Working Paper

Looking back to look ahead: insight into the effectiveness and efficiency of selected advisory approaches in the dissemination of agricultural technologies indicative of Conservation Agriculture with Trees in Machakos County, Kenya

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Summary

Sub-Saharan Africa is facing a challenge of low agricultural productivity, which threatens the ability to achieve food security for the continent's growing population. The low productivity has been attributed to a number of factors including climate variability and low soil fertility. Agricultural practices such as Evergreen Agriculture show promise in improving soil fertility and production in a sustainable way. One form of Evergreen Agriculture is Conservation Agriculture with Trees (CAWT), which combines the principles of Conservation Agriculture with tree-crop intercropping. The promotion of complex agricultural practices such as CAWT requires agricultural advisory approaches that are both effective and efficient. Effective in their ability to increase diversity of crop enterprises, productivity of staple crops and adoption of promoted relevant practices. Advisory approaches are also considered effective if they provide useful information and build social networks in the community. The approaches also need to be efficient, that is, be able to mobilize the community and provide training in a cost-and-time appropriate fashion.

This study assessed three agricultural advisory approaches in Machakos County, Kenya to determine their potential efficiency and draw insight on their effectiveness in promotion and scaling-up of CAWT practices amongst farmer communities. Baseline data from a before-and-after study was used to hypothesise on the effectiveness of selected approaches using proxy indicators. Landcare, a community based participatory advisory approach was observed as likely to be effective in promoting enterprise diversity, tree species diversity and practices related to CAWT when compared to the other approaches. The Landcare approach also showed likelihood to create the greatest social capital in communities and the same was observed with government extension approach in Mwala District. Respondents trained through government approaches reported the best connection to extension officers as sources of expert information in all districts.

Assessment of time and financial costs disposed in delivering CAWT training and mobilization potential, pointed to Landcare as the most time efficient in delivering farmer training. The Farmer Field School approach was the most efficient in terms of mobilizing the community while the government approach was the most cost efficient. More information on training quality and impact are needed to qualify these efficiency findings. Each approach thus had particular strengths. These initial results thus suggest that a pluralistic agricultural advisory system could be the most appropriate for scaling up CAWT in Machakos County, with lessons for scaling up in Kenya more broadly. The system could link government agricultural extension officers, who are currently the most accessible source of expert information in the county, to community-based facilitators, such as in the Landcare approach,

who could add value by further disseminating information to the community. Use of participatory approaches is hypothesised to enhance social capital and should be further investigated. The inclusion of Non-Governmental Organizations using Farmer Field Schools could also add value to the advisory system in specific circumstances, however the additional costs associated with this approach need to be qualified in terms of effectiveness as the initial results do not suggest they deliver greater practice adoption amongst trained farmers.

Keywords: Evergreen Agriculture, agriculture advisory, Conservation Agriculture with Trees, efficiency, effectiveness

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Acronyms

AF	Agroforestry
ARTC	Agricultural Resource and Technology Centre
ASDSP	Agricultural Sector Development Support Programme
CA	Conservation Agriculture
CAWT	Conservation Agriculture with Trees
CBO	Community-based Organization
CDF	Constituency Development Fund
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
ICRAF	World Agroforestry Centre
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
KASA	Knowledge, Attitude, Skills and Aspirations
KENDAT	Kenya Network for Dissemination of Agricultural Technologies
Ksh	Kenya Shilling
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
MoA	Ministry of Agriculture
NALEP	National Agriculture and Livestock Extension Project
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
SNA	Social Network Analysis
SSA	Sub-Saharan Africa
T&V	Training and Visit
WV	World Vision

1. Introduction

Achieving food security for a growing population is a topic of great discussion and concern in Africa (Garrity et al 2010). This concern stems from a number of factors that include low agricultural growth (World Bank 2008) especially since most agricultural production in the continent comes from resource-constrained smallholder farmers (Wiggins 2009). The poor performance of the agricultural sector in Sub-Saharan Africa (SSA) therefore calls for innovative approaches focused on smallholder farmers. Identifying low-cost and sustainable ways to attain food security and a sustainable environment for millions of smallholder farmers in SSA remains a major development challenge, however.

Agroforestry, defined as 'the inclusion of trees in farming systems and their management in rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability' (ICRAF 2013 p. 7), is one such approach. Two decades of research in SSA clearly demonstrate that agroforestry reduces poverty and increases returns to labour and land productivity (Ajayi et al 2011). Examples include agroforestry-based soil fertility improvement (Place et al 2005) and fodder shrubs for improved milk yields in East Africa (Place et al 2009).

One form of agroforestry that holds great potential to move African agriculture to more productivity in a sustainable manner is what has come to be referred to as Evergreen Agriculture. Evergreen Agriculture is defined as 'the integration of appropriate tree species into annual food crop systems. The intercropped trees sustain a green cover on the land throughout the year to maintain a vegetative soil cover' (Garrity et al 2010 p. 197), which provides a number of benefits such as improved water retention. Evergreen Agriculture can be practised in various ways, and one promising method is known as Conservation Agriculture with Trees (CAWT).

Conservation Agriculture with Trees combines the concept of intercropping trees with the principles of Conservation Agriculture. Conservation Agriculture (CA) is defined by the Food and Agriculture Organization of the United Nations (FAO) as 'an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely: continuously keeping mechanical soil disturbance at a minimum, maintaining permanent organic soil cover and diversification of crop species grown in sequences and/or associations' (FAO 2014). Dumanski et al (2006) noted that Conservation Agriculture, including agroforestry, could improve crop and animal production leading to greater food security and poverty reduction.

Some of the challenges associated with CA in SSA include maintaining soil cover because of low biomass production and competition with use as livestock feed. Establishment of trees in fields managed under CA holds potential to alleviate some of these challenges, adding biomass to the CA system that increases soil cover, as well as rejuvenating the soil structure and fertility. Garrity (2011) also noted that an additional benefit of incorporating trees into cropping might be an increased resilience of the farm enterprise to climate change.

While CAWT has the potential to increase farm productivity, the integration of agroforestry and Conservation Agriculture creates a complex and knowledge-intensive set of technologies, which may limit adoption amongst farmers and requires a significant change in the farmers' mindset. Before fully adopting a new technology, farmers need to be aware of the technology, learn about it and test it. Knowledge-intensive technologies often take a long period of time before farmers can adopt them and learn to use them efficiently (Shumet 2012). There is also need for farmers to interact with more knowledge sources before sufficient adoption of such technologies can occur (Kiptot et al 2006, Kassam et al 2009). Hence, there is need for the technologies to be disseminated through effective agricultural advisory services, which can provide the technical expertise needed by farmers to understand the new technologies.

Agricultural advisory services have been recognized as an important mechanism for delivering information and advice to the agricultural community (Anderson 2007, Ommani 2011) and can have a significant positive impact on adoption of new technologies and consequently agricultural productivity (Birkhaeuser et al 1991). Birner et al (2006 p. 17) defined agricultural advisory services as 'the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods and well-being.' Agricultural advisory services (also commonly referred to as agricultural extension) therefore have an important role to play in scaling-up the dissemination and adoption of Conservation Agriculture and agroforestry-related technologies.

Despite their significance, little has been studied about the quality, capacity and performance of agricultural advisory systems in SSA (Davis 2008). Recent studies on innovative approaches such as Farmer Field Schools (Davis et al 2010), and Volunteer Farmer Trainers (Lukuyu et al 2012) provide valuable information on their function and impact as individual approaches. For the successful dissemination and adoption of agricultural technologies, there is need for the use of a variety of advisory approaches (Cramb 2000, Place et al 2005). However, little is known about the ability of the agricultural advisory approaches already in place to promote knowledge-intensive integrated land management approaches. Particularly

needed is knowledge on what combinations of advisory approaches could be leveraged upon to support both dissemination and adoption of such technologies in varying agro-ecological contexts.

This working paper presents the baseline results and early findings of a study whose broad objective is to assess the performance, in terms of efficiency and effectiveness, of three agricultural advisory approaches in the dissemination to, and adoption of CAWT by farmers in Machakos County, Kenya. The objectives of this working paper are to: (i) propose hypotheses on the effectiveness of selected advisory approaches by assessing initial results against a framework, and (ii) comment on time and financial costs of delivering CAWT trainings through the different approaches. The broader objectives of the study, as outlined above, will be addressed in a future paper using both before-and-after results.

The three approaches assessed are the government extension, as the standard approach, compared to both Farmer Field Schools (FFS) and Landcare, which were customized and implemented by two NGOs and hereby hypothesised as the better performing approaches.

Within this study, an agricultural advisory approach is understood as the interaction between the farming community and advisors to enhance farmers' knowledge and skills. This paper particularly focuses on the way the interaction between advisors and knowledge recipients takes place. Effectiveness was defined as the adoption of CAWT related practices prior to the introduction of specialised CAWT training in the study area. Efficiency was defined as the time and financial investment by the different approaches to deliver training on CAWT to smallholder farmers through groups.

The rest of the paper is structured as follows: brief review of the history of agriculture advisory services, with particular focus on Kenya; methods used in the selection of the advisory approaches; framework for assessment; preliminary results and discussion and lastly conclusion and recommendations.

1.1. History and evolution of agricultural advisory services focusing on the developing world

Formal agricultural advisory service started in many countries in the late nineteenth and early twentieth centuries although the practice has its root as far back as 1800 BC The first modern service began in Ireland during the potato famine in 1845 (Swanson et al 1997). Early in the twentieth century, advisory services were relatively small scale and in their formative stages in developing countries with mainly the state providing the major service to farmers using

itinerant extension agents (Anandajayasekeram et al 2008). The scope of the advisory services expanded in the 1950's as countries sought to increase food production and spread the benefits of improved farming techniques to as many farmers as possible and advisory service provider organizations began aiming at covering broad national farming systems (Anholt 1994, Anandajayasekeram et al 2008).

The initial advisory structures were top down following a linear approach of technology transfer. Under this approach, it was assumed that the information coming from agriculture ministries was useful to farmers and all that was needed was for extension officers to transfer the information to the farmers (Schwartz and Kampen 1992). Technologies were developed at the universities or agriculture ministries and information was then transferred to farmers through advisory agents with no requirement for farmers to pay for the service (Anandajayasekeram et al 2008). The period between the late 1950's and 1960's saw the institutionalization of many national advisory services, which became part of agricultural ministries.

Transformation of the agricultural advisory systems occurred in the developing countries during the 1970's and 1980's after realizing the need to reach more farmers and to train the advisory agents better. This period saw the emergence of the World Bank sponsored 'training and visit' (T&V) advisory system (Axinn 1988, Venkatesan 1997). This system was designed to address some of the constraints in the previous approaches such as weak linkages with research and limited training of field advisory agents (Kiptot 2007). It used contact farmers to multiply agricultural advisory agents' effect. The T&V approach entailed visits by the frontline advisory officers only to contact farmers rather than the larger rural population (Morris 1991). The system was however criticized for being top down in nature and characterized by high costs and for having packages that were unable to meet the needs of the large variety of farming systems (Anandajayasekeram et al 2008). Despite being a supposedly improved system, farmers surveyed before and after the T&V system said that they were not receiving advice from advisory agents and the messages received were often irrelevant to their circumstances (Gautam 2000).

Further drawbacks of the T&V approach came from declining support for agricultural advisory services as donors became unwilling to fund large recurrent costs. The resultant fiscal restraint exerted extreme pressure on governments to demonstrate the returns from investing in the T&V approaches and to explore alternatives to public financing by involving the private sector, local authorities and producer groups in farmer advisory systems (Rivera and Alex 2004, World Bank 2006, Anderson et al 2006, Anderson 2007). Funding decline led to shortages of staff and shrinking of the advisory services (Ammanor and Farrington 1991),

and ultimately led to the fall of the T&V system as it was found to be unsustainable (Gautam 2000).

The 1990s witnessed a greater focus on changing the mindset of change agents to adopt participatory approaches in agricultural extension (Anandajayasekeram et al 2008). New approaches such as Farmer Field Schools (FFS) emerged. Donor support also shifted from governments to non-governmental organizations (NGOs) that were seen to be more transparent and democratic in their programs (Kiptot 2007). These organizations used participatory approaches that put emphasis on farmers playing a central role in technology development and extension (Kiptot 2007). The period however saw increased recognition of farmer advice as an input into modern farming and agricultural advisory services as an essential mechanism for delivering information (Swanson 1997). Currently there is a trend towards the privatization of the advisory services organizations, often as parastatals or as quasi-governmental agencies (Anandajayasekeram et al 2008).

The trend of providing farmer advisory services in Kenya is well captured within the Agricultural Sector Development Strategy 2010-2020 (Government of Kenya 2010). The document acknowledges a decline in the effectiveness of advisory services in the two preceding decades due to use of inappropriate methods and a decrease in operational budgets and thus human resources in the sector ministries. The performance of public agricultural advisory services has been identified among the areas affecting agricultural growth, but the government is resource-constrained with 80 percent of the budget allocation to line ministries covering only basic salaries (Muyanga and Jayne 2006, Kiptot 2007). As a response to this, Kenya has adopted a pluralistic advisory system, which includes line ministries, NGOs and the private sector and places greater emphasis on participatory approaches.

Between 2000 and 2011, the Ministry of Agriculture adopted a focal area extension approach through the National Agriculture and Livestock Extension Project (NALEP). This was a client-centred approach that saw farmers as central to the process of technology generation (Kiptot 2007). Under this approach, inputs into the design process were provided by the farmers who also played an important role in monitoring and evaluation with the farm being the key location for technology transfer (Kiptot 2007). NALEP was succeeded by the Agricultural Sector Development Support Programme (ASDSP), which is focused on commercialization and privatization of advisory services. ASDSP is also focused on ensuring that the clientele are empowered in information and knowledge sharing and in resource mobilization and allocation, which was not adequately addressed during NALEP (Government of Kenya 2011).

2. Framework for assessing effectiveness and efficiency of advisory approaches

Methods for assessing agricultural advisory approaches are scarce in literature and most documented evaluations focus on the impact of one approach such as FFS or T&V (Birner et al 2006). IFPRI's evaluation of FFSs in East Africa focused on changes in income, productivity and production (Davis et al 2012). Van den Berg and Jiggins (2007) outlined immediate and development impacts of integrated pest management FFS under technical, social and political domains. In 1975 Bennett proposed seven criteria for evaluating extension programs which included inputs, activities, people involved, reactions, knowledge, attitude, skills and aspirations (KASA), practice change and adoption (Bennett 1975). A framework for designing and analysing agricultural advisory services developed by Birner et al (2006) includes consideration of the frame conditions, characteristics, performance and impact of advisory services.

In this study, the assessment of approaches was based on their performance, specifically efficiency and effectiveness. Efficiency in this study aligns well with the definition used by Birner et al (2006) and effectiveness captures aspects of practice change, reactions and people involved from the Bennett framework.

2.1. Effectiveness of the selected advisory approaches

Effectiveness is herein considered as based on the Oxford Dictionary definition of producing a desired or intended result (Oxford University Press 2009). The intended result in this context is the improvement of food production and livelihoods in the target farming community through agricultural advisory services providing knowledge and skills, specifically the promotion and subsequent adoption of CAWT technologies.

Two important aspects of advisory services related to effectiveness are their ability to disseminate information and to promote social capital in the target community so that information is further shared and the potential for collective action and innovation enhanced. Also important is the ability to ensure the information provided is understood and applicable to promote testing and adoption of the taught practices.

To measure these aspects of the advisory approaches, baseline survey data was assessed to hypothesise on the likelihood of CAWT adoption by farmers after interacting with a facilitating agent and ability of the approach used by the facilitating agent to promote social capital and information dissemination as outlined below.

It is important to note that farming practices adopted by individuals and social capital and information flows in the community are influenced by a number of factors additional to the advisory approach used by the main facilitating agent. These include distance to markets and between individuals, culture, wealth and gender. Additionally, it can be expected that an individual farmer may access agricultural advisory services from a number of providers. These factors will be considered during a more detailed assessment of the advisory approaches against an elaborated framework using data from a post-intervention survey.

Assessing adoption of CAWT related practices

This study used baseline data so the influence of the advisory approaches on the adoption of specific CAWT practices could not be measured. Instead, proxy indicators were used to measure farming practices and production of surveyed farmers. The indicators used in this study included:

- Diversity of farm enterprises for the respondents at the initiation of the study as a proxy for risk averseness, adaptation to shocks such as climate change, diversification of food sources and marketable products.
- Productivity of staple crops at the initiation of the study as an indication of food security.
- Practices related to CAWT at the initiation of the study to determine the degree to which respondents were already practising the principles of CA and integrating trees in cropping land as hedges or scattered parkland trees.

Diversity, productivity and CAWT related practices (sustainable agriculture) of respondents reached through each approach were measured to determine the extent to which past trainings and interventions had impacted farming practices. This information was then used to hypothesise on potential adoption of CAWT under each advisory approach.

Level of CAWT practice was measured from the survey by assessing farming practices through the cropping cycle. CAWT practice was determined by separating the two components into practice of CA and AF. CA-related practices were rated following the three CA principles as outlined in Table 1, while the AF component was based on abundance and diversity of tree species.

Table 1. Assessment of CA practice

Principles of CA	Assessment
1-Minimum soil disturbance	A score of one (1) was assigned if respondent practised sub-soiling and/or ripping during land preparation, and 0 if not. Soil disturbance during weeding was not considered as the main practice change targeted was around land preparation.
2-Soil cover	Assessed at two stages: first stage, a score of 0.5 was awarded if respondent left stocks on farm or had cover crops during land treatment, 0 if not, and at the second stage, 0.5 was awarded if respondent intercropped crops and trees and 0 if not. (Note: the percentage of soil cover was not considered here)
3-Crop rotation/association	Was awarded one (1) if respondent practised crop rotation or intercropping for their crop enterprises, crop rotation for planting and/or land treatment and/or intercropped with trees, and 0 if not.

The scores assigned for each principle of CA in Table 1, were then added together and reported as shown in Table 2. The three principles of CA are seen as interdependent so no one principle was weighted higher than the other.

Table 2. Scores and associated practice levels for CA

Score	Level of CA practice
0	Not practising any principle
0.5	Partly practising soil cover only (either through intercropping or cover crops and manure)
1	Practising one principle only
1.5-2	Practising two principles only
2.5-3	Practising three principles (practising CA fully)

Assessing promotion of social capital and information dissemination

The ability by each advisory approach to transfer information and possibly change farmers' attitudes and practices were assessed using the social networks in each approach by district at the initiation of the study. Social network analysis provides a tool for analysing interactions within and between groups and organizations (Springer and de Steiguer 2011). It has been used to measure elements of social capital within communities and describe the flow of information.

2.2. Assessing the efficiency of the selected advisory approaches

The Oxford Dictionary defines *Efficient* as working productively with minimum wasted effort or expense (Oxford University Press 2009). Birner et al (2006) considered efficiency in terms of 'service delivery and other economic performance indicators.' Similarly in this study efficiency of each advisory approach was determined based on the financial and extension officer time costs expended to train farmers on CAWT. Additionally their capacity to reach the target farmers was considered.

The cost for the main training was calculated to include allowances, trainer wages for days utilized in training, fuel, stationery, venue and snacks/lunch if used, one day for organizing the trainings for each approach and follow-up visits for monitoring if needed. Refresher training costs included the allowance, transport, monitoring if needed and one day of organizing.

To determine time taken to deliver the main and refresher CAWT trainings, the number of training units, number of farmers trained, number of facilitators conducting the training and the numbers of days were considered.

3. Study approach

3.1. Study area

The study was conducted in Machakos County Kenya, specifically in Machakos, Kangundo and Mwala Districts[1] (Figure 1). The three districts were selected based on the agro-ecological zones found within the County so as to represent the highest, mid and lowest altitude zones respectively. Agricultural potential in the county is defined by altitude, therefore these districts represented varying productivity potential. Machakos County is one of the 47 jurisdictions of government devolution in Kenya with an area of 6,208 km^2 and a population size of 1,098,584 people, hence a population density of 177 people per km^2 (KNBS 2009). The county lies between latitudes 0º 45’ to 1º 31’ South and longitudes 36° 45’ to 37° 45’ East, located 64km southeast of Nairobi, and borders Embu, Muranga and Kiambu Counties to the North, Kitui County to the East, Kajiado County to the West and Makueni County to the South. The Kenya Integrated Household Budget Survey conducted in 2009 indicated that the county poverty index was 59.6 percent. It was rated position 33 (out of 47) in terms of poverty levels in the whole country.

[1] Districts have recently been renamed sub-counties in Kenya so any reference to district in this paper implies sub-county in current jurisdiction nomenclature.

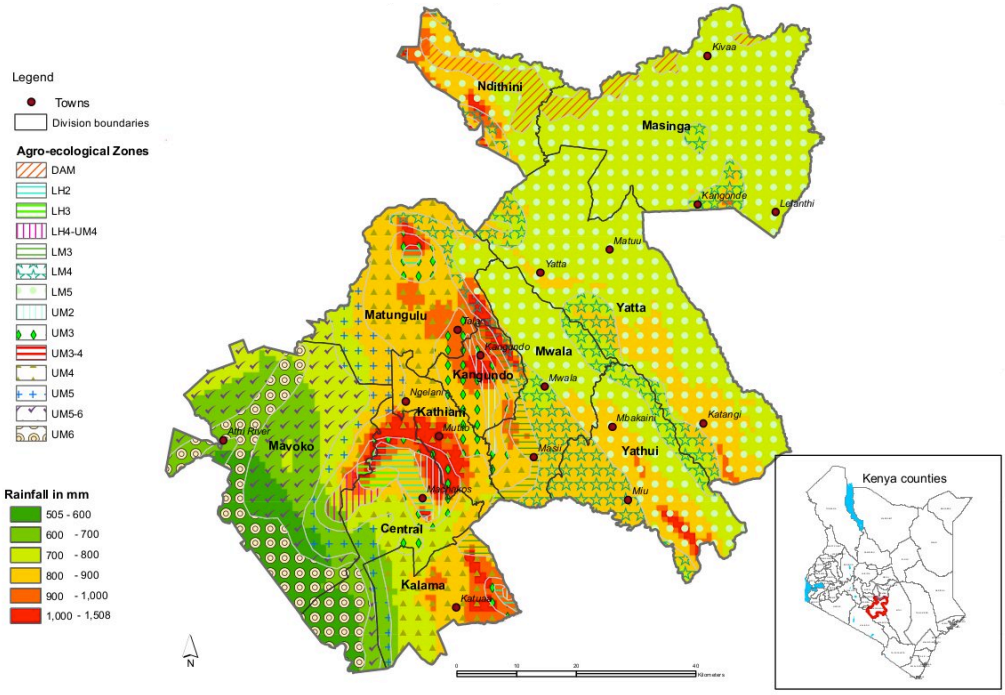

Figure 1. Map highlighting study areas in Machakos County (and indicating agro-ecological zones and rainfall)

As outlined in NEMA (2009), Machakos County is generally hot and dry, characteristic of a semi-arid climate and has a hilly terrain with altitudes ranging from 700m to 1700m above sea level. It experiences a bimodal rainfall pattern, with long (but unreliable) rains falling between March and May, and short (but more reliable) rains between October and December. The annual average rainfall ranges between 500mm and 1300mm. There are significant regional and seasonal variations within the county and rainfall reliability is quite low. Mean monthly temperatures vary from between 18^0C to 25^0C. The coldest month is July while October and March are the hottest. The highland areas, which receive higher rainfall, consist of 26 percent of the total area in the county and are more suitable for rain-fed agriculture than the lowland areas, while the plains support ranching.

The main economic activities of the people within the county are agriculture, commercial business and trade. Due to the climatic conditions, the main crops produced include maize, pigeon peas, cowpeas, millet and sorghum, while the main livestock kept are goats, cows, donkeys and poultry.

3.2. Study methods

This study was part of a wider project that sought to establish the factors likely to influence scaling up of Evergreen Agriculture, specifically CAWT, in Eastern and Southern Africa. This

study focuses on agricultural advisory approaches that could be utilized for scaling up CAWT in Machakos County.

The method selected for advisory approach assessment was based on a pre-post experimental design. Data was collected through key informant interviews and a household survey sought to establish a baseline for monitoring changes in farmers' practices, as well as assess the effectiveness of the outcomes achieved following the project interventions. Data to assess efficiency was collected through time and budget allocations by each approach to deliver CAWT trainings. This working paper uses baseline data to assess effectiveness so only hypothesis framing is possible from the assessment. A detailed assessment of the effectiveness of each approach in delivering and promoting uptake of CAWT will take place after the second, or post intervention survey.

3.2.1 Selection of agricultural advisory approaches

Information on the agricultural advisory approaches and agricultural projects present in Machakos County during project inception was collated through desktop review and key informant interviews with extension officers and participants at a project launch meeting that took place in July 2011 (see Appendix 1). The most prominent agricultural advisory approaches under implementation were found to be mainstream government extension and a range of participatory approaches used by non-governmental organizations (NGOs) such as Farmer Field Schools (FFS) and Landcare (definition is given further below).

The Ministry of Agriculture (MoA)[2] was selected to represent government extension as they deliver agriculture and crop related training and are the default advisory approach in Kenya. The selection of the NGOs and their associated approaches was based on: where they worked (presence in at least one of the three selected study districts), having previously trained farmers on agriculture/agroforestry and working at a sufficiently large scale within Kenya to demonstrate capacity to scale-up Evergreen Agriculture. Based on the stated criteria, World Vision (Kenya) and the Kenya Network for Dissemination of Agriculture Technologies (KENDAT) were selected.

World Vision (WV) is a prominent NGO in southeastern Kenya and has an area development programme in Mwala, one of the focus districts for this study. WV implements the FFS approach in the area. KENDAT worked with smallholder farmers through the Landcare approach in Kalama Division of Machakos District. Kalama Division has similar agro-

[2] The Ministry of Agriculture was renamed Ministry of Agriculture, Livestock and Fisheries after the initiation of this study, but in this paper will be referred to as MoA.

ecology to most of Machakos District, the only exception being the more humid Mua Hills area (Figure 1).

The Landcare approach is an innovative community-based and -led system, which focuses on developing social capital and building farmer groups from a grassroots perspective. The approach can be defined as a community-led natural resource management process focusing on empowering local people to willingly take action on local problems, with political and financial support by local government and technical support from other stakeholders. The approach combines sharing knowledge on relevant technologies with group capacity building and networking geared towards changing attitudes and stimulating new ideas among land users. Landcare has gained prominence as a farmer advisory approach in various parts of the globe (Catacutan et al 2009). In East Africa, Landcare was initiated in Uganda in 2002 but has since spread to pilot sites in Kenya, Tanzania, Ethiopia and Rwanda. These cases, along with well-documented use of Landcare in the Republic of South Africa and in the Philippines, suggest that this approach could be a valuable tool in scaling up CAWT in East Africa. As such, the study had a particular interest to assess the Landcare approach.

The Farmer Field School (FFS) approach is a participatory adult education approach; centred around an informal 'school without walls' where farmers are taught basic agro-ecological and management skills (Khisa 2004, Davis et al 2010). Groups composed of 20-25 farmers, commonly farm a communal piece of land where they meet regularly over the course of the growing season, learning, observing, experimenting and discussing practices and results. The approach was developed in Southeast Asia through an FAO project. FFS implementation started in East Africa in 1995 and, in general terms, participation has resulted in increased production, productivity and income (Davis et al 2010).

Key informant interviews using a semi-structured questionnaire were also used to obtain more information on how the organizations implemented the three selected advisory approaches (MoA, Landcare through KENDAT and FSS through WV[3]) in the county. More details on the advisory approaches as obtained from the key informant analysis are presented in the results section.

3.2.2. Group selection in each advisory approach and district

One common element in many advisory approaches is the use of farmer groups to disseminate information and receive feedback on promoted technologies. Working with farmer groups is

[3] In the rest of the paper the term approach may be used to imply the organization implementing the particular approach as listed here

seen as more efficient and able to empower farmers in the innovation system, aimed at a variety of purposes and functions such as utilizing, sharing, generating and applying knowledge and information (Heemskerk and Wennink 2004). All three selected approaches used farmer groups for information dissemination, and the study therefore focused on farmer groups rather than individual farmers in assessing the approaches.

There was a large variation in the number of farmer groups that the selected approaches were working with in the county, thus necessitating sampling through criteria to ensure good representation of the groups under each approach and site. The criteria for inclusion included the groups' main activity (agriculture-related) and membership of less than 40. The advisory approaches provided lists of farmer groups they worked with in the selected districts. MoA worked with a large number of groups, so stratified random sampling was used to arrive at the sample based on location and gender (including youth, male and female groups).

Of the 20 or so groups that KENDAT had introduced to the Landcare approach in Kalama Division, only 10 were active at the time of the study so all were selected. For WV, eight groups were selected using stratified random sampling based on gender, location and the length of time they had worked with the groups. A total of 44 groups were therefore selected as shown in Table 3.

Table 3. Number of selected groups and total number of group members and those surveyed from three farmer advisory approaches in three districts of Machakos County

Approach	District	Total number of groups listed	Number of groups selected	Total members of selected groups	Members surveyed
Ministry of Agriculture	Machakos	69	7	173	85
Ministry of Agriculture	Kangundo	127	11	250	110
Ministry of Agriculture	Mwala	52	8	228	77
World Vision (FFS)	Mwala	31	8	191	77
KENDAT (Landcare)	Machakos	10	10	263	84
Total			**44**	**1105**	**433**

3.2.3. Survey of CA/AF adoption and current practice

Once groups were selected, a survey was conducted to obtain information that would be used to assess smallholder farmers' knowledge and practice of agroforestry (AF) and Conservation Agriculture (CA), past trainings related to agriculture, social networks and other land management technologies that existed before initiating the project. A total of 1105 farmers was considered as the target population for this survey being the sum of all members of the 44

selected farmer groups. To achieve 95 percent confidence interval threshold, a minimum of 295 respondents was necessary for the survey, as determined using the equation below:

$$n = \frac{N}{1 + N(e)^2}$$

Where: n is the sample size, N is the population size, and e is the level of precision (Yamane T 1967).

In order for the survey to serve as the baseline to monitor adoption of the technologies after the project had delivered its training, an initial sample of 433 was selected, being higher than the confidence interval requirements (295) to allow for changes over the seasons such as farmers and/or groups leaving the project midstream. Members of the selected farmer groups were stratified into two sex-based categories: male and female. After stratification, respondents that were to be involved in the survey were randomly selected for interview.

Data collection through took place in May 2012, shortly after crop harvest to minimize recall error on crop productivity data. The information collected included general household and farm characteristics, land preparation and other farming activities, crop and tree productivity, knowledge and trainings received on AF and CA as well as social networks among farmers and other key players in the agricultural field. Enumerators were trained and the questionnaire pre-tested to ensure its applicability before the data was collected.

3.2.4. Training of extension staff as trainers of farmers

Following the survey, ICRAF staff and consultants trained extension officers and facilitators from the three selected institutions (MoA, WV and KENDAT) on the principles and practices of Conservation Agriculture with Trees in June 2012. The purpose of the training was to build the capacity of the officers, who would in turn train the farmer groups selected in their area on CAWT (Table 4). The training comprised three days of theory and two days of practical sessions. It covered topics such as an understanding the importance of Conservation Agriculture (CA), what constitutes CA including the main principles, the equipment used, the role of cover crops, weed management and incorporation of agroforestry practices in CA to comprise CAWT.

Table 4. Number of extension officers trained from each advisory approach on CAWT

Approach	District (site)	No. of extension officers trained
Government	Machakos	11
Government	Kangundo	8
Government	Mwala	7
WV	Mwala	9
Landcare	Machakos (Kalama Division only)	4
Total		**39**

Following training by ICRAF, the extension officers were facilitated to train the selected groups on CAWT based on the training they had received. Prior to the training, each organization had been requested to describe the approach they would normally use to train farmers. A brief on the logistics needed for preparation and the number of days required for effective farmer training of the CAWT package was also requested. The technology package was the only consistent factor in the training while costs and time needed for training varied between approaches as they had independently described. Based on the description of methods, budgets for the training were developed for each organization to reflect direct costs needed to deliver the CAWT training as described, but not to cover other costs associated with their workplace.

In all cases the main training was conducted between August and October 2012 before the planting season and a refresher training conducted between February and March 2013 after the first season in the study and before the second season.

MoA and WV carried out the main training in two phases with the first phase being a three-day theoretical training on the principles of CAWT, and the second phase a two-day practical training on use of CA equipment and agroforestry. The main difference between the two was that WV used their own staff for the theoretical training but also invited MoA staff for the practical part. Lunch was also provided to WV groups during training while no food was provided to MoA groups. The MoA approach included follow-up monitoring visits, which WV and KENDAT did not include.

For Landcare groups (KENDAT), training was delivered to each training unit (a number of groups clustered together) for two days, one day for theory and one day for practical. In each site a one-day practical refresher training was provided.

3.2.5. Data analysis

Diversity of farm enterprises, crop productivity and farming practices were collected as part of the survey at the initiation of the study. This data was analysed to identify differences between sites and respondents under the advisory approaches as well as to measure the level of CAWT practice in each project site. For yields of agricultural crops, respondents reported harvested quantities in kilograms or as bags, tins or *debes*, which were then converted to kilograms. Harvested quantities of maize did not consider green material used for livestock feed. Descriptive statistical analysis and calculation of correlation coefficients were used in the analysis. All the analysis was completed with a 95 percent level of significance. The

correlation tests carried out included Spearman rank, Kendall, Point biserial, Rank biserial, Cramer V and Phi coefficients.

The practice of agroforestry that depicts CAWT was assessed by taking an inventory of all the trees the farmer had established in cropland, but excluding those in woodlots and external farm boundaries. Analysis of the tree data was conducted using BiodiversityR to produce diversity indices, species accumulation curves, rank abundance curves and Renyi diversity profiles that depict tree species diversity in the farms. Descriptive statistics and frequencies were generated for each of the variables. Species richness was calculated as the number of tree species that had been recorded in the farms per site (district) and advisory approach.

As part of the survey, respondents were asked to list up to 10 people they would consult if they considered that their crop was not healthy. Within social network analysis the respondents and the people or organizations they name are called nodes or actors and the connections between nodes are called ties. In this study the number of ties between members of the same groups, advisory approaches and broader social network were measured and described. The results from this section were analysed using Social Network Analysis (SNA) conducted through UCINET (Borgatti et al 2002) and displayed through R – igraph package (Csardi et al 2006).

Network densities were calculated as the observed number of ties in a network as a proportion of the total number of possible ties given the number of nodes. This calculation assumes that everyone in the network could be connected and assesses the density based on that. Network maps were used to show the level of cohesion between those surveyed in each approach and district.

4. Results

4.1. Agricultural advisory approaches used by selected organizations in Machakos County

The results from the desktop review and discussions with key informants on agricultural projects under implementation in Machakos County during the study period are summarised in Appendix 1. Based on the selection criteria described in the methods section, World Vision (WV) was selected to represent the NGOs using the FFS approach. The Ministry of Agriculture (MoA) was selected as the main government advisory approach, while KENDAT was selected due to its interest in Landcare and previous work on Conservation Agriculture.

Responses to key informant interviews with officers from each selected institution about their advisory approach are expounded below.

4.1.1. Ministry of Agriculture (MoA)

The MoA is the default and most extensive network for dissemination of agricultural technologies in the county. A number of MoA extension officers from Mwala, Kangundo and Machakos Districts were interviewed in April 2012 and their responses to guiding questions summarised.

The ministry generally implements government and donor projects and usually partners with other development organizations to implement activities. A number of different advisory approaches have been used depending on the preference of the partner leading each project. Such approaches include:

- Group approach, which for instance had been used for a recent project on high-value crop seeds, which needed groups in order to train a large number of people together. This approach is generally cost-efficient but adoption rates can be low if not well monitored.
- Demand-driven, individual farm contact with extension officers. In this approach the farmer may visit the agriculture extension office for advice on a situation or provide logistical support for an extension officer to visit their property instead. The approach is generally found to have high adoption rates among those trained, but is not very efficient in terms of outreach and staff resource allocation.
- NALEP. This approach concentrated on one focal area, usually a division per year, and farmers either formed new groups or identified opportunities and gaps in their existing common interest groups. Technology was delivered along with group capacity building aspects such as leadership training and group dynamics, as well as value chain development.
- Farmer Field School (FFS; expounded on earlier). This approach had been used with six groups in Kalama Division and one group in Machakos Central Division. The approach was considered effective but takes a long time (1 year) and was seen to have high implementation costs.
- Open public events such as field days, agricultural and *barazas* (village meetings facilitated by local administration) for sensitisation on agriculture technologies. This approach is usually applied for general information distribution and may not lead to adoption of a technology on its own.

Generally, MoA had been moving from T&V (individual farmer) to use of group approaches because of financial limitations. Priority projects were also being identified in a more demand driven way with officers following guidelines associated with the specific programme being

implemented. Implementation plans are usually drawn up at district level implying that levels of success in promoting various agricultural technologies vary with districts because of variations in projects and approaches that various partners implement in different districts.

4.1.2. World Vision

Usually WV selects an area where it initiates an area development programme (ADP) and then focuses resources in the area for 10-15 years. Within the Mwala ADP, the Farmer Field School (FFS) approach had been used to disseminate agricultural information primarily on greenhouse farming, conservation farming using zai pits, goat-keeping, bee-keeping and tree nursery establishment. The WV approach differed from the normal FFS approach in that WV invested in an area for longer than a season such that the FFS could continue for more than one year and engage in several enterprises. Meals were also often provided during meetings and trainings, unlike other FFS-based projects. WV facilitated MoA officers to provide technical expertise to the FFS while WV staff supported the groups with the necessary inputs and follow-up visits. Key stakeholders in the area, usually district government staff, generally selected groups for inclusion in the WV programme. The groups, usually constituting 20-30 members, needed to be established with governance structures and an agreed piece of land on which to hold the FFS sessions before WV included them in their programme. In addition, the organization used field days, exchange visits and promotion of marketing groups to deliver advisory services. For a new project such as CAWT, WV would add the training onto the existing FFS groups.

4.1.3. Landcare approach by the Kenya Network for Dissemination of Agricultural Technologies (KENDAT)

KENDAT initiated the Landcare approach in Machakos County after their staff were sensitised and trained on the approach in Australia and South Africa. The Landcare approach involves community-based facilitators or coordinators who are central to the whole advisory process. They are trained to work with the groups and link them to extension officers and other information sources based on the needs expressed by the group members. Training is conducted with the whole group and the members are encouraged to share experiences. The community-based coordinators also help groups develop their soft skills, governance structures and independence in both fundraising and problem solving.

To introduce Landcare in Machakos, KENDAT selected 20 pilot groups in consultation with MoA staff. The selection was done from among groups that had earlier been formed to address land degradation issues and raise members' income. The participating groups were clustered on geographic/catchment basis for ease of administration. Most of the groups within the same catchment were within 2-3km of each other, thus facing similar natural resource

management issues and using the same cropping systems. As part of the Landcare approach, the pilot group members undertook a participatory exercise to identify their needs and concerns, prioritise these and consider solutions. KENDAT supported the groups with training on tree nursery establishment and Conservation Agriculture technologies as part of solutions to the identified environmental degradation concerns. The groups received technical support between 2005 when the Kenya Landcare Network was established and 2010, when the last funded project in the area was completed. Since that time a Landcare coordinator has continued to support group activities on a voluntary basis.

The Landcare piloting process in Machakos had a few deviations from the established Landcare programs from other parts of the world. One such deviation was that KENDAT played a central role in training of groups because the capacity of most coordinators had not been significantly developed for them to provide group facilitation. With time and funding the coordinators' role will grow, but at the time of this study Landcare in Machakos could still be considered to be in the development phase. Second, there were no formal or deliberate linkages established between the groups although interactions occasionally occurred during field days and training activities organized by local government, MoA and other government departments, as well as NGOs operating in the area. The most frequent interaction was with the Landcare coordinators who were assigned a cluster to administer and coordinate activities. Through this coordinator, the groups were able to share ideas, information and experiences.

4.2. Effectiveness of selected advisory approaches to influence farmers to practice sustainable agriculture

The framework for effectiveness outlined in section 3 of this paper was applied to the baseline survey results. Outlined below are the results for diversity of farm enterprises, crop productivity, information transfer and social capital for respondents under each advisory approach and site. Although the Ministry of Agriculture (MoA) was considered as one advisory approach results are reported separately for each district. This decision was arrived at based on the semi-independent planning done at district level (as earlier stated) and because delivery and results were not consistent between the districts.

4.2.1. Enterprise diversity and crop productivity data

The most common farm products obtained by respondents from their plots were food (grains), fruit, fuel wood, manure/compost, fodder, vegetables, livestock and livestock products (see Appendix 2). These products are herein considered as farm enterprises. There was a significant enterprise diversity difference between the approaches and sites. Landcare respondents had the most diverse farms since they had the greatest percentage of respondents with seven to ten enterprises with some respondents recording up to 12 enterprises, more than

those under other approaches. Most respondents from MoA Kangundo had a slightly lower enterprise diversity of between six and ten enterprises while MoA Machakos, MoA Mwala and WV had similar and lower enterprise diversities of eight or below.

Respondents from Mwala District, both under WV and MoA, who reported having livestock and associated enterprises on their farms were significantly fewer than in other sites. However, within the district (Mwala), more respondents from MoA groups produced vegetables, fuel wood, charcoal and manure/compost than those from WV groups. This finding is surprising because half of the respondents from WV groups had been working with WV for four years before the survey and had been provided with greenhouses in 2010. The provision of greenhouses did not reflect in the farm enterprise results as only 29 percent reported producing vegetables on their land, which was lower than those from the other approaches. Landcare respondents had vegetables, fodder, livestock, timber, fuel, charcoal and manure/compost more often than those from MoA in the same Machakos District.

Almost half (49 percent) of the households surveyed planted five main crops on their farms. Respondents from Mwala district (both WV 89.6 percent and MoA 93.5 percent groups) had a higher number of crops (mostly four or five) compared to those in Kangundo and Machakos where most respondents had three or four crops. More respondents from both Landcare (18.1 percent) and MoA (15.1 percent) from Machakos District had two crops compared to the other districts.

Most respondents practised intercropping (92.8 percent) with highest percentage recorded from MoA Kangundo respondents (97.3 percent). Few respondents (4.8 percent) practised crop rotation while almost a third practised monocropping (29.3 percent). More respondents from WV Mwala practised monocropping than from the other approaches (51.9 percent), including MoA (27.3 percent) respondents from the same district.

Maize had the highest production of the four main staple crops present under all approaches and sites (Table 5). Maize average yields ranged from 468.81kg per acre under MoA Machakos to 919.70kg per acre for MoA Mwala respondents. The yields for maize show standard deviations, often equal or higher than the average. However, the large n values in the study suggest that some information can still be taken from these averages. The full range of values for maize yields can be seen in **Figure 2** confirming the trend shown by the averages but suggesting the differences between approaches may not be as large as the averages suggest. WV respondents had the highest bean yield followed by respondents from MoA Machakos.

Table 5. Average harvest per crop (kg per acre) by advisory approach and district

Area and advisory approach	Rainfall Oct. 2011 – Feb. 2012 (mm)*	Crop yields Short rain season Oct. 2011 – Feb. 2012 average (kg/ha) (SD)			
		Maize	Beans	Cowpeas	Pigeon peas
Machakos– MoA n= 86	263.3	1158 (1103)	384 (471)	247 (232)	266 (384)
Machakos – Landcare n= 83	263.3	1511 (1662)	376 (338)	165 (212)	117 (188)
Kangundo – MoA n= 110	869.1	1329 (1922)	198 (249)	25 (21)	140 (160)
Mwala – MoA n=77	384.1	2273 (3187)	310 (273)	248 (262)	175 (220)
Mwala – WV n=77	384.1	1548 (1437)	392 (695)	193 (187)	197 (250)

* *Source of rainfall data: MoA, Machakos County and included October 2011-February 2012 figures as they would have affected the growing season before the survey in May 2012. Figures in parenthesis are standard deviations.*

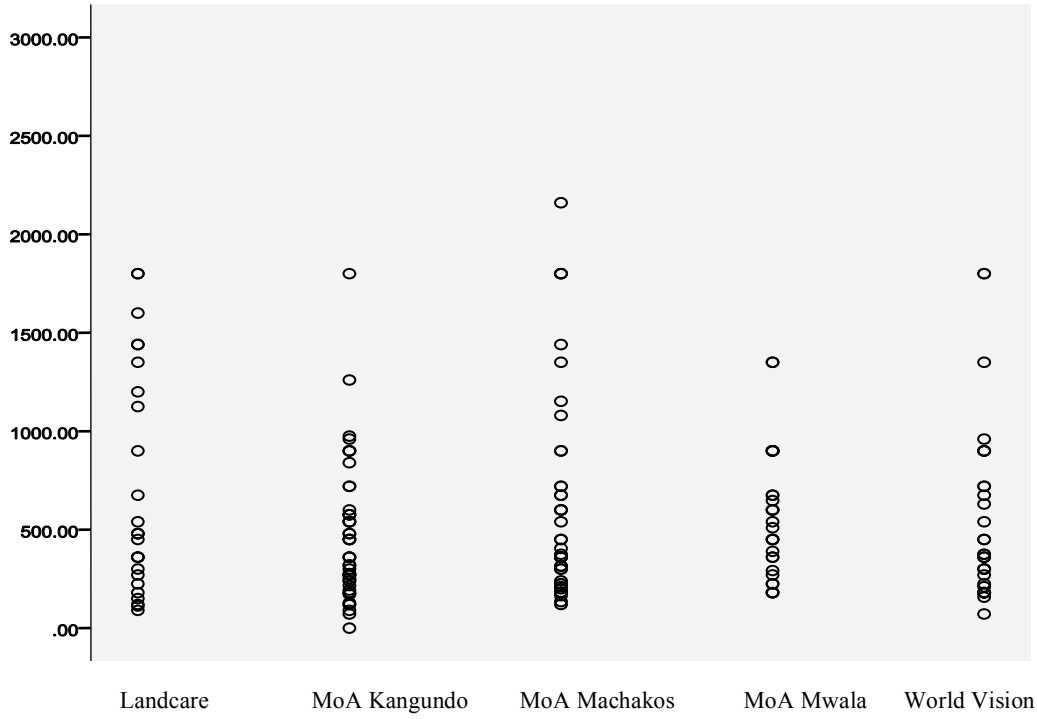

Figure 2. Maize yields (kg/acre) for each respondent grouped by advisory approach and district

Respondents from Kangundo District obtained the lowest or second lowest yields for all four main crops, even with the highest rainfall. Conversely Machakos District received the lowest rainfall but respondents from MoA groups obtained high yields for beans, cowpeas and pigeon peas while those from Landcare obtained comparable maize yields to Mwala WV respondents who received higher rainfall.

4.2.2. Training

Results indicated significant differences in the proportion of respondents' households that had attended any form of training in the three years preceding the survey. The highest attendance of trainings was by respondents from MoA Mwala groups followed by respondents from WV groups, while respondents from Landcare groups recorded the lowest attendance (**Figure 3**). Generally, only 17 percent of respondents' households had attended any agricultural training in the previous three years.

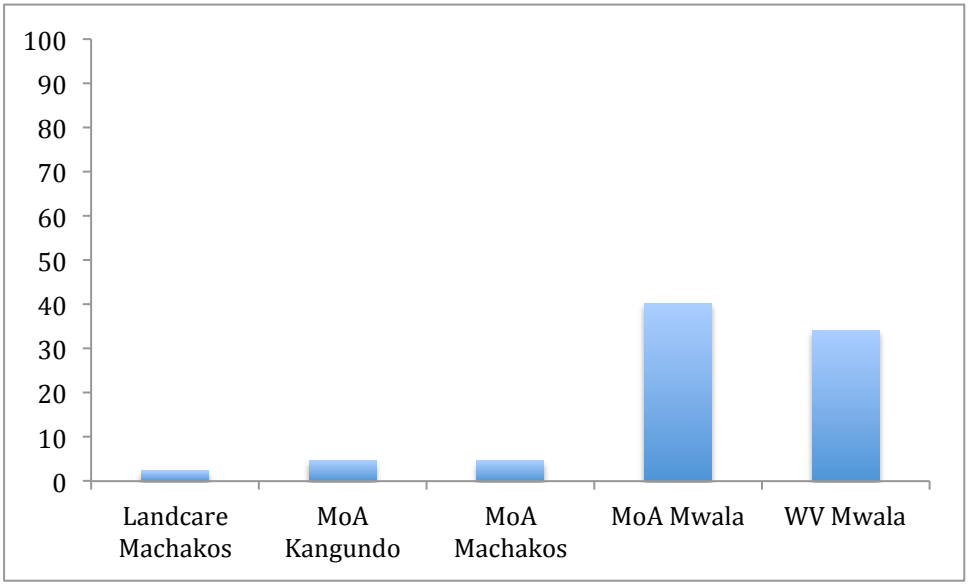

Figure 3. Percentage of respondents by advisory approach and district who attended training

The types of trainings attended by respondents were similar across the approaches with the most common ones attended being on agriculture, Conservation Agriculture and food security (Appendix 3). WV respondents were the only ones that had received training on manure making, greenhouse management and mango production. Most respondents from all approaches reported that they were practising what they had been trained on especially on agriculture, CA and tree planting.

MoA Mwala delivered most of the trainings attended by respondents and their households followed by WV (Table 6). WV Mwala respondents attended almost as many MoA trainings as WV trainings.

Table 6. Number of respondents who attended trainings provided by each approach and district

Training provider	Advisory approach and district					
	Landcare Machakos	MoA Kangundo	MoA Machakos	MoA Mwala	WV Mwala	Total
Ministry of Agriculture	1	6	2	16	11	36
KENDAT (Landcare)	1	0	1	0	0	2
WV (FFS)	0	0	0	9	13	22
Other	0	3	1	6	2	12
Total	2	9	4	31	26	72

Apart from training, 26.4 percent of respondents had access to information on CA and AF from other sources. The most common of these sources was radio (66 percent) followed by friends, media, relatives, periodicals and field days. More than half of the respondents (55.4 percent) from the Landcare groups received information from other sources, followed by WV (42.1 percent) and MoA Mwala (36.8 percent). Most respondents from MoA Kangundo and MoA Machakos depended on training as their main source of information with only 0.9 percent and 8.1 percent respectively obtaining information from other sources. Radio was commonly used among MoA and WV Mwala respondents while media other than radio was the main source for Landcare respondents.

4.2.3. Conservation Agriculture with Trees (CAWT) practices

CAWT is a combination of Conservation Agriculture (CA) principles with intercropping trees in the cropland, a form of agroforestry (AF). An analysis of respondents' understanding and practice of both CA and AF was conducted to see the impact of past training and any already occurring practices that align with CAWT.

Understanding of CA among respondents

A summary of the respondents' understanding of Conservation Agriculture is presented **Table 7** below. Only 2 percent mentioned CA as a combination of CA principles while more than half of the respondents (55 percent) reported that they had "no idea" what Conservation Agriculture was and 13 percent understood it as "conservation". Landcare groups had the least proportion of respondents with "no idea" of what CA is (14 percent) and the highest proportion of those who mentioned CA principles (7 percent). Respondents from other advisory approaches did not demonstrate an understanding of CA although close to one-third (29 percent) of respondents under MoA Machakos, understood it as "crop rotation". Past training on agriculture was not found to have significantly influenced understanding of CA among the respondents as 60 percent of those who had attended training reported to have no understanding of CA.

Table 7. Understanding of the term Conservation Agriculture by respondents under each advisory approach and district

	Advisory approach and district (percent)					
Understanding of CA	Landcare Machakos	MoA Kangundo	MoA Machakos	MoA Mwala	WV Mwala	Total
Combination of CA principles	7.2	0	2.3	0	0	1.8
Conservation	8.4	11.8	10.5	18.2	18.2	13.2
Crop rotation	0	0.9	29.1	0	2.6	6.5
High yields	13.3	0	1.2	0	0	2.8
Improving soil fertility	13.3	0.9	0	1.3	3.9	3.7
Minimum soil disturbance	2.4	0	1.2	0	0	0.7
No idea	14.5	77.3	46.5	70.1	59.7	54.7
Other understandings	31.3	8.2	9.3	6.5	14.3	13.6
Soil cover	9.6	0.9	0	3.9	1.3	3.0

Practice of CA

Crop association

Aspects of CA such as crop association, also referred to as intercropping, were commonly practised in Machakos. This practice was reported by 93 percent of respondents especially where maize was intercropped with legumes. Intercropping crops with trees was also practised by 76 percent of respondents. Crop rotation was however not a common practice and only 4.8 percent of respondents reported practising it. Crop rotation was practised more by Landcare (9.6 percent) and World Vision (7.8 percent) and least by MoA Mwala (1.3 percent) and MoA Machakos (1.2 percent) respondents.

Maintaining soil cover

The second CA principle of covering the soil is partly achieved through intercropping as a greater amount of the soil is covered by plant material when two or more crops are planted together. However, few respondents (5.1 percent) left crop residue on the field after harvesting and most cleared everything from the farm.

Minimum tillage

Minimum tillage, the other principle of CA, can be practised at several stages in the cropping cycle but mainly at land preparation, planting and weeding. Mindset change around tillage and use of the plough is however often cited as the most important change necessary for farmers to adopt minimum tillage (Anderson and D'Souza 2013) although there is some debate around this topic. For this study, only minimum tillage through use of sub-soiling or ripping at land preparation was considered to determine if a respondent was practising minimum tillage to capture the mindset change aspect.

Landcare had seven respondents practising minimum tillage. For the other approaches, only one respondent from WV and MoA Mwala and two from MoA Machakos practised. Six of the 11 respondents who practised minimum tillage during land preparation had learnt sub-soiling from KENDAT. Others reported having learnt it from NALEP, grandparents, themselves or copied from others.

The level of agricultural practices reflecting CA did not vary significantly between respondents under the different advisory approaches. Most respondents practised two CA principles especially in Kangundo (MoA) where all the respondents reported agricultural practices conforming to two CA principles (Table 8).

Table 8. CA practice level by advisory approach and district

	Advisory approach and district				
Level of practice	**Landcare Machakos n*=83**	**MoA Kangundo n=110**	**MoA Machakos n=86**	**MoA Mwala n=77**	**WV Mwala n=77**
Not practising at all	0.0%	0.0%	1.2%	0.0%	0.0%
Partly practising soil cover only	6.0%	0.0%	2.3%	1.3%	0.0%
Practising 1 principle	0.0%	0.0%	0.0%	1.3%	1.3%
Practising 2 principles	86.7%	100.0%	94.2%	96.1%	97.4%
Practising 3 principles	7.2%	0.0%	2.3%	1.3%	1.3%

*n= number of survey respondents

The influence of training in the previous three years on the practice of CA is not clear especially because many practices reflective of CA were carried out as a traditional form of farming rather than an intentional change to practice CA. Of the 13 respondents who had received training on CA in the three years prior to the survey, 11 practised two principles and only one practised all the three principles.

Increased understanding of the term CA did not correspond to greater practice levels. Respondents who had no understanding of CA, practised one, two and three principles and constituted more than half (56 percent) of those who practised two principles of CA.

Understanding of agroforestry (AF) among respondents

Respondents' understanding of the term agroforestry (AF) differed across the approaches and districts. A quarter of respondents understood AF as planting trees together with crops while 40.9 percent had no understanding of what AF entails. Most Landcare respondents (61.4 percent) understood AF as planting trees with crops while 18 percent had "no idea". For MoA Mwala and WV respondents, 26 percent said AF is planting trees on farm. The larger number who had no understanding of AF were respondents under MoA Kangundo and MoA Machakos.

Agroforestry practice

Most respondents (99.3 percent) practised agroforestry in that they had at least one tree established on their farm. Trees can be established in various niches in the farm such as boundaries, scattered in cropland and others. For the purpose of this paper, an agroforestry practice is taken as CAWT, only when there are trees established within cropland, either scattered or as hedges. Almost all respondents (95.6 percent) had at least one tree scattered or in hedges within cropland. This paper considers farms with more tree species established within them to have more focus on conservation and resilience than those with less.

Respondents from Landcare groups had larger farms than those from other approaches (mean of 1.6 ha) while those from MoA Kangundo District had the smallest land holdings (0.6 ha) as shown in Table 9. However, Kangundo farms had the highest number of trees per hectare (130) while those from MoA Mwala had the least (58).

Table 9. Land ownership and tree species diversity (abundance and richness) from different advisory approaches and districts

Advisory approach District		MoA Kangundo	MoA Machakos	MoA Mwala	Landcare Machakos	WV Mwala
Number of farms		110	86	77	83	77
Land ownership						
No. of farmers with no. of plots	1	55	66	52	57	47
	2	32	15	21	18	24
	3	11	3	3	7	5
	>3	12	2	1	1	1
Average farm size (total ha/ household)		0.55	0.87	1.28	1.61	1.35
Tree abundance (per ha)						
Mean		130	75	58	85	94
s.d		123	73	55	101	122
Species richness						
Total (AA)		57	62	53	65	65
Mean (per ha)		5.31_{ab}	5.30_{ab}	4.48_{b}	7.47_{c}	5.99_{a}
s.d.		2.47	2.54	2.42	3.14	2.77
% of farms with range of species	$0 \leq R \leq 4$	45	49	56	16	39
	$5 \leq R \leq 9$	49	43	40	52	48
	$10 \leq R \leq 14$	5	8	4	33	13
Shannon Index						
Total (AA)		2.52	2.95	3.05	3.21	3.04
Mean (per farm)		1.54	1.29	1.17	1.54	1.44
s.d.		0.50	0.39	0.52	0.50	0.42

Analysis of Species Richness

Species richness is the number of species that has been recorded for a specific group of organisms (only trees are considered in this case) during a specific time period and in a specific area. A total of 117 tree species were recorded from all the farms surveyed. A comparison of the sites under different advisory approaches shows that the respondents from the Landcare approach had more tree species established in their farms than other approaches and sites. A total of 65 species were recorded under the Landcare approach, which was similar to WV but the mean number of species per hectare was significantly higher under Landcare (7.5) than the others. The mean number of species per hectare observed in WV respondents' farms (6.0) did not vary significantly with MoA respondents in Kangundo and Machakos (both 5.3) but was significantly higher than MoA respondents in the same district (Mwala; 4.9).

The three sites under MoA did not have significant differences between them in terms of the mean number of species per ha. This observation was confirmed by the Shannon Index, which

placed the Landcare respondents at high diversity, both at site and mean farm diversity compared to the other approaches and sites (Table 9).

The Renyi profile (Figure 4) also shows that the Landcare approach had more evenness than the other sites while MoA Kangundo had the least evenness despite having more trees per hectare. This shows that a few species dominate the farms in Kangundo compared to other districts although the case is not very different in the other two MoA districts.

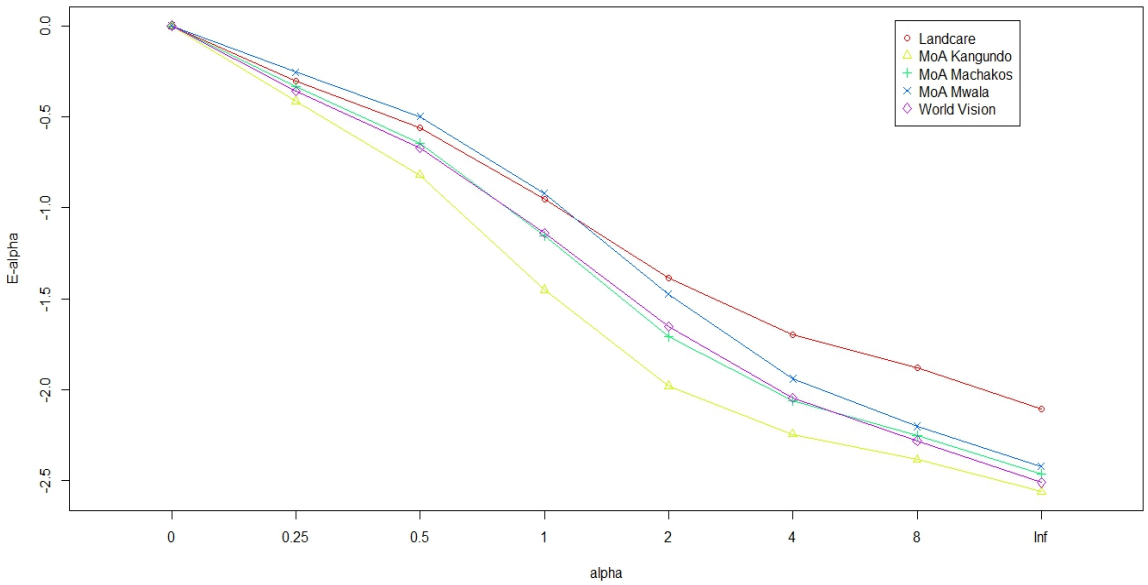

Figure 4. Renyi evenness profiles for tree species in districts under different advisory approaches in Machakos County

Mangifera indica, Grevillea robusta, Croton megalocarpus, Eucalyptus camaldulensis and *Persea americana* were the most common tree species in the county. However, as stated above, the tree species were not evenly distributed in the farms as shown in the rank-abundance curves below (Figure 5). Rank abundance is proportional abundance or the percentage of each species of the total abundance observed. From the specific rank-abundance curves of tree species in the districts under different advisory approaches, Landcare and WV show an abundance of species more than those under MoA Kangundo, Mwala and Machakos. The observation is also confirmed by the species accumulation curves plotted for the approaches and districts (Figure 6) which demonstrate that the species encountered in the Landcare approach respondents farms, and to an extent WV, are found in most of the farms. This is shown by the steep species accumulation curves of the two approaches that rise and flatten early above the MoA curves. The top ten tree species in each site are shown in Table 10.

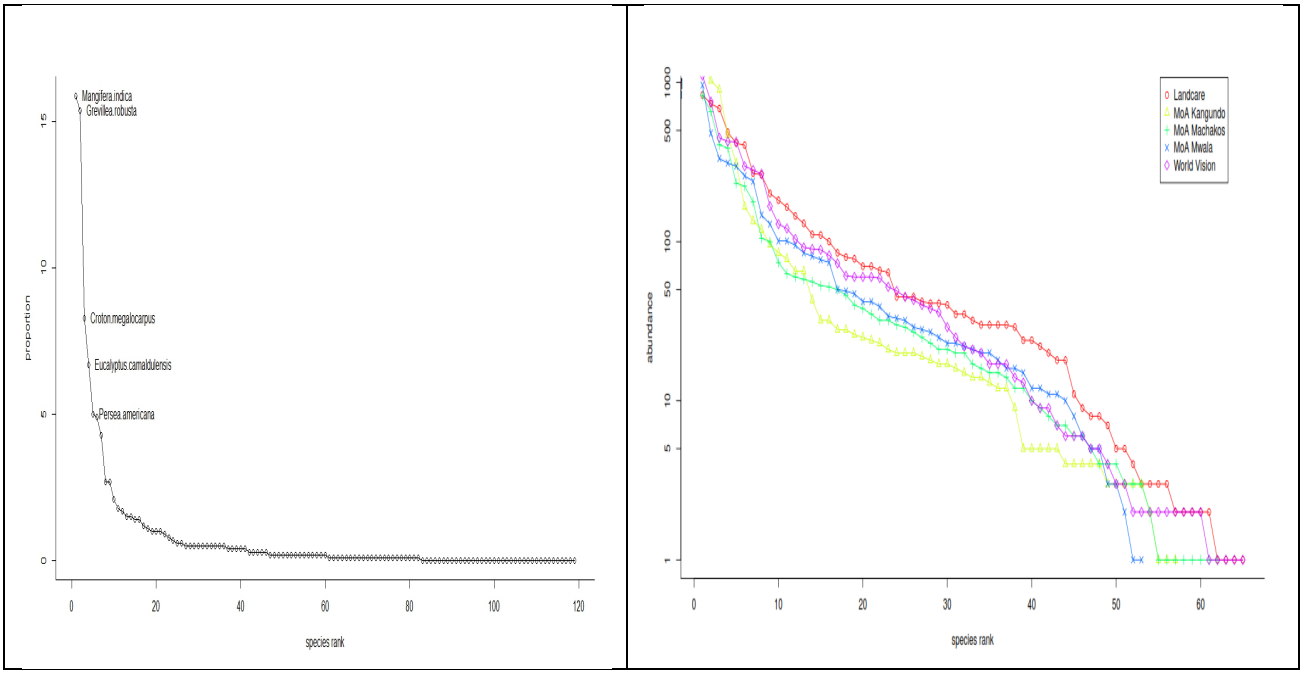

Figure 5. Rank-abundance curve for tree species in Machakos County (general – left) in districts under different advisory approaches (right)

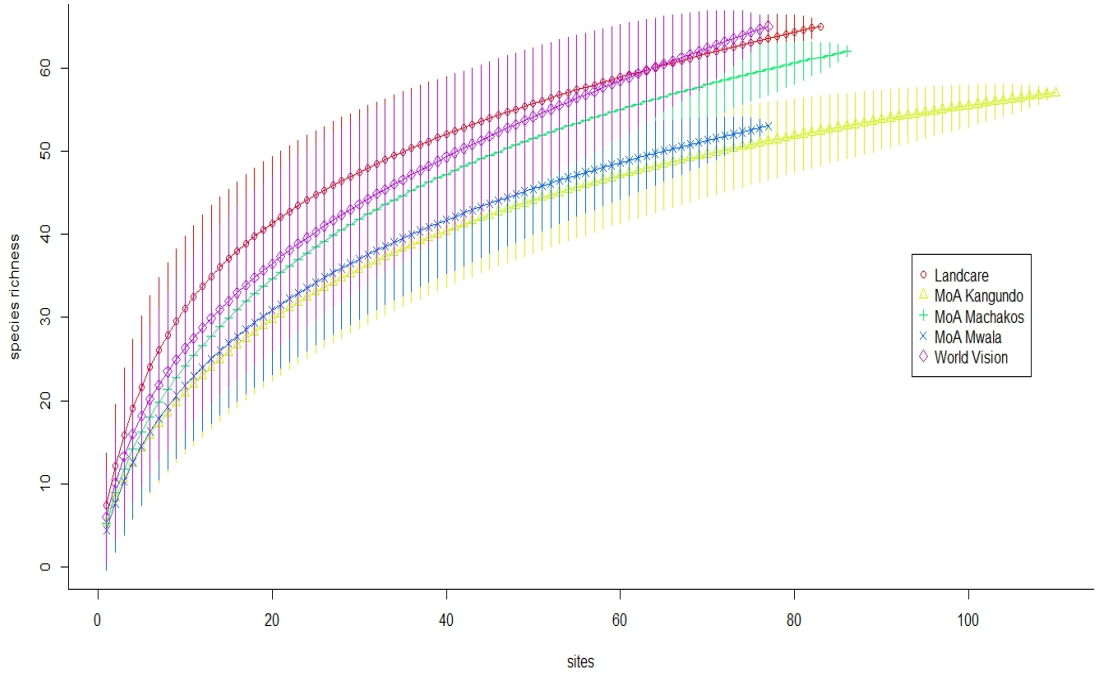

Figure 6. Species accumulation curves for tree species in districts under different advisory approaches in Machakos County

Table 10. Top ten most abundant trees species in farms in districts under different advisory approaches in Machakos County, rank is shown in parenthesis

	Kangundo	Machakos		Mwala		County
Species	MoA	Landcare	MoA	MoA	WV	Overall
Mangifera indica	90(1)	86(1)	55(3)	92(1)	79(1)	81(1)
Grevillea robusta	79(2)	64(3)	78(1)	29(4)	56(2)	63(2)
Persea americana	68(3)	82(2)	43(4)	13(9)	21(10)	48(3)
Croton megalocarpus	42(4)	52(4)	58(2)	26(6)	34(6)	43(4)
Carica papaya	16(9)	-	28(6)	36(2)	42(3)	27(5)
Acacia tortilis	20(7)	-	22(8)	29(4)	39(5)	25(6)
Eucalyptus camaldulensis	32(5)	28(6)	28(5)	-	-	21(7)
Citrus limon	19(8)	25(8)	13(9)	18(8)	23(9)	20(8)
Citrus sinensis	-	-	-	35(3)	29(8)	17(9)
Psidium guajava	24(6)	-	-	13(9)	-	15(10)
Senna siamea	-	-	-	25(7)	40(4)	13(11)
Acacia nilotica	-	-	24(7)	-	-	11(12)
Passiflora edulis	-	31(5)	-	-	-	10(13)
Syzygium cumini	-	20(10)	-	-	-	10(14)
Casimiroa edulis	-	-	13(9)	-	-	9(15)
Terminalia brownii	-	-	-	-	32(7)	9(16)
Acacia kirkii	-	22(9)	-	-	-	7(17)
Cupressus lusitanica	10(10)	-	-	-	-	6(18)
Acacia hockii	-	28(6)	-	-	-	6(19)

In summary, Landcare followed by WV, had more tree species diversity than the MoA respondents from the three districts studied. Kangundo had more trees per hectare but more of the trees were exotics and less species were present.

4.2.4. Information flow through Social Network Analysis

Social network analysis (SNA) was used to assess the network of people and organizations that farmers communicated with concerning particular agricultural practices under each advisory approach and district.

Contacts known to respondents on crop health

The number of people, named by the respondents as actors (nodes), whom they would consult on crop health issues from each of the advisory approaches are shown in **Table 11**. Of the 433 survey respondents, 94 percent named at least one actor they would contact when their crop was not healthy. One-tenth of the respondents named more than three actors while 6 percent did not name anyone, a majority of whom were under MoA Machakos. The groups from

Mwala district both under MoA and WV had more respondents who named more than three actors followed by Landcare Machakos.

Table 11. Number of actors named by respondents in each advisory approach and district

	Number of people named (percent)										
Advisory approach by district	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
MoA Kangundo	4.6	89.1	3.6	1.8	0.9	0	0	0	0	0	0
MoA Mwala	0	24.7	31.1	28.6	6.5	3.9	2.6	0	0	1.3	1.3
MoA Machakos	18.6	58.2	11.6	11.6	0	0	0	0	0	0	0
Landcare Machakos	3.6	41.0	26.5	12.1	10.8	2.4	3.6	0	0	0	0
WV Mwala	1.3	19.5	29.9	24.6	18.2	3.9	1.3	0	0	1.3	0
Total	5.8	**49.9**	**19.2**	**14.5**	6.7	1.8	1.4	0	0	0.5	0.2

Respondents reported different categories of actors (people or organizations) contacted for advice when they had concerns about the health of their crops. The categories are outlined in **Figure 7**. Overall, neighbours were the most contacted categories followed by agricultural extension officers. Extension officers played an important role as a source of information for MoA Machakos (63 percent) and Kangundo (48 percent) districts. Neighbours featured more prominently among respondents under WV (45 percent), Landcare (35 percent) and MoA Mwala (29 percent) followed by family members.

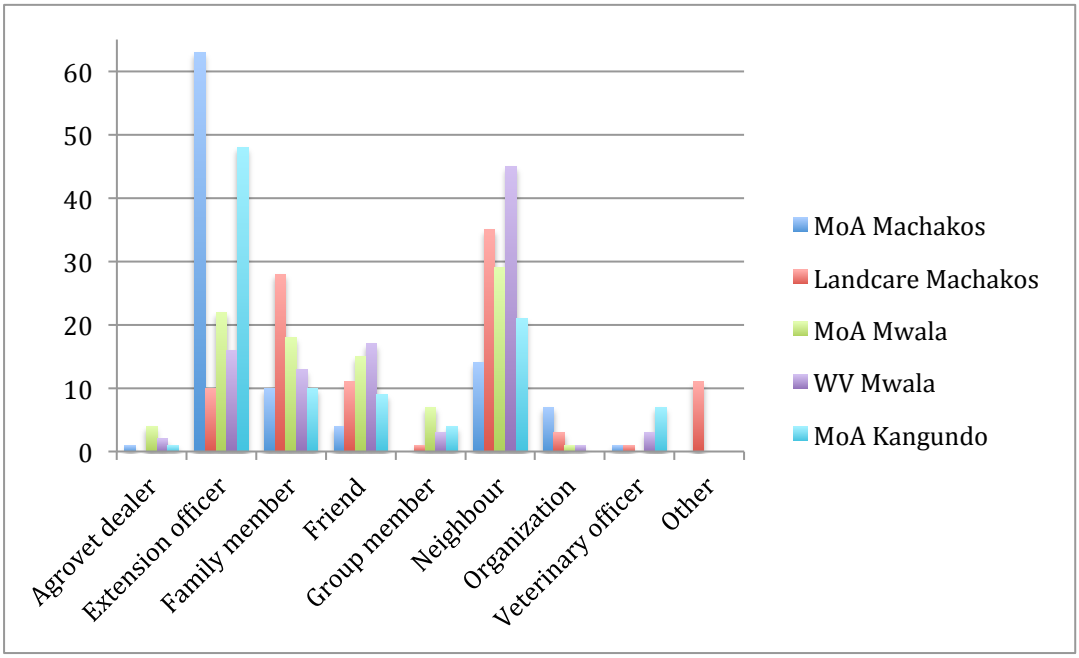

Figure 7. Categories of actors contacted by respondents on crop health issues under each advisory approach and district, shown as a percentage

Landcare, World Vision and MoA Mwala respondents contacted community members such as friends, family, neighbours and group members almost two-thirds of the time and contacted formal sources such as extension officers, organizations and others a third of the time. The opposite trend was found amongst MoA Machakos respondents while those from MoA Kangundo contacted both community and external formal sources almost equally.

Most respondents would contact extension officers in their district and some provided a name for the officer they would contact while others just said "extension officer". About one-quarter (24 percent) of respondents under MoA Kangundo and 69 percent under MoA Machakos provided a name for the extension officers. While for MoA Mwala, Landcare Machakos and WV Mwala the respondents provided names for 89, 82 and 78 percent of the officers they contacted, respectively. This suggests that respondents under Landcare (KENDAT), WV and MoA Mwala were more familiar with the extension officers and knew their names.

Connections between respondents and mentioned contacts

Half of the groups under WV and MoA Mwala had at least one tie (link between actors) between members of the same group (intra-group ties) while MoA Kangundo and Machakos each only had one group with intra-group ties (Table 12). For connections between individuals within the same advisory approach (inter-group), MoA Mwala had the highest number (41) and density but WV Mwala had a much lower occurrence of these connections. As not all groups from each approach and district were surveyed this is not a complete sample but rather gives an indication of the level of interactions within and between groups for discussion.

MoA Mwala respondents contacted group members and other individuals within groups under the same advisory approach and site (MoA Mwala) more than the other approaches and districts. Landcare respondents had high levels of interactions within the approach with 31 ties and a density of 0.005. This suggests that the advisory approach may create greater inter-group interaction than MoA Machakos. Other factors such as distance between groups could also influence this result. Both MoA Kangundo and MoA Machakos had low numbers of inter-group interactions to actors from included groups in the same approach.

Table 12. Number of intra-group and inter-group ties within and external of approach and associated network densities for each advisory approach and district

	District				
	Kangundo	**Mwala**		**Machakos**	
	MoA n=110	MoA n= 77	WV n=77	MoA n=85	Landcare n=84
Number groups with one or more ties between members (%)	1 (9%)	4 (50%)	4 (50%)	1 (14%)	3 (33%)
Number of ties between respondents in same approach and district (%)	13	41	13	2	31
Density of ties between respondents in same approach and district	0.001	0.007	0.002	0	0.005
Number of ties between respondents and any other actor in the network (%)	116	199	204	100	172
Density of all ties of respondents	0.005	0.006	0.004	0.006	0.004

n= number of survey respondents

The last row of Table 12 shows the density of connections (ties) between respondents from each approach and all other actors in their network. It is a calculation assuming that all actors could be linked to each other and is not restricted to their group or approach. These results show that MoA Machakos, Mwala and Kangundo all have high densities. This suggests that while respondents from both MoA Machakos and Kangundo had few ties between group members or actors under the same advisory approach in the district, they did have a strong network of connections to actors beyond their approach. More than half of all the respondents (52 percent) belonged to additional farmer groups with MoA Machakos respondents having the greatest percentage (66 percent). This may have provided MoA Machakos respondents with additional information sources and could have contributed to the overall density score.

The Landcare, WV (FFS) and MoA Mwala maps (Figure 8) show more interconnected ties while the MoA Kangundo and MoA Machakos maps show a number of single, unlinked ties with many respondents linked to only one node, for MoA Kangundo this was often an un-named extension officer.

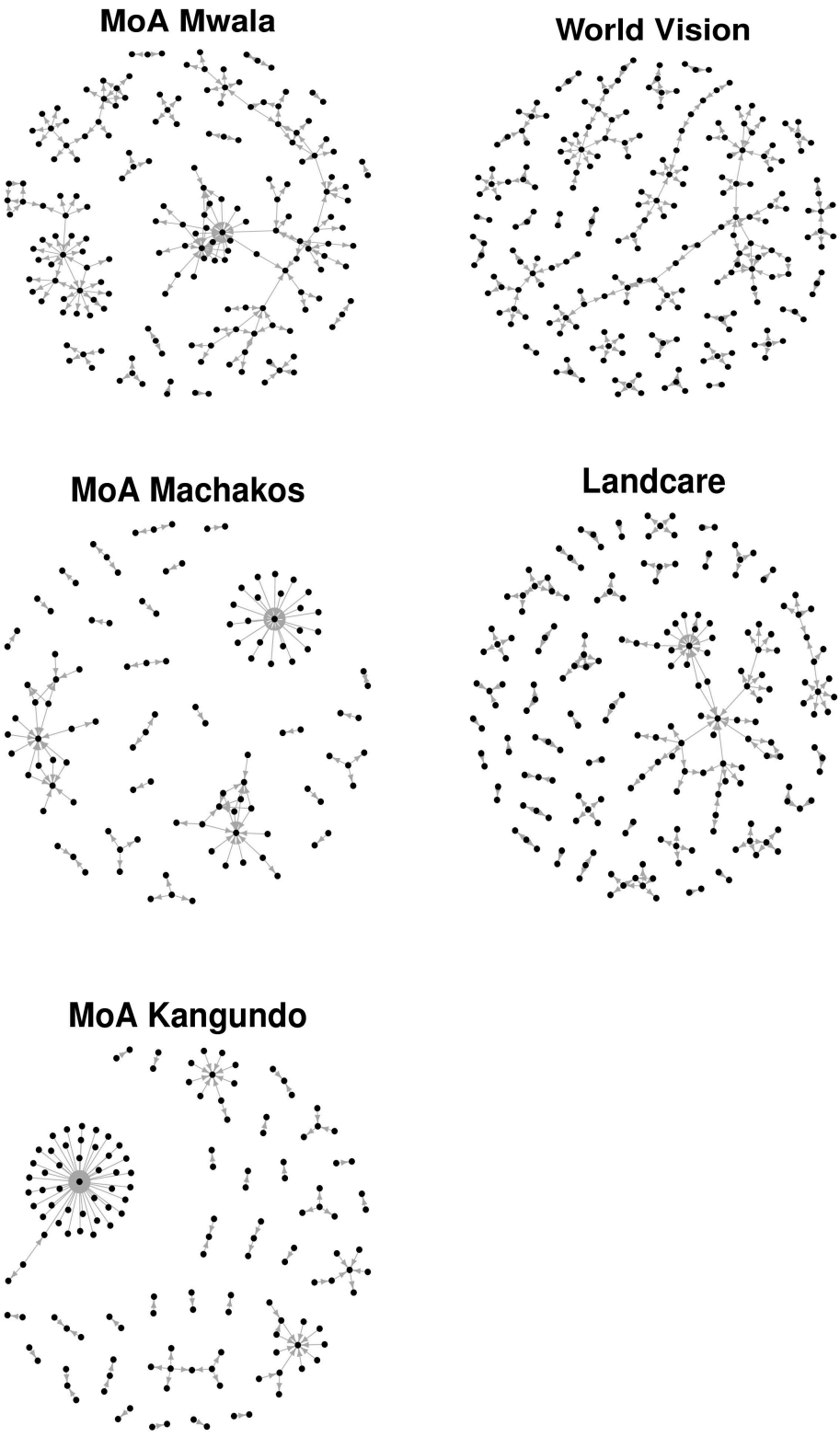

Figure 8. Advisory approach network maps for each district. Maps only include nodes (respondents) that contacted at least one actor

4.3. Efficiency of selected advisory approaches in delivering CAWT technologies to farmer groups

Efficiency of CAWT trainings under each approach were measured based on the delivery of a main and refresher training. Training costs, both financial and time, were recorded for each approach to deliver the CAWT training to their selected groups. Generally there were two trainers in each training session for all the approaches and districts. Information was collected on the number of farmers trained per group against the target number of farmers for the area as shown in Table 13. Women made up a greater number of group members for all approaches and as a result more women than men were trained. For all approaches, except Landcare, the participation levels for the refresher training were lower than that of the main training.

4.3.1. Financial cost analysis

The facilitators engaged by WV to train target groups under that approach managed to train a higher percentage of target farmers in both the main (97 percent) and refresher (91 percent) training sessions than the other approaches. Landcare had the least percentage (35 percent main training and 39 percent refresher training) of target farmers trained while in the sites under MoA a significantly greater proportion of target farmers was trained in Machakos district (88 percent main; 55 percent refresher) than Mwala (76 percent main; 50 percent refresher) and Kangundo (76 percent main; 45 percent refresher) districts. In summary, the mobilization potential of WV using FFS was significantly stronger and KENDAT using the Landcare approach was significantly weaker. For the MoA approach, Machakos performed better than Mwala and Kangundo districts for both trainings.

Table 13. Number of groups, target farmers and number and percentage of trained farmers by gender through the main and refresher trainings

District		Machakos		Kangundo	Mwala	
Advisory approach		MoA	Landcare	MoA	MoA	WV (FFS)
Groups trained		7	10	11	8	8
Number farmers in target groups		194	273	264	228	201
Number trained in main training on CAWT	**Female**	123	83	134	97	126
	Male	48	13	67	78	70
	Total	171	96	201	175	196
	% of target	**88**	**35**	**76**	**76**	**97**
Number trained in refresher training on CAWT	**Female**	81	90	89	64	125
	Male	26	18	31	50	59
	Total	107	108	120	114	184
	% of target	**55**	**39**	**45**	**50**	**91**

The cost of training farmers on CAWT through the three approaches in the three districts were collated and calculated at the level of each beneficiary for both the main and refresher trainings as depicted in Figure 9. Consistency was ensured in the number of days and budgets for training by MoA extension staff, which resulted in similar costs across the three MoA sites. The total financial cost of training a single farmer beneficiary by MoA ranged from Ksh 1,262 (Mwala) to Ksh 1,472 (Kangundo) which was significantly lower than KENDAT Landcare (Ksh 2,098) and WV FFS (Ksh 2,443). WV provided lunch to participants, which increased the cost to around double that of the MoA approach while the Landcare approach included higher facilitator fees, see Appendix 4.

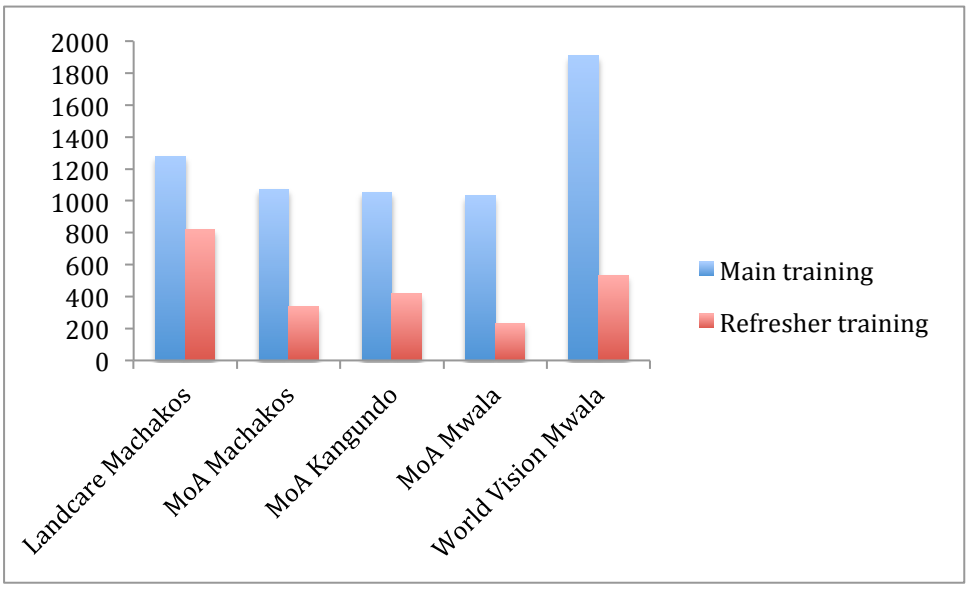

Figure 9. Cost in Kenyan Shillings (Ksh) of delivering the main and refresher training per farmer for each advisory approach in each district

4.3.2. Time costs analysis

Time costs were calculated as described in the methods and the time for the trainer (extension officer or facilitator) days per farmer are shown in Figure 10 and described in further detail in Appendix 5.

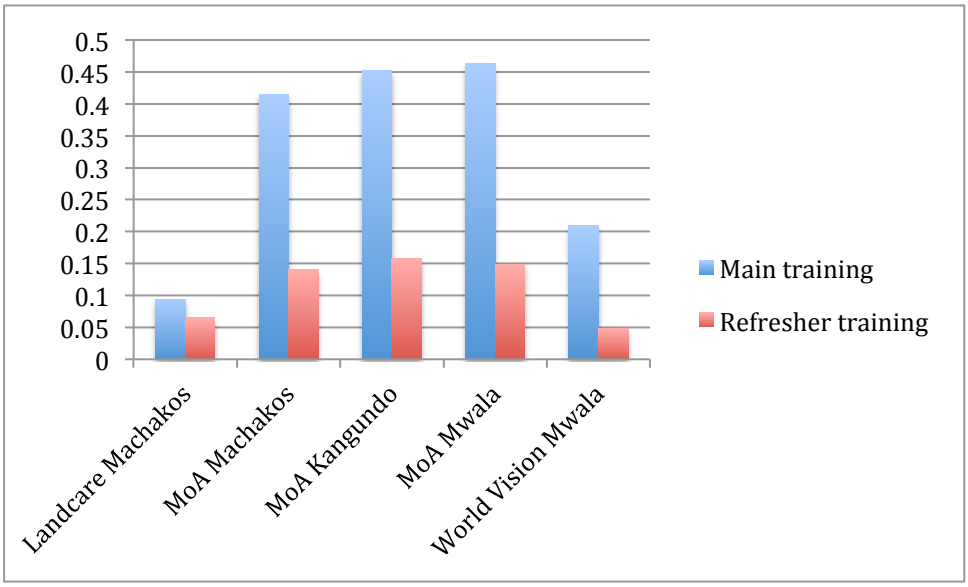

Figure 10. Time cost in trainer days per farmer for each advisory approach to deliver the CAWT main and refresher trainings

Time cost in extension officer days for MoA were similar across the districts. For Landcare and WV the time costs were much lower as they combined groups for training and so had fewer training units.

Table 14. Efficiency results combined

Advisory approach District	Total cost of training per farmer (Ksh)	Time cost in trainer days per farmer (overall)	Target farmers trained (%)
Landcare Machakos	2098	0.16	37
MoA Kangundo	1472	0.61	61
MoA Mwala	1262	0.61	63
MoA Machakos	1409	0.55	72
WV Mwala	2443	0.26	94

Overall results (Table 14) show similar financial and time expense and percentage of target reached under the three MoA sites. WV was the most expensive delivery approach in terms of financial expense but with low time requirements and the greatest mobilizing power. Landcare was also expensive to deliver, with low time costs but with a significantly lower mobilization potential. These results do not consider the quality of the training provided but that information will be available after a second survey of trained beneficiaries.

5. Discussion

Agricultural advisory services are an essential component of any program that aims to scale up sustainable agricultural practices such as Conservation Agriculture with Trees (CAWT). They provide the primary mechanism to disseminate information and develop skills in the community on CAWT practices. They can also foster capacity in the community to capitalize on collective access to inputs and markets. To inform the design of an agricultural advisory system for scaling up CAWT in Kenya, an on-going study aims to fill a knowledge gap on the performance, in terms of effectiveness and efficiency of existing advisory approaches in promoting CAWT related practices, with a focus on Machakos County. This working paper has provided information on the efficiency of the approaches in terms of financial and time costs. Baseline survey results have been shared to inform hypothesises on the effectiveness of the selected approaches.

5.1. Effectiveness

5.1.1. Enterprises, productivity and CAWT-related practices

Adoption of farming practices for enhanced diversity, crop production, conservation farming and social networks can be influenced by many factors. While the agricultural advisory approach a farmer is in contact with may be one important factor, the size and fertility of land, wealth and income, access to credit and inputs are some of the many other factors that can influence farming practices (Benin et al 2007, McCord et al 2015). This paper does not attempt to provide a final assessment of the effectiveness of each of the selected advisory approaches. Instead, it assumes that the advisory approach a farmer is reached through could have an influence on their farming practices and provides hypotheses for further study based on this.

The respondents selected through the Landcare approach, implemented by KENDAT, performed well using the criteria for effectiveness outlined in this study. They had the greatest farm enterprise diversities, the highest tree species richness overall and tree species per hectare of all the approaches. This is significant as it is predicted that farmers with a greater number of farm enterprises also have greater resilience and capacity to adapt to change (Martens et al 2013). This suggests that farmers under Landcare are more oriented towards building resilience and their capacity to adapt to shocks and climate change in their farming practices. This orientation which could be influenced by the Landcare approach as these results were not seen from farmers under the MoA approach in the same Machakos District and similar agro-ecological zone. Other factors may have influenced these results but a hypothesis from this study is that the Landcare approach builds resilience amongst its members more than the MoA approach.

Many respondents had received training from an organization different from the one under which they were selected for this study. For example, MoA Mwala officers trained many respondents from WV groups in the three years prior to the survey. In Machakos District both MoA and Landcare had provided the least number of training events to their members in the three years prior to the study when compared to the other districts. For Landcare this minimal training could be attributed to the fact that KENDAT did not have projects in the area after 2010.

Prior to 2010, KENDAT had provided trainings through the Landcare approach on both agroforestry and CA. The lessons from these trainings are reflected in the results as farmers under Landcare had the best understanding of CA and most could provide a definition of agroforestry. A small number of Landcare group members practised more principles of CA through applying minimum tillage during land preparation and KENDAT was referred to as the source of knowledge on sub-soiling. Of the Landcare respondents, 7.2 percent practised all three principles of CA on some of their land, which was more than the other approaches in the study. CA adoption rates for Africa vary greatly with reports coming from southern Africa of between 4 percent of farmland and 71 percent of target farmers practising some minimum tillage (Andersson and D'Souza 2013), while the practice level under the Landcare approach falls within this wide range it is at the lower end.

Respondents selected from MoA and World Vision groups in Mwala District performed reasonably against the criteria for effectiveness as they had high diversity of staple crops and high yields. Production of staple crops is important for food security and improved agricultural performance has often been promoted through agricultural extension by governments (Feder et al 2010). It can be hypothesised that food security was a major training theme in the district and the high yields could point to success of the approaches, particularly MoA. The post-intervention survey will provide further information to assess if this is the case. For other indicators such as enterprise diversity respondents from both approaches reported low numbers. WV farmers had greater tree species abundance than MoA in all sites and had a better understanding of the term agroforestry and more trees per hectare and greater species richness than MoA farms in the same district even though they attended less agroforestry related trainings.

An advisory approach that provides more knowledge to their end users, the farmers, is more effective than one that does not disseminate information. Training on new and relevant agricultural practices are important for farmers to learn new skills, adapt to changes and reach their sustainable production capacity. Both approaches in Mwala District provided more

training events and had greater attendance by group members, than the other districts. Some concepts from these training events appear to have been applied such as those on agriculture and food security by MoA groups while others appear not to have been implemented. MoA Mwala respondents reported more training on CA than other approaches but they had the second highest number of respondents with no understanding of the term and practice levels similar or below other approaches and districts. For WV groups in the district, the trainings on greenhouse management and making manure did not result in more farmers collecting vegetables and manure from their farms and for both these products MoA farmers in the same district who had not attended the trainings, collected more. A visit to some WV groups by the authors found that water harvesting and other issues such as the high costs associated with the greenhouses and limited ability to access credit to access finance had caused delays in their use but these results do not suggest high levels of application of trained skills under this approach.

Farmers from MoA Kangundo groups had moderate enterprise diversity but low staple crop diversity and low yields even though the district received the highest rainfall. The district had the highest number of trees per hectare; almost double most of the other districts, which could provide for a moderate overall productivity per hectare when crops and trees are combined. The tree species diversity in the district was low mainly comprising species exotic to the district, which could be a response to proximity to the Nairobi market as well as favourable climatic conditions including higher rainfall. A low training attendance was reported in the district and farmers reported little access to sources of other information on CA or AF suggesting the approach had not provided many opportunities to its members to learn new practices.

5.1.2. Information dissemination and collective action

The ability of each approach in the districts to transfer information and build connections between its members was considered as an indicator of effectiveness. Both approaches assessed in Mwala district (WV and MoA), as well as the Landcare approach had more groups that showed connections between members and better-linked networks. These connections may have been influenced by a number of factors such as the physical distance between group members. However, if the connections were influenced by the advisory approach, this would show the capacity of the approach to build social capital. This observation needs further investigation in subsequent post-intervention surveys.

Social capital can be defined as the norms of reciprocity associated with social networks and it can produce both collective and individual value (Putnam and Goss 2002). The World Bank (2011) identifies social capital as critical for sustainable development. The presence of social

capital is a necessary precursor for communities to work collectively to achieve benefits not easily accessible to individuals, such as accessing markets and inputs (Hellin et al 2009). Within the context of CAWT, collective action that promotes access to or sharing of inputs such as equipment, and allows farmers to sell products collectively for a higher return or access new markets, could promote adoption of CAWT technologies. The use of participatory approaches can facilitate social capital through social interactions and consensus- building (Woolcock and Narayan 2000). The Landcare approach is a participatory extension approach, which has been recognized for its ability to promote social capital (Sobels et al 2001) and the initial results from this study promote that finding as a hypothesis that ought to be specifically tested in Machakos.

The FFS approach, as described earlier in the paper, focuses mostly on building the particular group being trained and does not highlight linkages between groups. Thus, within-group capacity building was observed in the results under the FFS approach but the number of connections between members of different groups under the same approach was low compared to Landcare and MoA Mwala. Strong interactions within a group can assist in building collective action and trust but without sufficient connections out of the group, homophily[4] may develop and include imposition of social norms on group members and limit members ability to innovate and access new ideas (Newman and Dale 2007). This finding suggests a possible limitation of the FFS approach; as it did not appear build social capital in the wider community, which would link group members to new information.

An interesting finding of this study was the high social capital amongst farmers selected under the MoA approach in Mwala, particularly compared to those from MoA in the other districts. The groups under the MoA approach in Mwala District showed connections both within and between groups, which could support innovation and ability for collective action. It is possible that the extension officers in Mwala use a more participatory approach than the officers under MoA in the other districts and through this could promote more linkages. Further investigation into the possible causes and motivation for this difference would provide valuable insight and opportunities to enhance the MoA approach in all the districts so they can become more participatory and build social capital.

Social networks and information flows have an impact on adoption of agricultural technologies. Greater connections to external sources (such as extension officers or organizations) has been linked to greater agroforestry adoption (Isaac 2012) while innovative projects often require both expert and tacit knowledge sources (Esparcia 2014). The farmers

[4] Homophily here refers to a situation in which individuals only interact with others similar to them such as group or local community members with limited interaction with individuals outside their community or group.

under the MoA approach had more connections to extension officers, a case that was most evident in MoA Kangundo and Machakos. MoA Machakos respondents received information from expert sources more than from community members so they accessed new agricultural technologies easily but they did not appear to share the information within the community thus reducing the multiplier effect and capacity for local innovation. MoA Kangundo respondents had both expert and community based connections providing a good range of information sources. Once an individual received information, however, it was rarely shared with other community members. Community-based approaches such as Landcare and farmer-to-farmer are perhaps better able to promote community level information exchange than the government approach in general. This is a hypothesis that requires further investigation in Machakos County.

5.2 Efficiency

The most expensive CAWT trainings per unit beneficiary were provided by World Vision followed by Landcare, with the MoA approach providing the least expensive trainings in all districts. Landcare could be more cost effective if only community facilitators train farmer groups unlike the expert facilitator used in this case. The greatest additional cost under World Vision was the provision of lunch to each farmer on every day of the training. Higher mobilization ability was seen in the WV groups, which may be a result of the meals provided. However, further assessment of the impact of this cost on adoption of promoted technologies and social capital creation is needed to support this additional expense, particularly as early indications from this study show that provision of meals does not result in either higher social capital or adoption compared to the MoA approach in the same district where meals were not provided.

The MoA approach had more time expensed to deliver the trainings in all districts as a result of the decision to train farmers in smaller groups. Further investigation on the optimal size of a group for this type of training would help advise if this is a more effective choice.

The Landcare approach demonstrated very low mobilization potential with less than half the target farmers reached in this study. This result was unexpected as it was hypothesised that the Landcare approach would be more efficient in achieving high participation levels, as the approach should empower the community (Catacutan et al 2009). Additionally, the Landcare groups had identified both tree planting and soil conservation as important activities prior to this study. Discussions with the community level Landcare facilitator after this study pointed to issues around scheduling of the trainings to fit with the expert facilitators availability as one of the reasons for the low attendance.

To provide relevant advice, the efficiency results from this paper need to be combined with information on the quality of the trainings provided under each approach. This can be captured using a post-intervention survey, by measuring the changes in understanding of CAWT and testing of promoted practices, by those trained under each approach.

6. Conclusion and recommendations

The Landcare approach implemented by KENDAT is hypothesized to be the most effective in terms of enterprise diversity and CAWT related practices. Farmers under MoA and FFS, implemented by WV in Mwala achieved greater crop productivities while MoA Kangundo respondents had the greatest tree based productivity in terms of trees per hectare. MoA and World Vision using FFS in Mwala offered more agricultural trainings and their respondents attended more training than other districts, however, the lessons from these trainings do not appear to have all been applied in farms. MoA Mwala and Landcare approaches are hypothesised to promote the greatest social capital at the group and community level with FFS promoting strong social capital at the group level only. Farmers under the MoA approach in all three districts had greater access to information from extension officers but in the case of Machakos and Kangundo districts this information was not shared at the community level, thus limiting the local dissemination and innovation opportunities. The MoA approach was the most cost efficient while Landcare was the most time efficient in delivering CAWT trainings and WV through FFS achieved the highest training attendance. Further information on the quality and impact of these trainings are needed to qualify these results.

Our results concerning hypotheses of effectiveness and efficiency presented in this paper suggest a pluralistic agricultural advisory system with greater emphasis on participatory approaches would be the most appropriate for scaling up CAWT. This aligns well with current practice, as Kenya has been developing a more pluralistic advisory system around concepts of participation, facilitation and partnership (Davis and Place 2003). The challenge lies in the right combination of approaches to achieve the best results. As recommended by Feder et al (2010) using the potential in the communities, markets and the state will help create balance and overcome failures that can be found in all of them. Government agricultural extension officers are currently the most accessible expert source of agricultural information in Machakos County and should therefore be utilized and create a basis for scaling up CAWT. The use of community-based facilitators, such as in the Landcare approach, could add value to the government approach by further disseminating information available through extension officers to the community. Use of participatory approaches, as was seen in Landcare and the approach used by MoA in Mwala District, are hypothesized to enhance social capital and should be further investigated. The inclusion of NGOs such as WV using FFS could also add

value in specific circumstances, however the additional costs associated with this approach need to be qualified in terms of effectiveness as the initial results do not suggest they result in greater adoption of practices amongst trained farmers.

This study used proxy indicators to assess many aspects of effectiveness and aspects of attribution need to be clarified further. Following training of farmers on CAWT under each approach, a second survey will be conducted to capture any changes in understanding and adoption of CAWT. At that time the results and recommendations of this study can be reviewed and updated as needed. The additional survey will also provide information to allow better attribution of adoption to each approach, particularly as CAWT is a new concept in the area and with the exception of WV who use MoA officers in trainings, each farmer surveyed will only have been trained on certain skills through this study.

Further investigation into the delivery of extension in Mwala by government extension officers including the drivers will provide useful information on how the MoA approach could be more effectively delivered in Machakos and Kangundo districts. This information could also be integrated into the advisory system to scale up CAWT in Kenya.

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Appendices

Appendix 1. Key organizations and the agricultural projects they are delivering in Machakos County

Delivery organization	Project (s) and area of work (from consultation in 2011) in Machakos County	Work in other parts of Kenya (update 2013)
African Brotherhood Church (ABC)	Tree nursery demonstration and free trainings; plan to start charging for trainings in 2012. Trained groups from Machakos, Mwala and Kangundo Districts. Start monitoring and more training in 2012	Has three Agricultural Resource & Technology Centres (ARTCs) in Machakos (showground), Chumvini and Kibwezi
Hand-in-Hand	Capacity building in value addition, marketing and market linkages Work in Machakos District mostly	Had began working in 11 counties in Kenya
Poverty Eradication Network (PEN)	Activities include: subsurface dams, provision of nursery materials, developing community based organizations (CBOs) Works in Mwala, Kangundo and Machakos	Working mostly in eastern Kenya
Kenyan Network for Dissemination of Agricultural Technologies (KENDAT)	Working with 10 groups in two divisions in Machakos District focus on land degradation, Conservation Agriculture and tree nurseries. Started work in the area in 1998	Involved in promoting Conservation Agriculture in the country
World Vision Kenya (WV)	Food security projects in Mwala District (being an Area Development Programme; ADP, WV will remain in the area for about 15 years) Farmers field schools - Organic farming, green houses, fruit and tree seedlings	Well developed NGO working widely in Kenya and internationally
VI – Agroforestry	Starting operating in the area in agroforestry and have an office in Machakos	Most of their activities are in Western Kenya
Ukambani Christian Community Service (UCCS, an agency of the Anglican Church of Kenya)	Their programmes include an Integrated Food Security Program (IFSP) where they work with 12 CBOs on relief food support. Supports 24 tree nurseries, trains farmers on the water conservation measures.	Work with community based organizations in the target areas of Machakos, Makueni, Kitui and Mwingi districts.
CDF (Constituency Development Fund)	Provide water, ensure food security (goat distribution), enable households to have an income-generating source	Fund established for community development in constituencies across the country
African Nations Institute for Socio-Economic Development (INADES Formation)	Objectives related to soil, water and forest conservation, support farmer agricultural innovation, partnerships. Work in Mwala District	Working in Makueni and Machakos districts. After creation of smaller administrative units the activities are now concentrated in Kathonzweni and Mwala districts
Ngalani Acts Community Development	Some activities include; Water harvesting, promotion of drought tolerant crops, horticulture, capacity building, livestock, soil	Currently working in the Yatta plateau

Delivery organization	Project (s) and area of work (from consultation in 2011) in Machakos County	Work in other parts of Kenya (update 2013)
(NACODEV -A local faith-based organization)	and water conservation and agroforestry. Work in Mwala and Machakos Districts	
CARITAS (Catholic Diocese development organ)	Work on promoting food security through supporting agroforestry groups, crops/agriculture, soil conservation. Target the vulnerable community in Machakos, Kangundo and Mwala	Promotes small-scale agricultural production in the most poor regions of the country
Ministry of Agriculture (full name - Ministry of Agriculture, Livestock and Fisheries)	Five departments; extension, environment, agro-business, home economics and crop development. Had the National Agriculture and Livestock Extension Programme (NALEP) as one of the largest projects but also many others in the county	National public agricultural advisory organ
Kenya Forest Service (KFS)	Promotion of agroforestry in the county	Engaged in country wide forest management and surveillance

Appendix 2. Products collected from farms under each advisory approach and district

Advisory approach	Landcare	MoA	MoA	MoA	World Vision	Total
District	Machakos	Kangundo	Machakos	Mwala	Mwala	
Food crop	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Other cash crop	44.6%	54.5%	11.6%	5.3%	11.7%	27.8%
Fruit	98.8%	88.2%	81.4%	92.1%	83.1%	88.7%
Vegetables	65.1%	61.8%	33.7%	42.1%	28.6%	47.5%
Fodder	88.0%	89.1%	31.4%	31.6%	36.4%	57.9%
Livestock	89.2%	52.7%	68.6%	34.2%	39.0%	57.2%
Livestock products	86.7%	74.5%	76.7%	47.4%	45.5%	67.4%
Fish	0.0%	0.0%	0.0%	1.3%	0.0%	0.2%
Timber	9.6%	7.3%	3.5%	1.3%	3.9%	5.3%
Fuel wood	90.4%	94.5%	53.5%	71.1%	57.1%	74.8%
Charcoal	32.5%	6.4%	5.8%	27.6%	13.0%	16.2%
Honey	4.8%	4.5%	8.1%	7.9%	1.3%	5.3%
Manure/compost	89.2%	89.1%	41.9%	71.1%	45.5%	68.8%
Other products	2.4%	.0%	.0%	.0%	.0%	.5%

Appendix 3. Training theme by advisory approach and district

Advisory approach District	Landcare Machakos	MoA Kangundo	MoA Machakos	MoA Mwala	World Vision Mwala	Total
Agriculture	1.2%	0.0%	0.0%	14.3%	16.9%	5.8%
Climate change	0.0%	0.9%	0.0%	1.3%	0.0%	0.5%
Conservation Agriculture	1.2%	2.7%	2.3%	6.5%	2.6%	3.0%
Dryland farming	0.0%	0.0%	0.0%	1.3%	0.0%	0.2%
Food security	0.0%	0.0%	0.0%	6.5%	2.6%	1.6%
Greenhouse management	0.0%	0.0%	0.0%	0.0%	1.3%	0.2%
Livestock farming	0.0%	0.0%	0.0%	2.6%	1.3%	0.7%
Making manure	0.0%	0.0%	0.0%	0.0%	3.9%	0.7%
Modern farming technologies	0.0%	0.0%	0.0%	1.3%	1.3%	0.5%
Nursery management	1.2%	0.0%	0.0%	2.6%	0.0%	0.7%
Planting trees	0.0%	2.7%	1.2%	1.3%	0.0%	1.2%
Mango production	0.0%	0.0%	0.0%	0.0%	1.3%	0.2%
Tomato farming	0.0%	0.0%	0.0%	2.6%	0.0%	0.5%
Others	0.0%	0.9%	1.2%	1.3%	2.6%	1.2%
Total	**2.4%**	**7.3%**	**4.7%**	**40.3%**	**33.8%**	**16.4%**

Appendix 4. Financial cost of training for main and refresher training and per farmer for each approach by district

District	**Machakos**	**Machakos**	**Kangundo**	**Mwala**	**Mwala**
Approach	**Landcare**	**MoA**	**MoA**	**MoA**	**WV**
No groups	10	7	11	8	8
No of training units main	2	7	9	8	4
No of training units refresher	3	7	9	8	4
No of farmers trained main	96	171	201	175	196
No of farmers trained refresher	108	107	120	114	184
No of days training per unit main	2	5	5	5	5
No of days per unit refresher	1	1	1	1	1
No of trainers	2	2	2	2	2
Cost of organizing main training	1700	1100	1100	1100	5000
Allowance for organizing day refresher	1700	1100	1100	1100	5000
Trainer allowance per day	2500 for main 1833 for refresher	1000	1000	1000	2500
Actual total trainer allowance training main	10000	88500	93500	72000	80000
Total trainer allowance refresher	5500	14000	18000	16000	20000
Follow up, M&E allowances main	0	38500	36000	20000	0
Additional allowances for monitoring refresher	0	12000	15000	2000	0
Transport (includes fuel and driver if used) main	31280	33450	59360	65780	13282
Fuel/transport refresher	16000	6900	13700	5000	7604

District	**Machakos**	**Machakos**	**Kangundo**	**Mwala**	**Mwala**
Approach	**Landcare**	**MoA**	**MoA**	**MoA**	**WV**
Stationery	0	10579	11080	10579	10579
Venue main	4000	-	-	-	-
Venue refresher	3000	-	-	-	-
Snacks/lunch for farmers main	12759	-	-	-	215400
Snacks or lunch for farmers	12065	-	-	-	55500
Wage of trainers (1100 for MoA or 5000 for WV/trainer for 5 days) main	0	11000	11000	11000	50000
Wage of trainers (1100 for MoA or 5000 for WV/trainer for 1 day)	0	2200	2200	2200	10000
Expert trainer (12750 per day for training) plus M&I main	63000	-	-	-	-
Expert trainer (12750/day) plus M&I	50250	-	-	-	-
Total cost main	122739	183129	212040	180459	374261
Cost per farmer (Ksh) * main	1278.53	1070.93	1054.93	1031.20	1909.50
Total expenses refresher	88515	36200	50000	26300	98104
Cost per farmer (Ksh) refresher	819.58	338.32	416.67	230.70	533.17
Total cost per farmer (Ksh)	2098.11	1409.25	1471.59	1261.90	2442.67

* Ksh = Kenyan Shillings (exchange rate of 85 Ksh to 1 USD)

Appendix 5. Time cost of training for main and refresher training and per farmer for each approach by district

District	Machakos	Machakos	Kangundo	Mwala	Mwala
Approach	Landcare	MoA	MoA	MoA	WV
No of farmers trained main	96	171	201	175	196
No of farmers trained refresher	108	107	120	114	184
No. of days main training	2	5	5	5	5
No. of groups trained main training	2	7	9	8	4
No. of days refresher	1	1	1	1	1
No. of groups trained refresher training	3	7	9	8	4
No. of trainers	2	2	2	2	2
No. of days organizing main training	1	1	1	1	1
No. of days organizing refresher training	1	1	1	1	1
Total number of trainer days main	9	71	91	81	41
Total number of days refresher	7	15	19	17	9
Cost of trainer days per farmer main	0.094	0.41	0.45	0.46	0.21
Cost of trainer days per farmer refresher	0.065	0.140	0.158	0.149	0.049
Total cost of trainer days per farmer	0.16	0.55	0.61	0.61	0.26

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