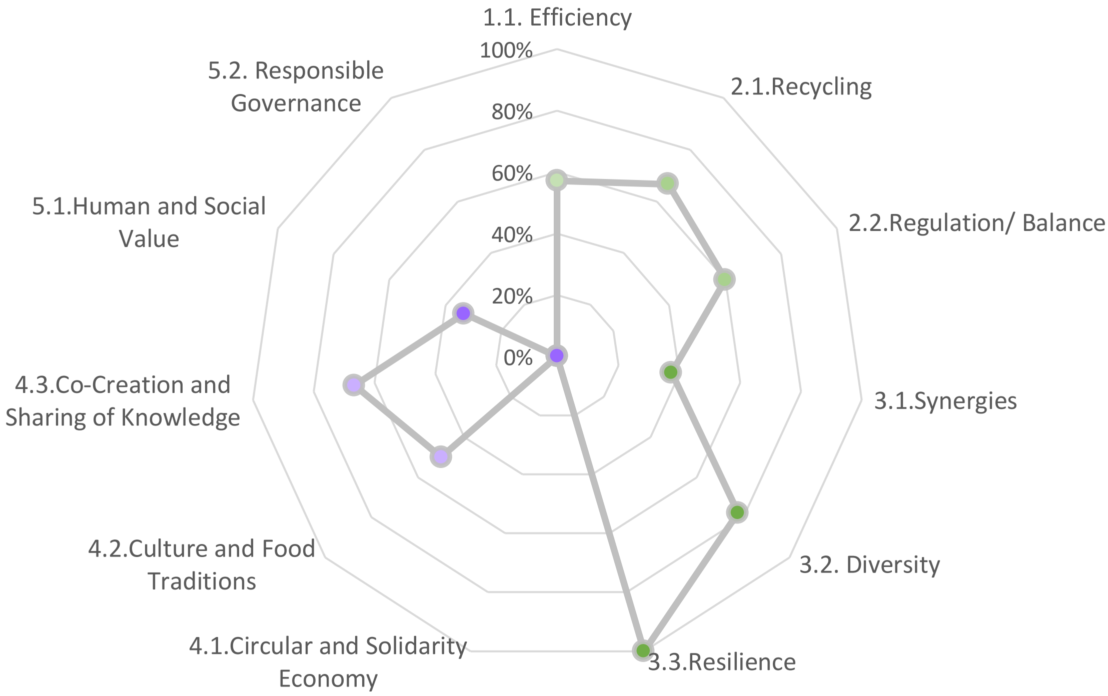

Figure 6 The degree to which Real IPM supports the eleven agroecological elements of ACT

Element 1.1 Efficiency – 57%

Real IPM provide training on water use efficiency through the use of drip irrigation and rainwater harvesting. Chemical pesticide use reduction is a core focus of the business's training on IPM and their use is viewed as a last resort after cultural, physical, and biological interventions have been tried. Vet medication requirements are minimized by focusing on provided livestock with a nutritious and diverse diet to foster strong immune systems.

Very little synthetic fertilizer is used at the demo farmer with small amount of diammonium phosphate being used as a basal fertilizer in the company's vertical grow bags. Seed use efficiency is demonstrated to farmers through the use of cross planting and training on nursery management. Waste reduction, energy efficiency and the use of resource efficient varieties are not a focus of the demo farm.

Element 2.1 Recycling – 67%

Compost, vermicompost, biodigester slurry are demonstrated as soil amendments that recycle farm nutrients. Cocopeat is additionally demonstrated as a soil amendment for nurseries. Green manures are not demonstrated, or part of the training provided. Wastewater recycling is demonstrated through the use of charcoal filter beds that redirect kitchen grey water into *Colocasia esculenta* production beds. Biogas is produced from manure and kitchen waste. Crop residues and weeds are used for animal feed, composting, insect cultivation and vermiculture. No specific work is done on carbon storage through tillage practices.

Element 2.2 Regulation/Balance – 60%
Real IPM demonstrate the use of introduced natural enemies which they breed and use at the demo farm. The IPM framework taught by the centre focuses on intercropping and rotations as cultural methods, scouting, trapping & farm hygiene (boot cleaning) as physical methods, organic sprays and natural enemies as biological methods, and the safe and effective use of chemicals as a last resort. Cover crops for pest management are not a component of their training, however *Medicago sativa*, *Desmodium* spp., and *Ipomoea batatas* are planted on terraces as cover crops for soil conservation. Perennial alternatives to annual crops are not demonstrated, nor is reduced tillage. Honeybees are kept for pollination and honey production. Some animal welfare enhancements are demonstrated through the provision of mattresses for cattle to sleep on in zero grazing units and biological tick control. Farmers are trained on improved animal nutrition through alternative fodder sources.

Element 3.1 Synergies – 38%
Agroforestry is not a focus of demonstrations or other training activity, however many examples of this type of farming are present on the farm for ecosystem services such as pollination, soil conservation, biodiversity enhancement, and food provision. Tree species include *Mangifera indica*, *Persea americana*, *Calliandra calothyrsus*, *Morus* spp., *Psidium guajava*, *Eriobotrya japonica*, and *Musa* spp. as well as native wild trees.

Sustainable grazing methods are not a focus for the centre given their use of zero grazing systems. The demo farm has mixed crop and livestock production which are integrated through the use of crop residues and weeds for feed and manure for fertilizer.
A number of landscape redesign features are demonstrated on the farm, including *fanya chini*[15] terraces, tree windbreaks, and year-round flowering trees for pollinators. No specific methods have been used for habitat manipulation for pest management.

Element 3.2 Diversity – 78%
Real IPM encourage the planting of indigenous vegetables but do not work specifically on breeding of these or other local seeds. A three crop rotation is demonstrated to farmers which see *Fabaceae* followed by leafy vegetables and then tubers or fruiting crops. Companion cropping in vertical growbags is demonstrated in the urban gardening section. The kitchen garden demonstration uses double dug beds with alternating rows of crops. The main horticultural sections are highly diverse.

Biodiversity conservation is demonstrated through the planting of trees and a buffer zone to protect a nearby river. Farmers are trained in the importance of environmental protection as part of the courses offered. Year-round flowering trees such as *Callistemon spp.* are used to enhance natural and domesticated pollinators, as well as other trees used for apiculture such as *Moringa* spp. Land-use diversity is enhanced through the use of different production areas. Farmers and staff are provided with training on dietary diversification and nutrition as a component of crop production.

Element 3.3 Resilience – 100%
Farmers are encouraged to increase their resilience to extreme weather events through the use of trenches to prevent soil erosion during heavy rains and windbreaks to reduce wind damage. Resilience to climate change induced pest and disease is enhanced through the provision of text message alerts to farmers about localized pest and disease attacks related to climate. Training on crop diversification and urban agriculture also aim to increase livelihood resilience.

Element 4.1 Circular and solidarity economy – 0%
No training is provided related to changes at the market level.

[15] *Fanya Chini* is Kiswahili for 'to make down'. These terraces are therefore constructed by digging trenches along contour lines on steep slopes, with the dug soil placed below the trench (creating a swale) for water harvesting and soil conservation. The soil mounds are then usually planted with a cover crop to stabilize the soil.

Element 4.2 Culture and food traditions – 50%

Healthy, diversified and culturally appropriate diets are encouraged through the inclusion of indigenous crops, nutritious training, and the focus on increasing urban farming to improve urban diets. No work is done in this regard related to policy development.

Element 4.3 Co-creation and sharing of knowledge – 67%

Farmer exchanges are facilitated between on-farm demos to connect farmer communities. Education is provided through training delivered on-site and in communities. No specific participatory approaches are used for knowledge generation or research.

Element 5.1 Human and social value – 33%

Real IPM work with women's groups to facilitate female empowerment in agriculture. They employ over 200 young people on the farm. No specific work is done on strengthening farmer organizational capacities nor on policy development related to social issues.

Element 5.2 Responsible Governance – 0%

Real IPM does not engage with policy development.

D. Evaluation of the Agroecology Criterial Tool (ACT) as a farm-level research tool

ACT holds great promise as an easy-to-use tool for farmers or communities to monitor their own agroecological development. Additionally, NGOs or extension workers could use it to evaluate the effect of training or other interventions, or to help farmers select areas for development.

However, ACT requires modification for use in assessing the agroecological status of farming systems or to track farm-level transitions. Recommendations are presented in this section based on the author's experience of using ACT as field data collection tool. The recommendations relate to the content of ACT and its practical application as a tool.

1.0 Content

1.1 Limitation of binary answers

The current version of ACT does not allow users to distinguish between varying levels of engagement with each criterion. For example, farmers who reduce chemical fertilizer use through spot application and soil testing are not distinguishable farmers who simply halve their fertilizer use.

Developing a gradient of answers within each criterion would enable users to identify how they could build on existing strengths related to various criteria rather than simply identifying general areas for improvement. Such a gradient is proposed by Tittonel (2020) for assessing criteria for agroecosystem resilience. Furthermore, if we assume a hypothetical situation in which a project/farm scores 100% at each level, the inclusion of such a gradient would highlight how such cases could further evolve in an agroecological manner.

Interestingly the current version of ACT does make distinction between a two- and three-crop rotation. It was unclear when using the tool whether or not to give a positive score for both criterion when a farm employed a crop rotation of three or more crops. By omitting a score for the two-crop rotation in this case meant the farm scored lower, despite three-crop rotations being arguably more 'agroecological'. This provides a good example where a gradient could be included to allow users to select from a range of options, e.g. from no rotation up to four or more crops.

1.2 Contextualising criterion for the farm-level

A number of the criterion require specific frameworks or documentation to be available. For example, criteria 2.1.5 suggests that "carbon stocks or GHG emissions should be clearly documented" and criterion in element 3.3 suggest that projects "should contain a reference to an explicit resilience framework or should explicitly mention "systemic resilience" or similar formulation.

Such criterion is useful in the case of national or international AgR4D projects. However, the training centres visited for this research demonstrated a variety of ways in which they were supporting these elements despite not having specific frameworks or documentation (table 1). One of the small-scale farmers interviewed suggested that they had improved their livelihood resilience (criteria 3.3.3) by working as a mason in addition to his farming activity. Such insights suggest the need for flexibility in these criterion to allow more localised projects and farmers to define for themselves how they are promoting these aspects of agroecology.

Table 18 Examples of the variety of ways in which demo farms in Kenya are promoting resilience of agroecosystems to extreme weather events and other disturbances without specific.

	Method of promoting criteria 3.3.1 "Systemic resilience of agroecosystems to extreme weather events and other disturbances"
Kenya Institute of Organic Farming (KIOF)	Dry-land farming techniques, integration of drought tolerant fruit trees.
KALRO Practical Training Centre	Water harvesting and storage (collaboration with Real IPM)
Grow Biointensive Agriculture Center (G-BIAC)	Promotion of planting drought tolerant fruit trees
Kaguru Agricultural Training Centre	Training on soil conservation methods
Laikipia Permaculture Centre	Soil and water conservation structures (swales) to manage heavy rain falls and floods as well as drought. Mulching for water retention.
Real IPM	Trenches to prevent soil erosion during heavy rains, windbreaks to reduce windfall.

1.3 Potential for 'double counting' across sections

The previous recommendation highlights how projects or farmers could use individual practices to fulfil multiple criteria across the different levels of agroecology. For example, water harvesting could contribute to criterion 1.1.1 (Reduce Water Consumption) and 3.3.1 (Systemic resilience of agroecosystems to extreme weather events and other disturbances).

This is not necessarily a problem as many practices can have an impact at field, farm and landscape levels (e.g. field margins offer refuge for natural enemies at the field level but are most effective when employed across landscapes). However, it is recommended that this potential is assessed to minimize problematic cases of 'double counting'.

1.4 Need for defining 'participation'

References are made to farmer participation across different levels of ACT, in particular *4.3 Co-Creation and Sharing of Knowledge.* However, the type of participation required to meet various criterion is not defined. This may be problematic as participation can mean different things depending on who is using the term. At best the term is used to describe approaches that seek transformation in the capabilities of individuals to determine and achieve their own goals, at worse it can be used as a veneer for stakeholder manipulation (Pretty 1995, White 1996). The exclusion of a specific definition of participation is also found in the work on which ACT is based (Gliessman 2007, FAO 2018, HLPE 2019).

It is recommended that greater nuance is given to the type of participation required for each criterion, or that a gradient is defined as previously described. Similar considerations should be given to the design, development, use and evaluation of ACT as a participatory tool.

1.6 Incorporating a 'non-applicable' option

In some cases, certain criteria are not applicable to farmers. For example, in resource constrained agroecosystems which operate as 'organic by default', there is no scope for farmers to reduce chemical usage. The current version of ACT would score such agroecosystems as equal to others which are making no efforts to reduce chemical use. Similarly, in many local contexts across the Global South people eat seasonal or local food by default giving criteria 4.1.3 (Encourage and sensitize for seasonal and regional demand) an ethnocentric bias to urban areas or industrialized nations.

It is recommended that an option be integrated into ACT to allow users to select 'not-applicable' to adjust for local contexts. Additional considerations will need to be given to how this affects the scores generated, in particular to maintain ACT's function as a tool for comparing different projects.

1.7 Contextualising Level 5 for farmers

Much of Level 5 (Rebuild the global food system so that it is sustainable and equitable for all) relates to policy development that supports various aspects of agroecology. However, there are a number of ways in which farmers and other stakeholders can engage with this level without necessarily informing policy. For example, one demonstration centre visited refused to engage in formal politics. Instead the centre focused their efforts on building a grassroots seed exchange system in Kenya, therefore contributing to criteria 5.2.2 (Establishment of equitable governance and rights over natural resources) without engaging in policy development. Another centre focused on providing integrated pest management job opportunities for rural youth but was not involved in policy on this topic.

2.0 Practical aspects of using act as a field tool

2.1 Development of efficient field data collection tools

The current format of the ACT when printed on A4 paper proved to be somewhat time-consuming as a tool for semi-structured interviews. This is no doubt due to the non-linear approach taken, suggesting that interviews may have been more efficient if the criteria had been discussed in order. However, this experience highlights the need for a practical means of using ACT in the field.

It is recommended that a paper based tool is developed for field data collection. Additionally, the development of a mobile application may also prove useful for efficient data collection and centralized storage. Such a tool could include a function whereby keywords can be entered (e.g. pest management) to highlight matching criterion.

2.2 Excel sheet functionality

The ACT excel spreadsheet currently allows users to view spider charts for one project at a time. Hence to compare these visual graphics users must extract the individual charts into a separate document. It is recommended that a function is built into the spreadsheet to allow multiple charts to be visible to allow easy comparisons between projects.

3.0 Concluding reflections

ACT holds promise as a participatory tool for farmers, communities, NGOs, and extension workers to assess agroecological transitions at the field, farm, and community level. However, its content requires modification to make it more appropriate for use at the farm-level. Its functionality as a field data collection tool could also be improved.

It is recommended that ACT is developed as a participatory farm assessment tool. Initial prototypes of the tool could be field tested by a range of actors e.g. farmers and extension workers. Ideally both a paper based and mobile application version of the tool would be created. Insights about the agroecological status of a variety of agroecosystems could simultaneously be gathered during development and may prove valuable for identifying at which agroecological level support is most needed.

E. Crops and Livestock farmed by workshop participants

Table 19 Livestock and their derived products and services identified as important by farmers during workshop. List includes animals not traditionally viewed as 'livestock' but categorized in this way by the participating farmers.

Name	*Primary Product*	*Secondary Product*	*Service*
Bees	Honey	-	Pollination
Chicken	Eggs, Meat	Manure	-
Cow	Milk, Meat	Manure, Biogas, Biodigester slurry	-
Dog	-	-	Security, Companionship
Donkey	-	Manure	Labour
Duck	Eggs, Meat	Manure	-
Fish	Fish	-	-
Geese	Eggs, Meat	Manure	-
Goat	Milk, Meat	Manure	-
Pig	Meat	Manure	-
Rabbit	Meat	Manure, Urine	-
Sheep	Meat	Manure	-
Worms	-	Vermicompost, Vermiliquid	Vermiculture

Table 20 Crops identified as important to farmers during workshop listed in alphabetical order.

African Nightshade	*Solanum nigrum*	Comfrey	*Symphytum officinale*	Parsley	*Petroselinum crispum*
Amaranth	*Amaranthus spp.*	Coriander	*Coriandrum sativum*	Passion Fruit	*Passiflora edulis*
Apple	*Malus domestica*	Cotton	*Gossypium spp.*	Papaya	*Carica papaya*
Arrow Root	*Colocasia esculenta*	Courgette	*Cucurbita pepo*	Pea	*Pisum sativum*
Avocado	*Persea americana*	Cowpea	*Vignasinesis*	Pigeon Pea	*Cajanus cajan*
Banana	*Musa spp.*	Desmodium	*Desmodium Intortum*	Potato	*Solanum tuberosum*
Barley	*Hordium vulgare*	Finger Millet	*Eleusine coracana*	Pumpkin	*Curcubita maxima*
Beans	*Phaseolus vulgaris*	Flowers	**undefined species*	Pumpkin Leaves	*Curcubita spp.*
Beetroot	*Beta vulgaris*	French Beans	*Phaseolus vulgaris*	Rhodes Grass	*Chloris gayana*
Brachiaria	*Brachiaria spp.*	Green Grams	*Vigna radiata*	Rosemary	*Salvia rosmarinus*
Aubergine	*Solanum melongena*	Green Pepper	*Capsicum annuum*	Sorghum	*Sorghum bicolor*
Brocolli	*Brassica oleracea italica*	Kale	*Brassica oleracea*	Spider Plant	*Cleome gynandra*
Butternut Squash	*Cucurbita moschata*	Lucerne	*Medicago sativa*	Swiss chard	*Beta vulgaris*
Cabbage	*Brassica oleracea*	Macadamia	*Macadamia spp.*	Strawberry	*Fragaria × ananassa*
Caliandra	*Calliandra calothyrsus*	Maize	*Zea Mays*	Sweet potato	*Ipomoea batatas*
Carrots	*Daucus carota*	Mango	*Mangifera indica*	Tea	*Camellia sinensis*
Cassava	*Manihot esculenta*	Mint	*Mentha spp.*	Tomato	*Lycopersicon esculentum*
Celery	*Apium graveolens*	Miraa / Khat	*Catha edulis*	Tree tomato	*Solanum betaceum*
Chilli Pepper	*capsicum frutescens*	Napier	*Pennisetum purpureum*	Watermelon	*Citrullus lanatus*
Clove	*Syzygium aromaticum*	Onion	*Allium cepa*	Wheat	*Triticum aestivum*
Coffee	*Coffea spp.*	Orange	*Citrus sinensis*	Yam	*Dioscorea alata*

Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway