A SCOPING STUDY TO DOCUMENT THE AGROFORESTRY TECHNOLOGIES/PRACTICES/SYSTEMS, AND THEIR CHARACTERISATION, RELEASE, ADOPTION AND USE BY FARMERS IN KENYA

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Prepared by
Dr. Othniel Yila (SEI)

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Acknowledgements

This work owes much to the many people who have given generously of their time, provided information, help, advice, direction and facilitated fieldwork.

Special thanks to:

- Biovision Africa Trust (BvAT) for the support and financing of this project. Special mentioned must be made of Dr. David Amudavi, Ms. Venancia Wambua and Mr. Hudson Wereh Shiraku especially for support on the development of the overall structure and study approach.
- This study would not have been possible without the good support of Dr. Jonathan Muriuki of ICRAF Kenya Office for the briefings and information on the study sites. Dr. Muriuki further assigned ICRAF field staff to arrange the logistics for the fieldworks and to accompany Mr. Wereh and me to the field.
- I am equally grateful to the ICRAF Kenya Office field staff who assisted in organizing, mobilizing and facilitating the Focus Groups Discussions (FGDs) meeting with farmers in Central, Eastern and Western Kenya regions and providing supporting documentation. The team members were also more than willing to share their experiences and ideas. Specifically, I owe much to Walter Odongo, Irene Okeiyo with ICRAF office in Maseno, Oscar Masika with the Evergreen Agriculture programme and Silas Muthuri with ICRAF Rural Resource Centre Machakos. It is exciting how these fellows championed agroforestry as important means for improving the livelihoods of hundreds of farmers in their beats. In addition, they are amazing in their work ethic and made the research process both fascinating and fun.
- Special thanks also to all other stakeholders (key informants) including researchers, staff of various ministries of agriculture across the country visited, and non-governmental organization (NGO) staff for creating time to meet and interact with the study team.
- I am particularly indebted to the many farmers who welcomed us to their villages with open hearts and hands and who took time off their busy schedules to participate in the study by sharing their experiences and allowing me to interfere with their privacy by sometimes asking very personal questions and taking measurements in their fields. The FGD's would not have been possible without their amazing generosity, openness, and honesty.

- I convey my appreciations to all reviewers who have enriched the report through their insights and discussion for their time and high value inputs to the report.
- Editorial assistance provided by Ms. Sarah Odera (SEI Africa Centre Communication Officer) is gratefully acknowledged.
- Lastly, even as I write these words, I think of the many individuals to whom I owe an enormous debt because of their help or their friendship, and yet whose names are not mentioned in these pages. I want them to know of my genuine gratitude to them in any case.

Acronyms and Abbreviations

AFRENA	Agroforestry Research Networks for Africa
AFS	Agroforestry Systems
ASAL	Arid and Semi-Arid Lands
BvAT	Biovision Africa Trust
CBO	Community Based Organization
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environmental Facility
GIAHS	Globally Important Agricultural Heritage System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) "*German Corporation for International Cooperation*" in English
ICIPE	International Centre of Insect and Pest Entomology
ICRAF	International Centre for Research in Agroforestry (now World Agroforestry Centre)
JICA	Japan International Cooperation Agency
JSTOR	Journal Storage
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KWAP	Kenya Woodfuel and Agroforestry Programme
LULUCF	Land use, land-use change and forestry

NGOs	Non-Governmental Organizations
OARE	Online Access to Research in the Environment
PELUM-Kenya	Participatory Ecological Land Use Management in Kenya
REDD	Reduced Emissions from Degradation and Forest Degradation
SIDA	Swedish International Development Cooperation Agency

Executive Summary

Agroforestry has received much attention in recent development efforts in Kenya. This has been reflected in numerous agroforestry based projects during the last three decades that were aimed at supporting the tree-growing efforts of the local people. Several ministries have been involved, notably the Ministry of Agriculture (MoA), the Ministry of Energy (MoE) and the Ministry of Environment and Natural Resources (MoENR). The efforts of the various government extension services have been complemented by the national and international research organizations such as Kenya Forestry Research Institute (KEFRI), World Agroforestry Centre (ICRAF) and non-governmental organizations (NGOs).

The scoping study report is a result of an intensive consultative process which started with review of existing documentation on agroforestry in Kenya, consultations with key informants in government, research organizations and NGO's who have decades of experience promoting agroforestry practices in the country. The study also involved field visits and focus groups discussions (FGD) with smallholder farmers in three regions which also double as three agro-ecological zones in Kenya. Personal observation of current agroforestry practices guided the 'face-to-face FGD'. The local community provided valuable inputs. The preliminary findings will be presented at the validation workshop to be held in the first quarter of 2016. Feedback from the validation workshop participants will help in the synthesis and compilation of the final report.

The Biovision Africa Trust (BvAT), World Agroforestry Centre (ICRAF) and Participatory Ecological Land Use Management (PELUM) Kenya commissioned this scoping study on "documenting agroforestry technologies, systems and practices". The aim of this scoping study therefore, is to examine the diversity of the technologies and practices developed by ICRAF and other research institutions since 1980 in Kenya, with a view to draw out key enabling conditions that have facilitated their uptake by farmers and identifying what and where gap(s) still exist.

This scoping report provides an overview of the context and extent of a range of agroforestry technologies/systems/practices and adoption being tested or implemented in Kenya. The scoping involved an analysis of the current efforts taking place among smallholder farmers in Kenya to identify the diversity of agroforestry interventions. The objectives of the study were to gather as much evidence as possible and map the results of agroforestry initiatives in Kenya and to examine the extent, range and nature of agroforestry in the country, including the dimensions of

agroforestry in smallholder farming systems. The report documents results from the field and research and response options on the state of agroforestry in Kenya in order to help promote the wider adoption of appropriate agroforestry technologies/systems/practices in Kenya through policy development and dissemination.

Key findings/messages

The study found the prospects for agroforestry in the country are conditioned by key drivers of land use, tree cover and climate change. These include deforestation, progressive land degradation following conversion from forest to pasture or exhaustion under agriculture as with cotton soils in the semi-arid region, both of which result in biodiversity loss and a negative carbon balance. There are also key problems with the regulation of water flow: too much in some places at some times, leading to floods, while there are problems with seasonal drought in other contexts. Markets for agricultural products are being conditioned by the middlemen that lead to Kenya farmers losing the value of their products- while the rising cost and decreasing availability of labor due to migration, often coupled with insecure land tenure significantly affects how agroforestry is practiced and the prospects for adoption of agroforestry technologies.

The study found that while a number of agroforestry-related programmes and projects are ongoing and a number of different agroforestry practices are being used in various parts of Kenya, these agroforestry systems are not widely spread across the country, partly because of limited financial resources, capacity, knowledge and policy support. However, various agroforestry interventions have been implemented and continue to be implemented, with variable success, using different approaches by individual farmers as well as national, regional and international organizations in Kenya. Various stakeholders have been involved in the promotion of agroforestry initiatives across the three counties visited by the researcher, including government departments; community based organizations (CBOs), the private sector, research institutions and lead farmers. Despite the fact that there is no particular agroforestry guiding policy, *National Food and Nutrition Security Policy (NFNP – 2010); National Forest Policy, 2005; The Agriculture Sector Development Strategy (ASDS - 2010); and* Vision 2030 are key documents leveraging support for agroforestry at national level, both technically and financially.

In appraising agroforestry projects it is obvious that consideration of the socio-cultural aspects are critical to success, yet its complexity has meant that it is often overlooked with bio-physical aspects taking precedence. Other considerations identified during the assessment of projects are: a) a need for strong partnerships and collaborations; b) a focus toward a needs oriented participatory training; c) project planning should be broad, inclusive and flexible, and; d) review instruments should be responsive with a minimal turnaround time from research and innovators to users, policy makers and other projects.

~~**Key findings/messages**~~

In spite of the benefits of agroforestry outlined by various literature, key informants and farmers and its promotion over the last 30 years in many policy and project efforts in Kenya, the adoption of agroforestry still remains not as desired in many parts of Kenya and saddled with challenges.

Attempts to promote agroforestry by field projects have been constrained among others by unfavorable local institutional arrangements, market environment, land tenure rights, and credit facilities available to smallholder farmers (Muriuki, 2014).

However, this has to be approached with caution since there are specific factors that would encourage adoption by farmers that should be looked into during design and dissemination of interventions. The study also finds that there is need for further research into how agroforestry technologies, systems and practices can be packaged and targeted so as to reach large numbers of smallholder farmers who inadvertently stand to benefit the most.

Institutional frameworks for scaling up of agroforestry technologies
In general, adequate institutional frameworks exist that are favorable to agroforestry in Kenya. However, the study noted that there is low coordination among the various actors and stakeholders that develop and promote agroforestry technologies in Kenya. In many instances, agroforestry activities are carried out in isolation by various actors and institutions. This suggests that agroforestry can best be promoted in collaborations with the existing community based organizations (CBO) structures active at the community level. These results suggest that there is a need for formal institutional frameworks to incorporate existing local institutions in the efforts to scale-up adoption of agroforestry. Institutional mechanisms are required to ensure that agroforestry is seen as a concept beyond agriculture and promote it as a theme ensuring effective linkages between research and development (R&D) activities. Agroforestry needs to aim at broad sense of contributing to livelihood strategies and move towards forming more structures/frameworks with appropriate commercial/agribusiness strategies to create environment for increased rural employment in areas where it is adapted.

Agroforestry is context specific
Although agroforestry is widely promoted in different parts of Kenya as a way of reconciling multiple objectives within a single farming system, but it is important to recognize that just because agroforestry can work well in some contexts does not mean that it is the best landscape option everywhere for everything. Agroforestry can also mean very different things to different people. On the course of the study and talking to different people, various perceptions of agroforestry were brought to bear. Some of these perceptions are a long way from textbook definitions, yet these mutated meanings can have a great deal of influence as to what forms of agroforestry are taken up locally and what its actual impacts are on the ground. Thus, the need to clarify the collective and contextual understanding of agroforestry is necessary. Ultimately, if communities are to achieve good adoption of relevant agroforestry technologies, there needs to be a clearer understanding by all parties as to what this means. Even accepting that agroforestry is a dynamic process rather than a fixed end state, targets and indicators can, and must, be developed to monitor the impact of agroforestry activities.

Agroforestry link with ecological agriculture
Many farmers in Kenya are organic by default, because they cannot afford to purchase agricultural inputs like fertilizers and pesticides. Agroforestry therefore provides an almost zero cost approach to restoring soil nitrogen by the use of nitrogen-fixing trees

and shrubs. However, soils are typically also deficient in other nutrients and trees cannot provide these (except by moving them from deeper soil horizons to the surface in leaf litter). So to fully close the yield gap farmers need to purchase these inputs, for which of course they need a source of income. Here agroforestry can again help since many of the highly nutritious traditional foods, medicines and other products of day-to-day use come from trees as fruits, nuts, leaves, bark, wood, etc.

Marketing constraints

Marketing agroforestry outputs is different from other agricultural commodities because of their diverse nature. Some products such as tea, coffee are often subject to government rules and regulations, which influence market conduct, performance and even structure. Imperfect and inefficient marketing systems reduce farmers' profit margin, thereby influencing their land use decisions on adoption of agroforestry practice.

Research bias for biophysical aspects

There is a strong research bias for biophysical aspects, but aspects such as development of markets, funding sources to initiate enterprises and clear analysis of the economic and social feasibility of AF systems have not been studied in depth, which might be undermining potential and adoption of technologies developed.

Policy issues and gaps

In general, the policy environment in Kenya is encouraging with entrenched incentives to boost the contribution of the agroforestry to national economic growth. Kenya has some policies that could support the scaling up agroforestry. Among the many policies evident are *National Food and Nutrition Security Policy (NFNP-2010), National Forest Policy (NFP-2005), National Land Policy (NLP-2007), National Irrigation and Drainage Policy (NIDP-*2005*) and Vision 2030.* However, farmers are disproportionately benefiting from national policies, with large holders or commercial growers benefiting more. Incentives for smallholders, albeit limitedly exist, correspondingly, disincentives persist. Although efforts are underway to uplift the lives of smallholder farmers or non-commercial, nevertheless, the path towards their transition to integration in the broader economy is no doubt long and winding.

Adequate resources and capacity must be committed to building relevant agroforestry systems.

Short-term interventions, with no provision for long-term operations and maintenance, are unsustainable. Value for money can be justified for many agroforestry interventions, but these will rapidly become a waste of money if they are not part of a longer-term plan of support that is founded on participatory approaches.

More thorough and systematic research is required to assess the effectiveness of agroforestry technologies interventions in all sectors

Long term monitoring of agroforestry interventions is required to establish which are most successful and cost effective. Given such monitoring must be undertaken over a multi-annual time scale it could be the responsibility of a central body, for instance the Kenya Forestry Research Institute. Currently it is extremely difficult to establish the long-term success rates of the plethora of agroforestry technologies on livelihood diversification programmes that have been implemented over three decades in Kenya. Logging all projects on a central database for review in future years would enhance understanding of the type of interventions, or critical factors in their implementation, that worked to sustainably build resilience. At the same time further research is required to quantify the financial and other benefits of wider resilience building interventions such as education and health care provision, roads, power and communications etc. Although there is general consensus that such interventions are good they are also expensive. As a result cash strapped Counties need to know how to prioritize such expenditures and what is the optimum level of investment to generate self-sustaining levels of resilience. The resilience building benefits of cash transfer programmes is still yet to be conclusively made. Given the funding involved in such programmes it is important that the opportunity costs of cash over other interventions are fully monitored.

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According to the lessons learned, there are among others four critical conditions that could encourage adoption of any agroforestry practice:

- it should be beneficial to farmers and other land users;
- there must be security of land tenure;
- inter-sectoral coordination is essential;
- good governance of natural resources is crucial.

Recommendations

Based on the research findings, the following recommendations are made. F

1. First the farmer themselves made research and extension recommendations, which they felt would best support their efforts in advancing agroforestry practices. **They recommended that:**

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- New tree species to be introduced should be compatible and noncompetitive with crops, non-shading, have tap roots and the ability to be used as live stakes. Ideally, and this was suggested in particular by many of the very small farmers, research should introduce trees that produce fruit and fuel wood simultaneously.
- There should be more research on suitable species to increase the number of options available to farmers. Farmers do not want to be constrained in their choices and put into a straightjacket by research and extension which offers them standardized solutions to the very diverse conditions of their farms. They demand a cafeteria system of new species' and technologies suitable for a range of biophysical and socio-economic conditions from which they can choose according to ' their own needs, goals and resources. They stressed that the availability of a variety of tree species (both indigenous and exotic) and tree management options was important to enhance their traditional strategy of diversification to overcome economic and ecologic uncertainties.
- Research and extension should ensure that new technologies (species) are made more accessible to farmers.
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2. Secondly, for policy makers the following are recommendations:

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- For effective agroforestry promotion, adequate mechanisms are needed for generating, capturing and disseminating knowledge and information through the use of effective processes and institutional arrangements. Sources of knowledge on agroforestry include scientific research and indigenous knowledge. After knowledge has been created and sourced, it needs to be disseminated to users to support adoption of agroforestry practices.

- For agroforestry knowledge dissemination a comprehensive capacity-development approach for all stakeholders that builds on a sound assessment of needs is required. In this regard, within the diversified extension service delivery, there is a need to build the capacity of all agroforestry-implementing organizations, with major emphasis on the extension directorate of the Ministry of Agriculture (MoA) and integration of agroforestry into the country's extension package. It is through the extension system that the technologies reach the wider community.

- The agroforestry technology promotion process has to be documented at all levels of implementation so as to undertake evidence-based promotion and up scaling of the technologies. Documentation would provide a good basis for those involved in the implementation of agroforestry to attain knowledge and methodologies, which could then be used and applied for influencing policy-makers and for developing networks for the promotion of best practices.

- In areas where agroforestry technology has not yet been popularized, demonstrations have to be given at farmers' training centers (FTCs) and on farmers' fields. In this regard extension materials such as leaflets and brochures and organizing experience sharing visits and farmers' field days are crucial.

- Agricultural research institutions should invest in agroforestry demonstration sites across the country to show location-specific good practices in agroforestry that can be easily adopted by farmers. This can be complemented by the establishment of community-based resource centres where communities can access information on various agroforestry technologies and practices.

- Agroforestry needs to be mainstreamed into core government strategies, guidelines, manuals and annual action plans. In this regard the experience of the SIMLESA Programme is a good lesson for integrating agroforestry technologies into project and programme implementation manuals. Priority needs to be given to agroforestry practices that bring productivity gains, enhance resilience and reduce emissions.

- Agroforestry has to be integrated into tertiary level education, including TVET colleges and universities, so as to develop a large number of professionals with an in-depth knowledge of the subject.

- Universities and tertiary-level education institutions need to be supported to develop agroforestry curriculum and training courses so as to enhance the knowledge of graduates in this area. This can be initiated by first conducting an assessment of knowledge, status and uptake of agroforestry in the tertiary education curriculum at national and sub-regional level. The presence of ANAFE headquarters in Nairobi will add impetus to this if tapped upon

- The agroforestry value chains need to be evaluated and strengthened in order to enable access to key inputs and equipment needed as well as enabling the sale of agroforestry produce.
- Value chain development for agroforestry inputs and outputs such as seedlings, chemicals and equipment as well as for processing, use and sales of agroforestry products is needed across the country. Specific agroforestry value chain studies for key agroforestry practices and key agroforestry commodities is required and would assist in identifying constraints and enabling factors for improvement of the agroforestry value chain.
- More action research on key agroforestry practices is needed, particularly with the aim of testing context and agro-ecological-specific practices. Research already available must be shared and scaled-up.
- Agroforestry stakeholders need to continue to work together and ensure coordination of agroforestry activities at national and sub-regional level. This will help reduce duplication and support effectiveness and sustainability of agroforestry programmes.
- There is a need to build the capacity of extension workers and support extension departments in county to integrate agroforestry into their extension package. This could be done through the development of agroforestry extension manuals and training syllabi or through the updating of current extension manuals so that they include agroforestry components. This work must be done in partnership with the relevant government ministries and departments to ensure ownership, and hence uptake.
- Since agroforestry is not a new concept, benchmarking is one of the key recommendations highlighted by most stakeholders. This could take the form of establishing a detailed inventory of contextualized agroforestry practices in the country. This can be further consolidated through exchange visits to places where agroforestry practices and technologies have been successful within the country, or to degraded places for farmers to witness the negative effects of deforestation.
- One of the key issues relates to financing –while the governments must make every effort to ensure sufficient budgetary allocation for the development of agroforestry, attention also needs to be given to identifying investments outside of government through bi- and multilateral development financing sources that target the same, or related, activities.
- BvAT, ICRAF and PELUM-Kenya are well positioned to act as champions for national agroforestry programs drawing together the issues of agroforestry production, environmental sustainability and climate change. There is a unique opportunity for these organizations to promote a shift to more sustainable agroforestry production systems, capitalizing on the current conjunction of rapidly changing, responsive agricultural economies; a new, longer-term, nationally oriented planning perspective stemming from awareness of climate change; and the "breathing space" of 10-15 years that projections suggest may be available to Kenya before the end of Vision 2030. By using this period to identify, pilot, implement and upscale measures to build more resilient communities through

agroforestry and ecological agriculture, Kenya will be better positioned to handle the more extreme changes predicted for the first third of the century - and more urgently, will alleviate current poverty and food insecurity.

- It is recommended that ~~these i~~the above institutions can contribute most effectively through targeted research programs leading to pilot implementation of new production modes; and by promoting understanding of the policy significance of emerging knowledge through national dialogue and analysis. By working in close collaboration with national research and management agencies to achieve these objectives, the trio can contribute to a third, equally important objective: building County (ies) and national capacity to plan and manage sustainable agroforestry production systems. Examples of priority projects in each arena include:

    - Research/pilot program on the provision of environmental services by agroforestry systems, with an initial focus on mitigation of greenhouse gas emissions.
    - Research/pilot program on redesigning landscape approaches to agroforestry planning to enhance production while maintaining environmental services.
    - Roundtable discussion and review of agroforestry systems and resulting projections of water availability for the country, to bring some consistency to the technical base for adoption planning.
    - Policy dialogue on the role of agroforestry development in the context of climate change adaptation.
    - Further develop and maintain institutional linkages and coordination with other national, regional and international bodies concerned with agroforestry scaling out and spillover.
    - Enhance agroforestry knowledge and expertise in innovation platforms.
    - Place greater emphasis on monitoring, documenting and learning lessons on the uptake and adaptation of agroforestry technologies and the effectiveness of knowledge products.

    - These programs would provide an opportunity at the national level for these organizations to invest in bringing the adaptation, mitigation and sustainability debates together and to spearhead an approach that explicitly recognizes their interaction, building from the substantial body of work already underway in the country.

~~One of the major outcomes of this study is the fact that agroforestry, as an ecologically sound and economic viable option for small-scale farmers, has not earned the much desired support from developers. This is in part due to the multidisciplinary and multi-institutional nature of agroforestry, which makes it to fall between the gaps of institutions. As a result, extension agents are usually ill prepared to disseminate agroforestry innovations in the field. The study argues that more active involvement of extension workers in the development of agroforestry innovations, using a participatory approach, will facilitate subsequent dissemination and adoption on scale.~~

Overall many strides are being made in Kenya in terms of agroforestry promotion and the counties involved in the study should be commended for the efforts being undertaken. However, a lot still needs to be done and support from all stakeholders as well as international, regional

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1.0 Introduction

Agroforestry is the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions. In other words it is a collective name for land-use systems in which woody perennials (trees, shrubs) are grown in association with herbaceous plants (crops, pastures) and/or livestock in a spatial arrangement, a rotation or both, and in which there are both ecological and economic interactions between the tree and non-tree components of the system (Leakey, 1996; ICRAF, 2007). The practice of agroforestry has been an age-old practice in the Kenyan farming systems with several traditional agroforestry systems that have been in practice for hundreds of years. Some have been documented such as the intensive agroforestry systems of the highlands of Central Kenya, Taita agricultural landscapes, Ameru agroforestry system, and the agro-pastoral and fishing systems of the Ilçhamus in Baringo County (Kitalyi *et al.,* 2013). One outstanding aspect of these traditional methods is the use of multi-layered systems with a mixture of annual and perennial plants, which imitate natural ecosystems.

Agroforestry, the purposeful growing of trees and crops in interacting combinations, began to attain prominence in the late 1970s, when the international scientific community embraced its potentials in the tropics and recognized it as a practice in search of science (Otsyina *et al.,* 2010). During the 1980s, the relevance of agroforestry for solving problems related to deterioration of family farms, increased soil erosion, surface and ground water pollution, and decreased biodiversity was recognized in Kenya (Kitalyi *et al.,* 2011). Thus, agroforestry is now receiving increasing attention as a sustainable land-management in Kenya because of its ecological, economic, and social attributes. Consequently, the knowledge-base of agroforestry is being expanded at a rapid rate as illustrated by the increasing number and quality of scientific publications of various forms on different aspects of agroforestry in Kenya.

However, since the 1980's, the World Agroforestry Centre (formerly ICRAF), collaborating with national research institutions, government extension services, NGOs and CBOs, has played a central role in promoting several agroforestry technologies, systems and practices in Kenya that now benefit thousands of farmers as an improved form of land management to reverse environmental degradation and improve sustainability (Sanchez, 1995). From a natural science perspective agroforestry can thus be valued as providing, in addition to all its social and cultural goods, four major environmental services: soil enrichment, biodiversity conservation, air and water quality improvement and carbon sequestration (Garrity, 2004; Jose, 2009). Owing to its high carbon storage capacity (Roshetko *et al.,* 2007) Kenya's tropical agroforestry landscape thereby has a potential to mitigate climate change while also serving as an adaptation strategy in synergy with mitigation (Verchot *et al.,* 2007).

Agroforestry in Kenya is significant in the production of both local commodities (such as timber, fodder, fruit and fuelwood) and global ones (tea and coffee). It also plays a strategic role in helping meet key national development plans, especially those related to poverty eradication, food security and environmental sustainability. In many communities its positive outcomes can be seen in food, fuelwood and watershed management, contributing to a more resilient food system.

Thus, existing research indicates that appropriate application of agroforestry principles and practices are a key avenue to help Kenya as a country to achieve more sustainable methods of food and fiber production that produce both profits for farmers and environmental benefits. Because successful and sustainable agroforestry practices are best developed by farmers and land owners working in partnership with researchers, extension staff, and other rural businesses this study uses a participatory approach in scoping the required information.

FAO estimates, over 65% of farmers in Kenya depend to varying degrees on agroforestry for their livelihoods owing to its capacity to enhance multiple functions in agriculture (FAO, 2011). Agroforestry will become increasingly important in land-use practices in years to come (ICRAF, 2008). If properly conceived and practiced, agroforestry can contribute to sustained productivity of natural resource base by enhancing soil fertility, controlling erosion, enhancing microclimate of cropping and grazing lands and general improvement of the environment. The importance of agroforestry in Kenya can therefore, not be understated (Kilewe *et al.,* 1989). For Kenya, the country has two strong paradigms for exploiting the potential benefits of agroforestry (Marenya and Barret, 2007).

Firstly, the potential for agroforestry to improve farmers' livelihoods is in line with the many National Development Plans and Vision 2030 part of poverty eradication strategy, which aims at modernizing agriculture/developing farming for improved food security and commercial gain. Unlike other agricultural modernization plans, which focus on mechanization and high-tech systems, the Vision 2030 focuses on ensuring that subsistence farmers have better access to a wide variety of sustainable, low-input agricultural techniques - including agroforestry (ICRAF, 2011).

Secondly, the district forest services within the decentralized government framework, enables service providers to promote appropriate agroforestry interventions depending on local conditions. In addition, there are a number of strong campaigns by government and non-government organizations in favor for agroforestry in order to relieve the pressure on natural forests (Marenya and Barret, 2007). Agroforestry technologies and innovations can therefore, make significant contribution towards addressing high levels of poverty and associated land degradation in Kenya. For this to happen, however, there is need to promote agroforestry technologies and innovations that farmers can invest in and that in turn generate incomes and/or save them costs they incur.

In developing a more productive and sustainable agroforestry technologies, systems and practices the following need to be considered:

- A participatory approach to tree domestication enhances adoption and agroforestry development.
- Successful tree domestication initiatives require an understanding of markets and value chains.
- Public–private partnerships are useful for promoting tree domestication and business development.

- Targeting women groups for assistance can increase their involvement and benefits.
- All steps in a management learning and decision cycle might be gender specific.

In conclusion, a great deal is already known about how agroforestry technologies, systems and practices need to change and, in many cases, there are “win-win” solutions that deliver both increased production and environmental benefits. The difficulty lies not in what should be done but in how to do it in a context where changes in land use practice are sought from poor farmers whose livelihood options are limited. Thus, new mechanisms for promoting sustainable land use are needed, drawing on the experience from emerging financial models based on mitigation payments through schemes such as Reducing Emissions from Deforestation and Forest Degradation (REDD), payment for environmental services and harnessing global trade to promote change. Reorienting agroforestry production presents opportunities to work with rural producers to diversify and improve their livelihood options, and to build adaptive, resilient communities that are better integrated and better able to meet both food security and new market demands. It is upon this background that this study sought to raise the emerging issues for promotion of agroforestry in Kenya.

In documenting the agroforestry practices and systems, a large volume of documents was reviewed, several key informants from different institutions were interviewed, and drafts of the report were shared with experts and interested individuals for their comments and suggestions to improve the document. This report is intended to provide valuable insights for policy makers and representatives of government and non-government agencies dealing with agroforestry practices in both Kenya and other developing countries with resulting outputs of contributing to improving agroforestry project planning and implementation. Thus, this study is expected to facilitate decision making and practice by farmers, extension agents, research and development organizations, academic institutions, and national and regional ecological organic networks, as well as public and private policy and decision makers in Kenya.

2.0 Objectives of the scoping study

The general objective of the study was to document existing agroforestry systems in Kenya. Specifically, it aimed to:

a) Identify the existing agroforestry technologies/practices/systems practiced in Kenya
b) Describe the existing agroforestry technologies/practices/systems in the country and
c) Assess and solicit information about the problems encountered by the farmers as basis in formulating and prescribing improvements in their existing agroforestry practice.
d) Carry out a comprehensive review of grey and published literature and data on agroforestry systems adoption in Kenya.

3.0 Study approach / methodology

The scoping study followed the accepted practice in reviewing relevant published and unpublished documents, synthesizing information and producing a narrative account (Ritchie and Spencer 1994; Pawson *et al.,* 2002; Gumbo *et al.,* 2013). Levac *et al.,* (2010) describe scoping as a process to determine a range of issues of specific interest and identify issues relating to a proposed action. Thus, the extent and type of a given research activity may also be mapped using this approach (Gumbo *et al.,* 2013).

While past scoping studies have focused on literature reviews, there is an increasing tendency to incorporate consultations into the study (Gumbo *et al.*, 2013). In so doing, professionals and key informants knowledgeable in agroforestry promotion and implementation in Kenya as well as farmers who are implementers and end users of the agroforestry systems were consulted, which helped contextualize emerging issues. The processes associated with scoping studies are thus 'not linear but iterative, requiring researchers to engage in a reflexive way' (Arksey and O'Malley, 2005).

The four main steps in undertaking this study were planning, data collection, data analysis and report writing, as shown in Figure 2. Study methodology primarily involved the collection of primary and secondary data on agroforestry from various sources.

PLANNING	Development of a work plan, study methodology and tool (in this case a structured questionnaire). Development of itineraries with BvAT staff.
DATA COLLECTION	Review of other available agroforestry documents within Kenya. Face-to-face interviews with key stakeholders guided by the study toll; meeting key agroforestry focal persons in the county and selected counties; i.e. government ministries, the private sector, NGOs and civil society organizations
DATA ANALYSIS	Consolidation of a variety of information on technologies, practices, policies and stakeholders involved in the promotion of agroforestry.
REPORT WRITING	Post-study draft submitted for comments before preparation of final report.

Figure 3.2: Steps in undertaking the study

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The task had four main activities which were undertaken as outlined below:

1. The inception phase
2. Review of literature associated with agroforestry technologies/practices/systems in Kenya
3. Key informant interviews
4. Focus group discussions and narrative walk with smallholder farmers on agroforestry farm sites in three regions of Kenya (Western, Central and Eastern region) representing three agro ecological zones

The methodologies associated with these four main activities are described in the following sections.

3.1 Inception phase

The inception phase involved developing the work plan for the study and agreeing on it with the client, Biovision Africa Trust (BvAT). It also involved developing the conceptual framework, analytical framework, survey tool and methodology for each phase. Terms of reference for regional/agro-ecological visits were developed and arrangements for visits started in consultation with the ICRAF Kenya Office and various field coordinators.

3.2 Literature review

The review of literature through which existing knowledge can be synthesized and then used during the consultative stage is the core of any scoping study. The literature review for this scoping study is based on a desk review of relevant literature as well as a search through key institutional databases for relevant documents. Relevant information from these sources were extracted and coherently presented to best illustrate agroforestry technologies/practices/systems and adoption in Kenya. The literature review revealed extensive amount of formal study on agroforestry systems, techniques and adoption in Kenya.

The review of relevant literature was loosely guided by Arksey and O'Malley's framework (2005) for scoping studies. Rather than having a highly focused research question at the outset, scoping studies aim to identify all relevant literature related to a topic regardless of study design (Arksey and O'Malley, 2005). Although this study aimed to be as comprehensive as possible in the coverage of available literature, some limits had to be applied to the extent of the search due to time constraints. As such, the literature review was initially limited to those publications available through the ICRAF online library network and subsequently included other articles which had been cited in articles found in the journal search ("snowballing").

As already indicated, the whole point of scoping the field is to be as comprehensive as possible in identifying primary studies (published and unpublished) and reviews suitable for answering the central issues. To achieve this, a strategy that involved searching for research evidence via different sources was adopted:

- electronic databases
- reference lists
- hand-searching of key publications, journals, reports, bulletins
- existing networks, relevant organizations and conferences.

From a practical point of view, decisions had to be made at the outset about the coverage of the review in terms of time span and language. Reflecting time constraints, only those studies published between January 1980 and October 2015 in English were included. The start date of 1980 was chosen because it was felt that this covered the time when formal agroforestry was introduced in Kenya. Foreign language materials were excluded because of the cost and time involved in translating materials. Whilst these limits had to be adopted for practical reasons, it is worth pointing out that potentially relevant papers could have been missed.

To identify studies on agroforestry technologies, systems, practices and adoption in Kenya, digital databases, citations in relevant studies, and library catalogues were searched. The digital databases included OARE, JSTOR, ProQuest, Web of Science, Econlit, Google, Google Scholar, Science Direct, Scirus and Scopus. The library catalogues included the World Agroforestry Centre (ICRAF) in Nairobi, which houses a collection of unpublished studies of agroforestry. In constructing electronic searches, I cast a wide net to identify as many studies as possible using a variety of combinations of search terms, including

"agroforestry"; "NRM"; "agroforestry system"; "agroforestry practices"; "agroforestry classification"; "agroforestry technologies"; "agroforestry adoption"; "release, adoption and use**"**; "land rehabilitation"; "watershed management"; "sustainable land management"; "livelihoods"; "food security"; "biodiversity conservation"; "ecosystems management"
AND
"agroforestry extension and research"; "alley cropping"; "carbon sequestration"; "farm forestry"; "forest garden"; "landscape change"; "~~homegarden~~home garden**"**; "tree garden shelterbelt"; "taungya"; " "land use change"; "land-cover";
OR
"tree crop"; "tree growing"; "woodlots"; "farm trees"; "fodder bank"; "mixed species fallows, tree nursery"; "fruit tree"; "tree fodder"; "tree farming"; "windbreak"

To complement the desk review, some relevant guidelines, toolboxes, and frameworks were also added as possible additional sources. These were collected through a simple Google search for agroforestry guidelines/frameworks/toolboxes or different combinations of the same phrase. It is important to note that due to the time constraints involved, additional databases could not be covered in this study. Furthermore, definitions and categories of agroforestry were found to vary across organizations and there may be other research which do not have the keywords 'agroforestry or 'tree-crop' in their title, and are therefore not included in this study but may still be relevant to the topic.

The literature review was critical for the preliminary gathering of information about available proven technologies and knowledge products, and for reviewing secondary information on past experiences and conditions that have enabled knowledge and technology transfer and spillover within the 3 selected regions and elsewhere. Findings from the desk review were used to inform the survey tool used during the fieldwork and to analyze the findings from the fieldwork.

3.2 Focus Group Discussions (FGD)

Focus group discussions and narrative walks were also conducted with small groups of farmers (8 -15 persons on average) during the final stages of the knowledge acquisition phase in six sites, two villages/communities each in three regions namely Western, Central and Eastern region of Kenya representing three agro ecological regions in Kenya. Figure 1 shows the FGD study sites.

Fig 3.1: FGD study sites

These sites were selected in conjunction with ICRAF Kenya Office. Importantly there are a number of key differences between the sites – not least the topography and the cultural context for the agroforestry systems which will account for some significance between the sites. Furthermore, the site offers insights into issues surrounding agroforestry generally under conditions that climatically represent Kenya. The FGDs were used to triangulate information obtained from the detailed review of literature and key informants' interview. The discussion with smallholder farmers provided an opportunity to learn more about their practices across the three regions and gain further insight on constraints to agroforestry across the country.

A checklist was used in focus group discussions meetings (Appendix B). Through the checklist questions, the groups identified key agroforestry systems, practices, technologies and resources and prioritized issues affecting their management and use. Issues affecting implementation of agroforestry initiatives were identified (e.g. information, technologies, institutional capacity, etc.,) at local, district and sub-county levels. The following questions were also examined in the FGD:

- How agroforestry could be run under a decentralized management system
- Key constraints that hinder the achievement of sustainable agroforestry and land management;
- How the constraints can be addressed in projects implementation
- Ability of communities to adapt to the impact of climate change and variability and ecosystems change;

- Gaps and capacity needs of communities to effectively engage in sustainable agroforestry and;
- Prioritization of actions, timeframe, the lead and other stakeholders responsible for implementation of recommended interventions and possible partners.

This method enriched the responses of the groups as it allowed for the diversity of views expressed while at the same time giving room for consensus among the participants.

In addition to the FGD, narrative walks through some of the group members' farms were undertaken in each of the six sites locations. Field observation was conducted throughout the walk. Land use pattern, cropping practices, farming systems, crops, livestock, tree, land clearing, land preparation, cultivation techniques, and practices, tillage practices, fallow management, land type, soil quality, soil erosion and vegetation type were observed during the field visit and walks. Photographs were taken of important events. This served as entry points for other major issues discussed with the farmers during the FGD.

Credit: BvAT/Hudson Shiraku

Plate 1: Focus group discussion in Mua village, Machakos County. A woman (left) stressing a point during the discussion

Credit: BvAT/Hudson Shiraku

Plate 2: Narrative walk with farmer group members to a member farm site in Kahawa village, Muhoroni Sub-County, Kisumu County following a FGD

Credit: BvAT/Hudson Shiraku

Plate 3: Narrative work with a farmer (middle) on his farm in Embu County showing his just harvested fodder stunts

3.3. Key Informant Interviews

A key informant approach using semi-structured questions was conducted. The approach adopted for the survey ensured informant representation was broad enough to furnish a synopsis of the perceptions of farmers towards government, non-government organizations and agroforestry technology adoption and farmers' aspirations.

A question guide was developed (Appendix C) and used for interviewing key informants to determine their understanding of agroforestry systems, their AF related activities and key challenges to implementing AFS. A total of 7 key informants were consulted, representing government officers from several ministries/departments, researchers and farmers' organizations. The key informants discussed legal, institutional, and policy barriers or gaps, which—if effectively tackled—would result in a major boost for agroforestry adoption in Kenya.

3.4 Description of project and study sites

Focus Group Discussions were conducted in three regions of Kenya (Figure 1). These study sites, were selected in conjunction with ICRAF as these were projects sites where ICRAF and other partners had or are implementing agroforestry projects.

Table 3.1: Some key characteristics of the study sites in Kenya where FGD were held

Descriptions	Kyanda and Mua village - Machakos County (Eastern Region)	Kyeni and Karurumo village Embu County (Central Region)	Kahawa and Tuiyabei village Kisumu County (Western Region)
Coordinates	Latitudes 1º37' S and 1º45' S and between Longitudes 37º15' E and 37º23' E	Latitudes 0° 22' S and 0°19' N and between Longitudes 37° 5' E and 37° 55' E	Latitudes 0° 20'S and 0° 50'S and between Longitudes 33° 20'E and 35° 20' E
Agro-Ecological Zones	Lower Midland (LM) Lower Highland (LH) and Inner Lowland (IL)	Upper Highland (UH), Upper Midland (UM) and Lower Midland (LM)	Lower Midland (LH) and Upper Midland (UM)
Annual Mean Temperature	22.6°C	17.8°C	23°C
Annual Mean Rainfall	The rainfall is bimodal, ranging from 600 to 900 mm, with long rains season starting from March to July and short rains season from October to December.	The rainfall is bimodal, ranging from 400 to 2200 mm, with long rains from March to June and short rains from October to December.	Annual relief rainfall that ranges between 1200 mm and 1300 mm in different sectors. The rain mainly falls in two seasons. Kisumu is known for its thunderstorms, which are the major type of precipitation and normally occur in mid-afternoon

			during the rainy season.
Soils	The soils are predominantly Luvisols and Ferrasols	The soils are mainly Humic Nitisols	Acrisols Ferralsols Nitisols

Kisumu County

Although much of the food-based land use system of Western Kenya falls within the high to medium potential agricultural zone, agricultural productivity in this area is constrained by declining soil fertility, diminishing land holdings arising from high population growth and density, and the low use of agricultural inputs. The Maseno Agroforestry Research Project jointly established by the World Agroforestry Centre (ICRAF), the Kenya Forestry Research Institute (KEFRI), and the Kenya Agricultural Research Institute (KARI), was initiated in 1988 to address problems of declining soil fertility, soil erosion and inadequate fuel wood and fodder supplies. Since 1990, the on-farm component of the project has been involved in testing four agroforestry technologies: hedgerow intercropping, improved fallow, boundary planting, and fodder banks with several hundreds of farm households in Kisumu County. The FGDs undertaken in Kisumu were with the groups involved with the Maseno Agroforestry Research project.

From focus group discussions, the major uses and ecosystem services identified in the County include fuel-wood collection, water supply, crop cultivation, fishing, grazing and charcoal making. The major natural resources issues highlighted in the County are reduced tree cover and increased pressure for tree resources due to expansion of agriculture on previously forested steep terrains. This, according to the farmers, has led to soil erosion and further resulting in the silting of rivers and lakes and the loss of water catchment areas. This mode of land degradation has seriously affected many areas in Kisumu County.

The farmers also attest that there is degradation of arable land and rivers, resulting from heavy run-off, landslides and soil erosion, loss of soil fertility, silting of lakes, rivers and wetlands, reduced land productivity and loss of livelihoods. The major causes of degradation were reported to be rampant tree cutting for charcoal making as a source of income, poor farming methods, and overgrazing on the hillsides.

Embu County

Embu County is essentially a high potential area in terms of farm productivity and natural biodiversity. Despite this reality, poverty among the local residents and biodiversity losses are real and both continue to lose out. Threats to sustainable growth and biodiversity conservation are pointed out to be mainly due to problems related to human population density and their related activities, including inadequacy of land use policies. Community consultations revealed agricultural expansion for food and cash crops due to population growth, fuelwood and charcoal for commercial purposes as the leading causes of deforestation in upland and valley forest ecosystems on both private and public land.

In addition, agroforestry trees have been identified to provide a wide range of products and services to the people, and equally play an important role in conserving soil and biodiversity within the farmlands. Agroforestry practices, especially those that involve woodlots, improved fallows, live fences, remnant indigenous tree species, as well as farmland sites free from agrochemicals, have particularly been found to play a major role in the conservation of small mammals, avifauna as well as the indigenous tree species themselves which are endangered in the County. The study notes that agroforestry practices will continue to play a leading role in maintaining a balance between farming activities, social development and conservation of biodiversity in rural farmland areas of Embu.

In 2010 the International Maize and Wheat Improvement Center (CIMMYT) with support from the Australian Centre for International Agricultural Research (ACIAR) started a programme on sustainable intensification of maize–legume cropping systems (SIMLESA) covering five countries in Eastern and Southern Africa. The aim was to increase household and regional food security and incomes. SIMLESA is a regional collaborative programme implemented by national agricultural research systems (NARS) in Ethiopia, Kenya, Malawi Mozambique and Tanzania in collaboration with international and regional institutions. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is among the regional collaborating institutions. For Kenya, Embu County was one of the sites for the implementation of the SIMLESA project. The two groups interviewed in Embu County although now under the EverGreen Agriculture project were earlier involved and drawn from the SIMLESA project.

As the name suggests, EverGreen Agriculture refers to an agroforestry practice which advocates for the maintenance of green cover on farmlands throughout the year. EverGreen Agriculture incorporates particularly selected tree species in annual cropping systems preferably integrated with conservation agriculture practices. It is emerging as an affordable and accessible science-based approach to caring better for the land and increasing smallholder food production through realizing multiple benefits which include:

- Nitrogen fixation and nutrient cycling
- Maintaining vegetative soil cover
- Weed suppression
- Enhancing soil structure and water infiltration and penetration
- Food, fodder, fuel, fiber and income from tree products
- Carbon storage
- Biodiversity conservation

The overall objective of the EverGreen project is to improve the livelihoods of smallholder farmers in Eastern and Southern Africa while sustaining the natural resource base, by promoting the conservation agriculture and agroforestry practices.

Machakos County

Based on information from the visited villages in Machakos County the major ecosystem services highlighted in the drylands were grazing, crop cultivation, streams for water supply, woodlands for fuel-wood and building materials. The key environmental and natural resources management issues reported in the area were high runoff and water shortage, river silting and floods particularly desertification resulting from overstocking and overgrazing, rampant tree cutting for fuel wood and charcoal, poor farming practices, bush burning, and prolonged droughts.

The FGDs undertaken in Machakos County were with two farmers groups involved with the EverGreen Agriculture programme. As mentioned above the purpose of EverGreen Agriculture is to build capacity of smallholder farmers in conservation agriculture and agroforestry practices for improved nutrition, household income and landscape health. The EverGreen Agriculture has been rolled out through the ICRAF Rural Resource Centre in Machakos. The RRC Machakos is foreseen to play two major roles:

- Hubs for production and distribution of high quality tree planting materials, development of dissemination and propagation techniques, and training of nursery operators, farmers, small scale processors and extension officers.
- To develop to serve as a collection point and marketing center for tree products, notably, quality seeds and seedlings, medicinal plant products and fruits among others.

Demonstration plots serve as participatory trials where further biophysical tests can be conducted while demonstrating the benefits of EGA to farmers. Focus has been on candidate tree species such as *Gliricidia sepium, Calliandra calothyrsus and Faidherbia albida* intercropped with maize and legume species ICRAF staffs have established several plots together with farmers and extension staff. In Machakos about 40 demonstration sites have been established so far. Each participating group hosts a demonstration plot where they can learn together with facilitation by ICRAF staff and the assigned extension officers. In Machakos, the species intercropped in the crop farms included *Faidherbia sp, Calliandra sp and Gliricidia sp*. The main crop planted by the groups involved with the EGA project is maize and the cover crops are cow peas and pigeon pea.

3.5 Validation workshop

The initial findings of the scoping study will be presented in a stakeholders' workshop in 2016 for validation. The workshop is aimed at collecting more views and information from stakeholders including those that were unable to participate in the previous consultations. Following the validation workshop the consultant will revise the draft report in line with the outcomes of the validation workshop and detailed comments by BvAT, PELUM Kenya and ICRAF on the draft report. The relevant views and information gathered in the workshop will then be incorporated into the final report.

4.0 Natural resources management and agroforestry context in Kenya

4.1 Background: Policy and institutional context for NRM in Kenya

Kenya's economy experienced domestic and external shocks in 2011, dampening growth prospects and reducing gains from higher economic growth and recovery in 2010. High global food prices have contributed to the domestic food crisis, and agricultural policies are also to blame. Despite these shocks, the growth momentum remains strong underpinned by structural reforms, a new constitution and a dynamic private sector. The Kenya Constitution (2011) is one of the long-term issues that the current government committed itself to when it was sworn in on 09 April 2013. This will enable the government to address other long term issues, including land reforms among others.

Large parts of Kenya have been affected by drought, leaving 3.7 million people in need of food and other aid. The affected population is nearly 10% of Kenya's population (estimated at 40 million), increasing poverty levels and compounding development challenges.

On the biophysical side, the degradation of Kenya's natural resources and critical ecosystems continues unabated, albeit with all the numerous initiatives of government, NGOs and civil society organizations at conservation. Environmental problems are generally attributed to the complex interplay of socio-economic, policy and institutional factors aggravated by population growth and rapid urbanization. The antagonistic perceptions and attitudes of local communities towards the government's regulatory approaches exacerbate the situation. These negative perceptions grew out of stringent enforcement of soil and water conservation measures by colonial settlers during the pre-independence period. The Swynerton Plan of 1954 saw most of the settled high-and medium-potential areas terraced with the aid of coercive and restrictive regulations (Yatich *et al.,* 2007).

The clear disconnect between the provisions and enforcement of the law and the sheer lack of public literacy about these laws have strained government relations with local communities. This worsened after independence, as farmers failed to construct new conservation structures or maintain the old ones. Since then, enforcement of soil and water conservation regulations has relaxed and communities are increasingly involved in managing resources.

The current state of natural resource management (NRM) can be traced to Kenya's pre-colonial, colonial and post-colonial experience with respect to the country's political economy, which can be best summarized by the three epochs of development transformation. The pre-colonial mode of resource management was based on communal resource ownership governed by cultural and religious norms with binding regulations and sanctions. Low population density, the use of simple tools, limited trade, and relative abundance of natural resources ensured that communities met their needs without damaging the environment. The dawn of colonialism adversely transformed the relationship between local communities and "their own resources".

This transformation was driven by changes in resource rights, use and ownership. Through gazettement, the colonial government appropriated huge chunks of arable and forest land for agricultural expansion to provide raw materials for the European market. Forests were declared off limits for local communities, who were pushed into crowded colonial reserves. Native reserves became "pools" of cheap labor for settlers' farms. Coercive and restrictive law enforcement and economic deprivation caused conflicts between the "governed" and the "governors", providing the impetus for Kenya's liberation campaign.

After independence, the government continued to enact laws and pursued governance structures that extinguished the stewardship rights of communities over natural resources. Kenya's post-colonial government employed a vertical planning approach in which local communities were treated as passive recipients rather than active players in NRM.

Integrative policy and legislative reforms, albeit minimal, started in 1980s. As government resources dwindled and the population increased, the authorities saw the need to promote collective action by involving local communities in NRM. This was reflected in Kenya's National Development Plan of 1974-1978 and in subsequent policy and legislative frameworks. Reform-based initiatives at the national level were catalyzed by international policy processes, beginning with the Stockholm Conference on Environment and Development in 1972 and the establishment of the National Environment Secretariat. Kenya's participation in Multilateral Environmental Agreements and the Earth Summit in Rio de Janeiro and Johannesburg can be seen as the turning point for mainstreaming environmental concerns in long-term economic development planning (Yatich *et al.,* 2007).

This new thinking opened up opportunities for partnerships among different stakeholders for sustainable NRM that continued into the new millennium. However, this transformation process was not without problems. This new approach was viewed by large-scale farmers and the business sector as anti-development and prone to corruption and selective law enforcement. For instance, some developers view environmental impact assessment (EIA) requirements as anti-development despite the planning and management advantages. Over the years, resource users have come to grips with the reality of natural resources conservation for sustainability purposes. Today, Kenya's governance structure provides more space for the integration and implementation of other innovative strategies such as the agroforestry approach.

Current devolution of resource management and financing — like the Constituency Development Fund (CDF) — provides opportunities for "real" community participation in planning and decision-making. However, despite efforts of the Kenyan government to adopt bottom-up approaches, many critical decisions remain a preserve of the central government. This double-standards approach has perpetuated inequitable distribution of resources, especially in rural areas. Lack of alternative livelihood opportunities in some of these areas has left the people with land as the only resource to mine for their basic needs, putting heavy pressures on the land. Without a comprehensive approach to sustainable livelihoods, rural communities are degrading the very environment on which they depend.

Suffice to say that the policy environment in Kenya is constantly changing. Macro-and micro-economic policies interact at different scales, influencing NRM strategies. The policy formulation approach is often multi-sectoral, but is often centralized, with devolved structures provided only for local implementation. This has had ambivalent results at different scales. Thus, agricultural policy and ongoing reforms take place in the context of the government's overriding socio-economic development strategies. Ongoing policy reviews are undertaken as an integral component of the broader policy reforms in conformity with the Structural Adjustment Programme and poverty reduction strategies. These policy reviews provide an excellent opportunity to formulate 'outward looking' policies, but the process is only valuable if it can be exploited by proactive leaders, developers, planners and managers as well as knowledge and information being used to inform sound decisions (Yatich *et al.,* 2007).

The *Economic Recovery Strategy (ERS) for Wealth and Employment Creation* (2003, 2007) provides the framework for economic growth. Under this general framework, the government pursued strategies to reform governance, raise the production levels of its productive sectors, reduce poverty and create 500,000 jobs annually. The building and construction industry was of particular interest, since its projected growth rate rocketed to 18 percent. Overall, this was promising for the economy, but was pursued without considering the potential impacts of the industry on the natural resource base. The ERS is embodied in Kenya's Vision 2030, which is aimed at achieving Second World economic status by 2030. In this Vision, environmental concerns are embedded in the social pillar aimed at achieving a "just and cohesive society enjoying equitable social development in a clean and secure environment" (Gakuru, 2007; Yatich *et al.,* 2007). This policy statement is profound, but if Kenya were to achieve a double digit economic growth in the next two decades, its leaders should rethink the environmental policies and push for a paradigm shift among technocrats and politicians towards putting emphasis on development plans that will lead to creating opportunities for employment.

Despite their temporal scales and societal dynamics, policies formulated after independence still underpin resource allocation, affecting the current state of the ecosystem. Sessional paper No. 10 of 1965 on African Socialism and its Application to Planning in Kenya and Sessional paper No. 1 of 1986 on Renewed Growth for Economic Development are considered milestones for economic development planning and NRM (Yatich *et al.,* 2007). These policies targeted the high potential areas as "hotspots" for spurring development with expected trickle-down effects in arid and semi-arid lands (ASALs). But until recently, a widening socio-economic gap between low-and high potential areas persists, creating an impasse in the debate on the need for a 'Marshall Plan' for ASALs. Currently, the development of the ASALs is a key issue in ongoing constitutional and land use policy reforms. The failure to synergize the provisions of different legislations has promoted overlapping and wasteful efforts on the part of government.

It is worth to mention that traditionally, Kenya's approach to policy making has been piece-meal and fragmented, with significant shifts to multi-sectoral integrated approaches only in late 1990s. The need to shift from a fragmented policy formulation and implementation was expressed through Sessional Paper No. 1 of 1999 on Environment and Development, which defined an integrated policy framework for sustainable environment, NRM and poverty reduction, with specific goals for soil conservation, forestry, wetlands, and water resources management. The policy paper recognized the widespread degradation of natural resources and its intractable links to declines in economic productivity and poverty. It also outlines strategies that seek to balance the achievement of both conservation and development goals. These strategies seek greater involvement of non-governmental organizations, local communities and the private sector. Furthermore within this policy paper, the government advocated for population control to maintain the carrying capacity of the country with respect to man; land ratio. This particular aspect was articulated as a policy in Sessional Paper No. 1 of 2000 on Population Policy for Sustainable Development. Subsequently, the government formulated the environmental framework law, referred to as Environmental Management and Coordination Act (EMCA) No. 8 of 1999. EMCA provides for the "establishment of an appropriate legal and institutional framework for the management of the environment and for matters connected therewith and incidental thereto". Institutional structures created and legal instruments applied for were meant to be synergistic and interconnected with other regime structures.

4.2 Agroforestry in Kenya

Agroforestry in Kenya is an ancient practice. It is therefore a new name for old practices as from time immemorial; many farmers nurtured trees on their farms, pasture lands and around their homes (Muriuki *et al.,* 2012; Kitalyi, *et al.,* 2013). Agroforestry holds substantial promise for ameliorating critical development and environmental problems in Kenya as a land-use system that combines the production of food, livestock, and forest products, preferably on the same unit of land on a sustained yield basis (Muriuki *et al.,* 2012). Agroforestry offers potential for reducing increasing conflicts between arable farming, livestock keeping, and forestry interests, especially in the high-potential areas that are facing intense population growth (Kilewe *et al.,* 1989). Many people use agroforestry products and services in both rural and urban areas every day of their lives to cook with, eat, drink, take as medicine and sit on products grown on agroforestry systems (Muriuki *et al.,* 2012).

Thus, products from agroforestry trees bring the much needed income to the rural families and assure them food and nutritional security especially in drought periods (Muriuki *et al.,* 2012). Trees under agroforestry do provide farmers with many products and services such as food, fuel wood, fruits and nuts, poles, fodder, medicine, timber, mulch, shade and windbreak. They also play an essential role by providing food security to the farming community, covering the soil from agents of soil erosion, enhancing soil fertility by recycling nutrients, improving microclimate, providing living fences, demarcating boundaries, protecting biodiversity and controlling weeds (Franzel *et al.,* 2001). Many farmers in Kenya especially in the highlands have very small pieces of land ranging from quarter of an acre of land to two acres and for this reason there is no other option to meet the above mentioned advantages other than practice agroforestry (Muriuki *et al.,* 2012).

Kenya's national forest cover is less than 3 per cent compared with the internationally accepted level of 10 per cent. Policies have been put in place, which support agroforestry extension officers with a target of achieving 20% of Kenya land under tree cover by the year 2020. These policies are in favor of agroforestry and tree planting in general some of which prohibit cutting down of trees in forest areas. Adoption of agroforestry has improved over the years. Promoting on-farm forestry and conservation of natural environment is ongoing. Initiatives aimed at introducing commercial tree species in ASALs to control desertification and improve livelihoods have been undertaken (ASDS, 2010). There are also other policies in favor of non-governmental organizations to provide agroforestry extension services to farmers (GoK, 2009).

Agroforestry is a recent national policy concern. The earlier emphasis given to sustainable development has provided a platform for agroforestry to be considered within several sector policy processes. However, in spite of these sector polices there is no over-arching national agroforestry policy at present, with policy direction remaining anchored in the 2005 National Forest Policy. Several national initiatives have been undertaken at the strategy level: the National Food and Nutrition Security Policy (NFNP – 2010); National Land Policy (NLP – 2007); and the Agriculture Sector Development Strategy (ASDS – 2010).

The 2010 ASDS represents a significant milestone, but there is a need for it to be further strengthened to include: (i) the identification of priority programmes; (ii) their budgeted costs; and (iii) the expected sources of funding, if implementation is to be secured. The Strategy was developed through a thorough and extensive consultative process involving different thematic groups, where stakeholders could present their views to provide input and influence the process. What is less clear is how these stakeholder views were later analyzed and incorporated into the strategy. The financing of agroforestry actions appears to be treated primarily as a budgetary rather than a policy issue, with the national strategy providing only the briefest of references to the financing mechanisms required to implement agroforestry actions.

At present, the implementation of specific interventions and activities related to agroforestry are carried out in the respective Ministries, Departments and Agencies (MDAs) and Local Government Authorities (LGAs) according to their roles and responsibilities under the agriculture and forestry and their related mandates.

4.3 Analysis of actors involved

4.3.1 Key actors involved in agroforestry in Kenya

Agricultural research in Kenya dates back to before 1910 when small trial plots were laid out to test cash crops such as sisal, maize and cotton. Livestock experiments started around the same time. Forestry research was not organized in a coherent manner until 1934, and the Kenya Forestry Research Institute (KEFRI) was established as late as 1986.

Compared to that in agriculture and forestry, agroforestry research is very recent in Kenya. A major landmark was the establishment of the headquarters of the World Agroforestry Centre (ICRAF) in Nairobi in 1978. Gradually during the 1980s and 1990s agroforestry research progressed and a large number of institutions are now involved in various types of research. With ICRAF and its support for national institutions Kenya has in fact emerged as one of the global centres of agroforestry research (Tengnas, 1994).

- ***World Agroforestry Centre (ICRAF)***

ICRAF was initially established as the International Council for Research in Agroforestry, and was aimed mainly at facilitating research carried out by other institutions. The headquarters' initial priorities were to create a documentation centre to establish field demonstrations and to develop methods for agroforestry research. It was not until the late 1980s that ICRAF began its own research on a significant scale (Tengnas, 1994).

In 1991 the institution's name changed from International Council to International Centre for Research in Agroforestry. During 1991, ICRAF became a member of the Consultative Group on International Agricultural Research (CGIAR) with global responsibility for research in agroforestry. These developments marked a shift for ICRAF from being a body that gives advice to being a focal point for agroforestry research (Tengnas, 1994).

The institutional goal for ICRAF is *"To mitigate tropical deforestation, land depletion and rural poverty through improved agroforestry systems"*. Research focuses on three agro-ecological zones: the humid, sub-humid and semi-arid tropics. Although the mandate is clearly global, work in areas suffering from land depletion will continue to focus on Africa where these problems are most serious. Collaboration with national and other institutions, which has been a main feature of ICRAF's work, will continue. The four existing Agroforestry Research Networks for Africa (AFRENA) will continue receiving support through ICRAF.

ICRAF's own research has so far mainly been on-station, and focused on:

- Agroforestry technology design and management
- Species screening
- Soil fertility and soil conservation
- Fodder.

Most research has so far been applied and descriptive (trying to understand what happens) rather than process-oriented (trying to understand why it happens).

Kenya is one of the countries participating in the AFRENA for the highlands of East and Central Africa, which was initiated in 1986. The objectives of AFRENA are the development of appropriate agroforestry technologies and development of national capabilities to carry out agroforestry research. The participating countries in this AFRENA are Kenya, Uganda, Rwanda and Burundi. There are several research sites in each country, and the research focuses on the sub-humid highlands at altitudes ranging from 1,000m to 2,500m. The sub-humid highlands in those countries have been designated as a zone since they share common features. Population density is high, farm sizes are small and land-use systems are among the most intense in Africa. Agricultural practices have not always kept pace with the increasing pressure on land, resulting in a decline in the natural-resource base (Tengnas, 1994).

A key consideration in the design of the research programme has been complementarity among activities in each country. Agroforestry technologies with potential for the zone as a whole are being tested at multiple sites under varying environmental conditions. The choice of technologies to be tested has been based on Diagnosis and Design (D&D), i.e. surveys of existing land use, with associated potentials and problems have been used as a basis for setting research priorities. Such D&D studies have been carried out at the national (macro) scale by teams constituted of ICRAF scientists and scientists from national institutions. The main institutions with which ICRAF is collaborating in Kenya are the Kenya Forestry Research Institute (KEFRI), and the Kenya Agricultural and Livestock Research Institute (KARLO).

4.3.2 Other institutions

A large number of other institutions conduct research or informal trials on agroforestry, often closely coupled with extension. Only a few of those organizations are mentioned here.

- *Ministry of Energy (KREDP, KWDP/KWAP)*

The Ministry of Energy has been the parent ministry for both the KWDP/KWAP, which has already been described, and the Kenya Renewable Energy Development Project (KREDP). Both projects have contributed to agroforestry development, but research was a particular part of the agenda at KREDP. Agroforestry Energy Centres were established in the early 1980s. One of these centres is located at Mtwapa in the coastal zone. The main objective of the Centre is to address the problem of declining soil fertility and to find solutions to the shortages of firewood and poles in the coastal zone. Hedgerow intercropping trials with several tree species in combination with maize are continuing there. A large amount of data were collected from those trials, but unfortunately very little has been analyzed.

- *International Maize and Wheat Improvement Centre (CIMMYT)*

CIMMYT has been implementing the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) project. CIMMYT is also undertaking, or is involved in, a number of other projects with an agroforestry component, which include the Conservation Agriculture and Smallholder Farmers in Eastern and Southern Africa (CASFESA) funded by EU-IFAD; the Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project; and the Adoption Pathways Programme.

- *International Livestock Research Institute (ILRI)*

KALRO (formerly KARI) and ILRI (formerly the International Livestock Centre for Africa, ILCA) also carry out collaborative research in the coastal zone. The main focus is on fodder and milk production, with special emphasis on how best to utilize available land and labor. Research is conducted both on station and on farm, with improved milk production as a main objective.

- *CARE*

CARE and KEFRI have run a collaborative programme since 1985 in Siaya District. Activities include trials on hedgerow intercropping, soil-conservation measures, farm woodlots, boundary planting, intercropping and mulching of fruit trees, live fences and windbreaks.

- *Kenya Energy Non-Governmental Organizations (KENGO)*

Although KENGO is not a research body, some of its activities have contributed significantly to knowledge and technology development. Of particular interest are KENGO's activities with regard to the development of fuel-saving stoves and documentation of indigenous tree species.

- *Universities*

Egerton University, Moi University and the University of Nairobi are all conducting research on agroforestry or closely related issues.

- *Tea Research Foundation*

The Tea Research Foundation is conducting research on trees in relation to tea growing.

- *Coffee Research Foundation*

The Coffee Research Foundation is conducting research on trees in relation to coffee growing, and in particular on the effects of trees shade on coffee.

- *The National Museums of Kenya/Freedom from Hunger Council Indigenous Food Plants Project (IFPP)*

The East Africa Herbarium is a valuable institution for agroforestry. The Herbarium can often assist in tree identification, and in addition researchers are carrying out research on rare tree species. The Indigenous Food Plant Project (IFPP), which is run in collaboration with the Freedom from Hunger Council, has contributed in documenting indigenous species and their uses for food.

- *African Conservation Tillage Network (ACT):*

The core mandate of ACT is the mainstreaming of conservation agriculture through stakeholder engagement. ACT is implementing a number of agroforestry and conservation agriculture projects not only in Kenya, but across Africa. In Kenya some of the main projects being implemented include the following:

- ***Agro-Ecology-Based Aggradation-Conservation Agriculture (ABACO) Project:*** The project is targeting the establishment of site-specific innovations that rely on site-specific agro-ecology and aggradation measures to restore soil productivity in order to improve food security in semi-arid Africa. This project is targeting local research and extension institutions designing or promoting conservation agriculture in semi-arid regions of Africa, including Kenya. ABACO principles are rehabilitation of degraded soils, increased water productivity, intensifying agro-ecological functions, innovation support systems and institutionalizing of enabling policies and market conditions.

- ***Up scaling Conservation Agriculture for Increased Resilience to Climate Change and Improved Food Security in Eastern and Southern Africa (CA4CCFS–ESA):*** This project is conducted in collaboration with NORAD with the aim of strengthening resilience to climate change, thereby contributing to increased food security among rural communities of Eastern and Southern Africa.

Participatory Ecological Land Use Management (PELUM)

PELUM is a network of civil society organizations / NGOs working with small-scale farmers in East, Central and Southern Africa. The Association membership has grown from 25 pioneer members in 1995 to over 250 members in 2014. PELUM- Kenya is the Kenyan country chapter of the PELUM Association and has a membership of 44 member organizations.

- *Biovision Trust Africa (BvAT)*

Established in Kenya in 2009, the Trust's goal is to alleviate poverty and improve the livelihoods of smallholder farmers in Kenya and other African countries through supporting dissemination of information and knowledge on appropriate technology to improve human, animal, plant, and environmental health. BvAT holds the perspective that agricultural output and food supply are hindered by various environmental factors and lack of information and relevant training for the African smallholder farmers. For instance, plant pests, are responsible for up to 80% of crop losses. Thus, ecologically sustainable solutions hold the practical alternative for African farmers to achieve good crop yields without relying on expensive chemical fertilizers and pesticides. Hence, BvAT lead on the Ecological Organic Agriculture (EOA) Initiative supported by the African Union and currently implemented in eight countries (Benin, Ethiopia, Kenya, Mali, Nigeria, Senegal, Tanzania and Uganda) with the focus of the EOA initiative targeting promotion of agroforestry.

- *Vi Agroforestry* (Vi-skogen)

~~(~~Vi-~~skogen)~~Agroforestry is a Swedish development cooperation organization, fighting poverty and improving the environment through tree planting. This is done together with smallholder farming families and farmers' organizations in the Lake Victoria Basin in East Africa. The foundation of Vi Agroforestry's work is sustainable agriculture and agroforestry – growing trees

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alongside crops and livestock. It provides increased access to food, access to sustainable energy sources, more income. Sustainable agriculture contributes to the mitigation of climate change and protects against the negative effects of climate change. Since its inception in 1983, the organization has helped planting over 100 million trees and improved the livelihoods for 1.8 million people.

4.4 Agroforestry in the state policy and education system

4.4.1 State policy

Since 1980, Kenya has been promoting policies to improve the competitiveness of the different productive sectors and encouraging national capacities for technological development. Thus, Kenya has some policies that could support the scaling up of agroforestry. Some of these policies are:

- *National Food and Nutrition Security Policy (NFNP – 2010);*
- *National Forest Policy, 2005;*
- *National Land Policy, 2007;*
- *Extension Policy, 2005;*
- *The Agriculture Sector Development Strategy (ASDS - 2010);*
- *National Environment Policy*
- Vision 2030

The Ministry of Agriculture has the “policy for environmentally sustainable agricultural development”, which has as part of its subprograms the need for research and implementations ofagroforestry arrangements and the strengthening of silvopastoral and agrosilviculture proposal for land recovery. The “National Forestry Policy” in 2005, recognized agroforestry as a viable option for the establishment of trees on farms and in pastures and as a way to enhance the cash flow and income of farmers. At the provincial and county governments also have agricultural policies, which are coordinated by the department of agriculture. These policies may or may not have agroforestry included in the plans depending on the agroforestry knowledge of the provincial or county government staff (Integrated County Development Plans document there are some references to agro-silvocultural systems as a way to achieve sustainable land management.

4.4.2 Education system

Currently, three Kenyan universities namely Egerton University, Moi University and the University of Nairobi are offering an undergraduate and postgraduate degree in agroforestry. Although prominent Kenyan universities such as Kenyatta University, Maseno University and Jomo Kenyatta University of Agriculture and Technology (JKUAT) don’t have full degree programmes in agroforestry, they do have courses or lectures included in related degrees and are active in agroforestry research. Technical courses in agroforestry are also offered by many institutions such as Kenya Forestry College; Embu Agricultural Staff Training College; Bukura Agricultural College; Baraka Agricultural College; and Taita Taveta University College.

Fourteen Kenyan universities and colleges form part of the “ANAFE” (The African Network for

Agriculture, *Agroforestry* and Natural Resources Education) a network of 136 educational institutions in 35 African countries whose objective is to strengthen the teaching and mainstreaming of integrated education and training programmes in Agriculture, Agroforestry, Forestry and Natural Resources within African colleges and universities for improved livelihoods (ANAFE, 2015). The ANAFE secretariat is hosted at the World Agroforestry headquarters in Nairobi. This provides a vantage position for network management, linkages with the research and development activities of ICRAF and its partners through the World Agroforestry's convenient communication facilities.

4.5 The current trends in promotion of agroforestry practices in Kenya

The current agroforestry practices in Kenya have borrowed many elements of the traditional agricultural systems. It could be a modification of an existing practice such as managing different tree species and crop varieties but managed in a familiar way. However, others are managed in a totally new way such as the improved fallows which is a completely new way of farming in most areas (Place *et al.,* 2012). The FAO Forest Resources Assessment Report indicates that the total tree cover in Kenya outside the forests (mainly in agroforestry systems and trees in urban areas) is greater than tree cover within the forests. In addition the forest cover in Kenya continues to decrease while the tree cover on the farms is increasing (FAO, 2003). The trend is likely to continue because of increased demand for tree products and services as human population increases. The importance of smallholder agroforestry systems is likely to be reinforced with increased attention and resources allocation to agroforestry whereby more efforts are being made to protect forests and simultaneously expanding tree growing on farms (Place, *et.al,* 2012; Kitalyi *et al.,* 2013).

In the 1990s, various research and development agencies including SIDA, GIZ, KWAP and FAO, teamed up with government agencies to promote agroforestry practices. Agroforestry projects were initiated in several parts of the country and mainly focused on fast growing exotic tree species such as *Grevillea, Leucaena, Calliandra and Casuarina*. There was very little that was done to restore the indigenous tree species in the farmlands possibly because these species take a long time to mature. The Ministry of Agriculture in collaboration with SIDA had a nationwide programme known as the *"Catchment Approach"* that focused on integrated farm management approach through soil and water conservation, fodder and fruit production. The programme aimed at increasing agricultural productivity and ecosystem conservation through reduction of soil erosion on sloppy areas and protection of water catchments in the country. This initiative yielded dividend since lots of awareness was created, lots of sloppy land was terraced and agroforestry trees were planted in the farms contributing to wide scale changes on the landscapes (Kitalyi *et al.,* 2013).

Some of the research and development organizations focused on agroforestry systems that are geared towards production of specific commodities. ICRAF, KARI and KEFRI researched and promoted agroforestry systems that focused on soil fertility improvements, fruits and dairy production. ICIPE focused on agroforestry systems that deal with bee production (apiary) and silk worm production (sericulture). GEF, KEFRI, Green Belt Movement and KFS, promoted agroforestry systems that aimed at protecting and conserving Mount Kenya and Aberdare forests. The communities that live adjacent to these forests illegally rely on wood and non-wood products from state owned forests and therefore are major contributors to the destruction of the forests. They need to be sensitized and educated on the need to incorporate agroforestry practices in their own farms to reduce the pressure they exert on forests. Currently, there are a number of national and international institutions such as KALRO formerly KARI), KEFRI, KFS, Green Belt Movement, ICRAF and GEF that have agroforestry based projects around the Aberdare and Mount Kenya forests. The projects include silviculture (trees with crops), silvo pastoral (trees with pastures and livestock), apiculture (trees for honey production) sericulture (trees for silkworm production) and aquaculture (trees with fish). These projects aim at the restoration of the forest ecosystem. There is need to integrate other conservation measures such as the increased use of renewable energies like solar, wind and hydro energies to replace the use of wood energy. Production of charcoal and use of firewood has been quite detrimental to the environment and is associated with climate change as a result of emission of greenhouse gases such as carbon dioxide. Tree species that produce high quality charcoal such as *Olea* and *acacia* face extinction due to overexploitation (Kitalyi *et al.,* 2013).

Organizations that are promoting agroforestry practices often encourage incorporation of trees and shrubs into the farm as live fences, boundary markers, windbreaks, hedges for soil erosion control, fodder banks, wood lots, etc. Increased planting of trees and shrubs on the farms help in conservation and protection of natural forests as wood products and services can be obtained from the farms and thus reduce the pressures on exploitation of forest resources (Wambugu and Franzel, 2012). There is scientific evidence that some of the tree species can directly help in increasing land productivity and mitigate on climate change. Fodder shrubs can effectively replace some of the concentrates and part of the basal diet of dairy livestock leading to increased milk production per cow (Franzel and Wambugu, 2007). This may necessitate the reduction of the number of cattle in the farm and subsequently reduce the amount of methane emission at an individual farm (Thornton and Herrero, 2010). In case of fodder production, only the leaves are harvested leaving behind the woody stems above the ground and the root systems below the ground and thus an immense contribution towards carbon sequestration (Wambugu and Franzel, 2012).

During the Second Kenya National Seminar on Agroforestry, held in Nairobi, in 1988, it was found that institutional issues were the main constraints limiting the full realization of the potential of agroforestry to increase the productivity, sustainability, and economic diversity of rural lands in Kenya (Kilewe *et al.,* 1988). The participants noted that agroforestry development in Kenya has suffered because of a lack of institutional coordination in field extension. There has also been concern about an institutional base for agroforestry extension. It was at almost the same time where some efforts to formalize institutional cooperation on various aspects of agroforestry were identified, and these include (i) setting up of a National Steering Committee on Agroforestry Research under the National Council for Science and Technology (NCST) with all main governmental and NGO "actors" being members, (ii) drafting a Memorandum of Understanding for ministerial cooperation and coordination of agroforestry efforts in Kenya, (iii) developing six agroforestry centers to be valuable extension tools for both the Ministry of Agriculture and the Ministry of Environment and Natural Resources (MoENR) as well as being main suppliers of multipurpose tree seeds for a variety of government and NGO projects in the country; (iv) setting up a National Tree Seed Committee to coordinate issues related to quality control and dissemination of tree seeds throughout Kenya (Kilewe *et al.,* 1988; Muriuki *et al.,* 2012).

5.0 Classification/Characterization of agroforestry technologies, systems and practices in Kenya

This section provides information about classification of agroforestry technologies, systems and practices and brief description of some common agroforestry practices in Kenya. According to Sinclair (1999), the primary purpose of a general classification of agroforestry is to identify the different types of agroforestry that occur and to group those that are similar, thereby facilitating communication and the organized storage of information about them. While different classifications may be suitable for different purposes, it is useful to have a generally accepted way of classifying and describing the major types that occur frequently to be able to communicate without having to perpetually clarify.

5.1 Agroforestry system, practice and technology

The words "system", "practice" and "technology" are often used synonymously in agroforestry literature. However, some distinction can be made between them.

An *agroforestry system is a specific local example* of a practice, characterized by environment, plant species and their arrangement, management, and socioeconomic functioning. On the other hand, an *agroforestry practice* denotes a *distinctive arrangement of components* in space and time. Although hundreds of agroforestry systems have been recorded, they all consist of about 20 distinct agroforestry practices. In other words, the same or similar practices are found in various systems in different situations (Nair, 1993). Table 5.1 lists the most common agroforestry practices that constitute the diverse agroforestry systems throughout the tropics and their main characteristics. It may be noted that both the systems and the practices are known by similar names; but the systems are (or ought to be) related to the specific locality or the region where they exist, or other descriptive characteristics that are specific to it. In the scoping study here, the two concepts (systems and practices) are used interchangeably.

Another term that is also frequently used is *agroforestry technology.* In other words this refers to an innovation or improvement, usually through scientific intervention, to either modify an existing system or practice, or develop a new one. Such technologies are often distinctly different from the existing systems/practices; so they can easily be distinguished and characterized.

However, the distinction between systems and practices are vague, and even not very critical for understanding and improving them. Therefore, the words systems and practices are used synonymously in agroforestry, as they are in other forms of land use.

Table 5. 1: Major approaches to classification of agroforestry systems and practices

Categorization of systems based on their structure and functions			Grouping of systems (according to their spread and management	
Structure (nature and arrangement of components, especially woody ones)		Function (role and/or output of components, especially woody ones)	Agro-ecological environmental adaptability	Socio-economic and management level
Nature of components	Arrangement of components	*Productive function*	*Systems in/for*	Based on level of technology input
Agrisilviculture (crops and trees incl. shrubs/trees and trees)	In space (spatial) Mixed dense (e.g., ~~homegarden~~home garden)	Food Fodder Fuelwood Other woods Other products	Lowland humid tropics Highland humid tropics (above 1,200 m a.s.l., Malaysia) Lowland sub-humid tropics (e.g. savanna zone of Africa, Cerrado of South America)	Low input (marginal) Medium input High input
Silvopastoral (pasture/animals and trees)	Mixed space (e.g. most systems of trees in pastures)			*Based on cost/benefit relations* Commercial Intermediate Subsistence
Agrosilvopastoral (crops, pasture/animal: and trees)	Strip, (width of strip to be more than one tree)	*Protective function* Windbreak Shelterbelt Soil conservation Moisture conservation Soil improvement Shade (for crop, animal and man)	Highland sub-humid tropics (tropical highlands) (e.g. in Kenya, Ethiopia)	
Others (multipurpose tree lots, apiculture with trees, aquaculture with trees, etc.)	Boundary (trees on edges of plots/fields In time (temporal) *Coincident *Concomitant *Overlapping *Sequential (separate) *Interpolated			

(Source: Nair 1993)

5.2 Classification of agroforestry systems

As with many new sciences in search of an identity, agroforestry has had its fair share of classification efforts (Combe and Budowski, 1979; King 1979; Torres, 1979; Grainger, 1980; Vergara, 1981 Nair, 1985, Sinclair, 1999). In the early 1980s, ICRAF completed an inventory of agroforestry systems in the tropics and sub tropics (Nair, 1985). Sinclair (1999) used the same database to update the classification, focusing on agroforestry practices rather than agroforestry systems. Across these classifications, agroforestry practices are categorized according either to (i) components, (ii) predominant land use, (iii) spatial and temporal structure, (iv) agro-ecological zone, (v) socio-economic status, or (vi) function (Table 5.2).

Table 5.2 Classification of agroforestry systems based on their components, spatial and temporal arrangement, function, agro-ecological zone, and socio-economic aspects

Classification method	Example categories	Major area of application
(i) Components	**Agrisilviculture:** crop and trees, of which Silvoarable comprises arable crops with trees **Silvopastoral:** pasture/animals and trees **Agrosilvopastoral: crops:** pasture/animals and trees **Other:** multipurpose tree lots, beekeeping with trees, aquaculture with trees	
(ii) Predominant land use	**Primarily agriculture** **Primarily forestry**	Administration
(iii) Spatial and temporal	**Spatial** Mixed dense (e.g., home gardens) Mixed sparse (e.g., most systems management for of trees in pasture) Strip planting (e.g., most systems involving agricultural machinery) Boundary (trees on edges of plots and fields) **In time** Coincident separate	Particularly useful in research on plant management for optimizing interactions
iv) Agroecological	Humid, arid mountainous	Land use planning
(v) Socio-economic	Commercial, intermediate, subsistence	Socio-economic analysis of agroforestry potential
(vi) Function	**Productive functions** Food, fodder, biofuel, wood, other products **Habitat functions** Biodiversity **Regulating functions** Shelterbelt, soil and water conservation, shade **Cultural functions** Recreation and landscape	Developing projects for exploiting agroforestry potential

(Modified from Nair 1990, 1993; Young 1997 and Sinclair 1999)

Nair (1990) suggests that the first stage of classification should be on the basis of the components, but any subsequent classification should be based on the purpose. However, it would take too long here to make a detailed review of all the proposed classification systems. Certain criteria for differentiation of agroforestry systems, however, commonly recur. According to Nair (1993) he most common set of criteria used by many authors to classify agroforestry systems and practices are

- Structural basis—refers to the composition and arrangement of the components, both spatial and temporal.
- Functional basis—refers to the main function or role of the components especially the woody components as for soil conservation and soil fertility improvement (i.e. productive or protective).
- Socioeconomic basis—refers to the intensity or scale of management and goals of the system. This refers to the purpose of the system with regard to human livelihoods, usually broken down into subsistence, commercial, and/or intermediate production systems. Agroforestry may be promoted to meet specific social goals such as poverty alleviation and food security.
- Ecological basis—refers to the environmental and ecological suitability of systems. There can be separate sets of agroforestry systems for arid and semi-arid lands or humid and sub-humid tropics.

As stated from the introduction section many definitions have been proposed for what constitutes agroforestry. Some have even gone to the extent of exaggerated and presumptuous claims that agroforestry, by definition, is a superior and more successful approach to land use than others. For the purpose of this report the definition by ICRAF is being adopted which reads as follows:

> *Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management unit as agricultural crops and/or animals, either on the same farm of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components.*

This definition implies that:

I. agroforestry normally involves two or more species of plants (or plant and animals), at least one of which, is a woody perennial;
II. an agroforestry system always has two or more outputs;
III. the cycle of an agroforestry system is always more than one year; and
IV. even the most simple agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a mono-cropping system.

Following the definition by ICRAF, the basic groups of components in an agroforestry system can be two or three: woody perennials, herbaceous crops and/or animals. Since the woody perennial forms the common denominator in all agroforestry systems, a component-based classification scheme will logically have to be based on this predominant component. Here again, the criteria, as pointed out by Torres (1983) can be several: the *type* of woody perennial, its *role and function* in the system, the nature of *interaction* between the woody and other components, and so on. All component-based classification schemes of agroforestry systems have so far considered the type of woody perennials as the first step in the exercise and based on these three basic components, agroforestry systems can also be classified for all practical purposes according to their component composition.

- Agrisilvicultural systems
- Silvopastoral systems
- Agrosilvopastoral systems

The agrosilvicultural system combines the production of tree crops (forest, horticultural-, or agricultural plantation-) with herbaceous crops, in space or time, to fulfill productive or protective roles within the land management systems. Examples can be hedgerow intercropping (alley cropping), improved "fallow" species in shifting cultivation, multistorey multipurpose crop combinations, multipurpose trees and shrubs on farm lands, shade trees for commercial plantation crops, integrated crop combinations with plantation crops, agroforestry fuelwood production systems, shelterbelts and windbreaks and so on (Nair, 1984).

The silvopastoral systems integrate woody perennials with pasture and/ or livestock. Examples include animal production systems in which multipurpose woody perennials provide the fodder (protein bank), or function as living fences around grazing land or are retained as commercial shade/browse/fruit trees in pasture lands (Nair, 1984).

The agrosilvopastoral systems, as the name implies, combine trees and herbaceous crops with animals and/or pastures. The use of woody hedgerows for browse, mulch and green manures and for soil conservation, the crop/ tree/livestock mix around homesteads, etc. are good examples of this system. It is also a common practice in some places to have sequential patterns (integration in time) of agrosilvicultural phase followed by a silvopastoral one so that initially trees and crops are established and later on the crops are replaced with pasture and animals are brought in.

For the description and evaluation of systems and practices, several classification schemes have been developed. Table 5.1 give an overview of the classification approach of Nair (1993), which is widely accepted. For this study, the classification criteria and framework proposed by Nair (1993) are applied in a simplified way to identify appropriate and innovative agroforestry practices in Kenya.

Agroforestry is a complex subject in nature and the classification of agroforestry even at national level is not an easy task. The data available previously was a hypothetical estimation which ranged wildly. Agroforestry is still a growing discipline and the classification of agroforestry systems and practices is in the stage of infancy which will take the time to come in a stage of maturity but on the basis of this study it can be said that although this is the beginning but significant step towards destiny.

5.3 Classification of agroforestry in Kenya

5.3.1 Agroforestry systems in Kenya

A substantial literature exists on agroforestry systems in Kenya. Throughout Kenya, agroforestry systems come in a wide variety of shapes and forms. Many of these systems have little more in common than the coincidence of woody perennials with agricultural crops and/or livestock. Basic data collection by the FAO does not clearly stress the segregation between forests and agricultural landscapes with trees. This can be seen as an historical anomaly rather than a reflection of incompatibility between annual and perennial plants within a farming system (Kitalyi *et al.,* 2013).

Trees or shrubs on farms and in landscapes can occur as solitary individuals, in lines, as woodlots or in the seemingly random constellations that characterized the forest that was present before the establishment of agriculture. Depending on the environmental, climatic, economic and socio-cultural niches they occupy, different types of agroforestry systems have arisen in different places. A number of approaches have been proposed for defining a typology of agroforestry practices and systems but inclusion of multiple characteristics is necessary for grasping all major distinctive attributes of agroforestry systems. Cheikh *et al* (2014) typology of classification is relevant in the context of developing a classification of for Kenya. Diversity of agroforestry (AF) classification by Cheikh *et al* (2014) is shown in Table 5.3.

Table 5.3 Diversity of agroforestry (AF) classification

Typology of AF	Key elements	Examples AF practices	References
Ecological	Geographical location (AF system adaptability to particular ecologies)	Lowland humid or sub-humid tropics AF	Nair 1993, Torquebiau (2000)
Physiognomy	Parkland	*Faidherbia* Shea butter parks in West Africa	Garrity *et al.,* 2010
	Mosaic Multistoried ~~homegarden~~home garden	Long term fallows	
Compositional/ structural	Simultaneous or sequential combination of trees, crop, animal	Trees in pasture and rangelands (silvopastoral) and agriculture	Nguyen *et al.,* 2013

		(agrosilvopastoral)	
Practices (systems)	Management systems, livelihood strategies	Hedgerows, long term fallows, alley cropping, improved fallow, multilayer tree cropping. woodlots	DeSouza *et al.,* (2012), Nair (1993)
Functional	Erosion control, soil fertility	Wind breaks, shelterbelts, erosion control/soil conservation, scattered nitrogen fixing trees, boundary planting	DeSouza *et al.,* (2012), Bayala et al., 2011
Socioeconomic	Scale of production and level of technology, input and management (Commercial, subsistence AF)	Low input, high input agroforestry	Thorlakson and Neufeldt (2012), Assogbadjo *et al.,* (2012), Sood and Mitchell (2011)

Adapted from Cheikh *et al.,* (2014)

It is worth to point out that several agroforestry practices can be relevant for different agro-ecological zones, and many systems with a range of different compositions can fulfill essentially the same functions for livelihoods and landscapes. There is therefore no single classification scheme that can be nationally applied. The basic premise is that what differentiates agroforestry from other land uses is the deliberate inclusion of woody perennials on farms, which usually leads to significant economic and/ or ecological interactions between woody and non-woody system components. According to Cheikh *et al.,* (2014) in most documented cases of successful agroforestry establishment, tree-based systems are more productive, more sustainable and more attuned to people's cultural or material needs than treeless alternatives. Yet agroforestry is not being adopted everywhere, and better insights are needed into the productive and environmental performance of agroforestry systems, socio-cultural and political prerequisites for their establishment, and the trade-offs farmers face in choosing between land use practices. These site factors are likely to vary at fine spatial and possibly temporal scales, making the development of robust targeting tools for agroforestry intervention a key priority in agroforestry research.

An inventory of agroforestry systems and practices that exist in Kenya was undertaken during FGD. The examples found in different geographical and agro ecological regions were as follows in Table 5.4.

Table 5.4: Field examples of some common agroforestry systems and practices and some of the woody species involved in Kenya

Sub-system practice	Some examples of the woody species involved
Agrosilvicultural Systems -Humid/Sub-Humid Lowlands (Kisumu)	
Multipurpose trees and shrubs on farmlands. Trees scattered haphazardly or according to some systematic pattern	*Anacardium occidentale* *Ceiba petandra* *Mangifera indica* *Manilkara achras*
Agrosilviculturl Systems - Tropical Highlands (Embu)	
Multipurpose trees and shrubs on farmlands	*Ceiba petandra* *Eriobotrya japonica* *GrevilZea robusta*
Crop combinations with plantation crops	*Grevilea robusta*
Shelterbelts, Windbreaks, Soil Conservation Hedges	*Cajanus cajan* *Eucalyptus* *Populus ssp* *Gliricidia sepium* *Sesbania grandiflora*
Agrosilvicultural Systems - Arid and semi-arid Regions (Machakos)	
Multipurpose trees and shrubs on farmlands	*Acacia spp* *Cajanus cajan* *Adansonia digitata* *Balanites aegyptiaca* *Erythrina*
Silvopastoral Systems - Humid/Sub-Humid Lowlands (Kisumu)	
Live fences	*Erythrina abyssinica* *Euphorbia tirucalli*
Silvopastoral Systems - Tropical Highland (Embu)	
Live fences	*Gliricidia sepium* *Erythrina abyssinica* *DovyaLis caffra* *Iboza mutifiora* *Caesalpinia decapetula* *Dracena spp.*
Silvopastoral Systems - Arid and Semi-arid Region (Machakos)	
Live fences	*Acacia spp* *Commiphora Africana* *Euphorbia tirucalli* *Zizyphus mucronata*

The classification of agroforestry systems is rather broad and complex. It may not be easy to group a certain agroforestry system within one of these major categories of practices. For instance, it may be difficult to draw a line between a complex (i.e. multi-species) silvoarable system and a forest farming system. Moreover, agroforestry systems are dynamic systems, i.e. subject to continuous changes. An agroforestry plot may start as a silvoarable system, but may change into a silvopastoral system in later years. Nevertheless, the following description of the four considered agroforestry practices gives an impression of the range of possible agroforestry systems for Kenya

5.3.2 Agroforestry technologies in Kenya

The key agroforestry technologies that have been the focus of research and development efforts in the last 30 years in Kenya are shown in Table 5.5. The experience with regards to the adoption of agroforestry technologies in Kenya has not been too different from the global trend. Although agroforestry is financially profitable and there has been an increasing trend in the uptake of the technologies by farmers, the widespread adoption of agroforestry technologies by many more smallholder farmers is nonetheless constrained by several challenges such as local customs, institutions and policies at the national level as highlighted during FGD Table 5.5

Table 5.5 Agroforestry technologies options promoted and researched upon in Kenya

AF Technology	Tree species used
"Fertilizer tree systems"	The plant species used in fertilizer tree systems to overcome soil fertility problems in Kenya include improved fallows based on *Sesbania sesban, Tephrosia spp., Gliricidia sepium and Cajanus cajan*
Rotational woodlots	The main woodlot species that have been promoted in Kenya are acacias especially *Acacia crassicarpa, Acacia polyacantha* and *Acacia auriculiformis, Eucalyptus saligna, Acacia Mearnsii,* and *Grevillea robusta.*
Fodder banks:	*Acacia angustissima, Albizia lebbeck, Cajanus cajan, Calliandra calothyrsus, Calliandra tetragon, Flemingia macrophylla, Gliricidia sepium, Leuceana leucocephala, Leuceana diversifolia, Sesbania grandiflora, Sesbania sesban, Erythrina arborescens, Erythrina buranas, Erythrina edulis*
Planting on Homesteads	The most common tree species under this technology included, *Magnifera. indica, Eriobotrya japonica, P. Americana, P. guajava* as fruit trees and *Spathodea campanulata, Markhamia lutea, Prunus africana, Terminalia mentalis, Pinus patula, Casuarina equisetifolia* and *Jacaranda mimosifolia,* for shade, timber, fuel wood and herbal medicines.
Boundary marking	Tree species mostly observed for use in this technology included, *Grevillea robusta, Croton megalocarpus, Cupressus lusitanica* and *Acacia Spp.*
Hedges	The tree species that were found commonly used in this technology included: *Lantana camara, Dovyalis caffra, Cupressus lusistanica* and *Psidium guajava.*
Home garden	Fruit trees included *Magnifera indica*, *Musa esculenta, Persia americana, Psidium guajava, Carica papaya and citrus spp.* Fodder tress included *Sesbania sesban, Leucaena leucocephala, Calliandra calothyrsus* and Napier grass.

Alley Cropping	Tree species used in alley cropping *Cassia siamea, Leucaena leucocephala, Sesbania sesban Gmelina arborea, Grevilea robust*

Several empirical studies have been carried out to gain insights into the adoption of agroforestry technologies in Kenya. The specific studies investigated the types of farmers who adopt (do not adopt) agroforestry (Mugendi *et al.,* 1999; Marenya and Barrett, 2007; Otsuki and Ogo, 2009; Otsuki, 2010). Other studies examined the factors that drive the adoption of agroforestry; why do some farmers continue to adopt more than others (Place *et al.,* 2005; Franzel and Scherr, 2002; Scherr, 1995). Among the factors considered in these studies as affecting farmers' decision to adopt agroforestry technologies in Kenya are wealth, age, sex, education, labor/household size, farm size, uncultivated land, use of fertilizer, off-farm income, and village exposure to improved fallows.

Following the successful demonstration of the potential of agroforestry technologies to make positive impact on the livelihoods of smallholder farmers in Kenya, various agroforestry research and development institutions have been focusing efforts in scaling up these technologies to reach a greater number of resource-poor smallholder farmers who could potentially benefit from the technologies. Scaling up is expected to bring more quality benefits to more people over a wider geographic area, more quickly, more equitably and more lastingly. However, due to the complexities of factors that affect scaling up, going to scale requires vertical and horizontal processes. The vertical process represents efforts to influence policy makers and donors and is generally institutional in nature. While the horizontal process (often referred to as scaling out) refers to the spread across communities and institutions and geographic boundaries (IIRR, 2000). Both processes characterize scaling up interventions of agroforestry. Agroforestry partners have focused efforts on a process of institutionalizing agroforestry in the research, extension, and development and education arenas in order to get policy makers, researchers, extension workers, development workers, educationists and farmers to forge their efforts jointly to address the factors that influence going to scale.

Three major interrelated and mutually enforcing strategies employed in the scaling up of agroforestry technologies in Kenya according to literature, key informants and FGD's are capacity building, partnerships and networking and promoting policies more conducive to adoption with the central focus being strengthening of local capacities to innovate as a way of ensuring sustainability of technological enhancement (Place *et al.,* 2002). Among the key interventions characterizing these strategies are the following: farmer-centered research and extension approaches, establishment of strategic partnerships, knowledge and information sharing, establishing viable seed systems, developing market options, local institutional capacity strengthening, diversification of agroforestry technologies and influencing policy at different levels. In building farmer capacity and providing them with management and problem-solving skills through learning by experience in the field, a mixture of approaches are used to reach farmers and improve their lives through agroforestry.

5.4 An inventory of agroforestry technologies in Kenya

An inventory of agroforestry technologies that exist in Kenya was undertaken during FGD. The results of the inventory of agroforestry technologies in the six focus groups discussion revealed a number of technologies/innovations being used by farmers. A total of seventeen technologies/innovations were documented and these ranged from apiary systems, biomass transfer, boundary planting, fodder bank, improved fallowing to other technologies such as homegardens, trees on cropland, windbreaks/shelter belts and woodlots (Table 5.6).

Table 5.6: An inventory of agroforestry technologies in Kenya

Technology	Description
Apiary system (apiculture	A form of silvopastoral system where bees are considered as a mini livestock. Traditional methods of apiary systems are still very common in Kenya.
Biomass transfer	Mulching or green leaf using foliage of trees and shrubs cut and carried on cropping area. Common trees and shrubs species used in biomass transfer are *Canavalia enziformiz, Mucuna pruriens, Tithonia diversifolia, Sesbania sesban , Calliandra calothryzus, Crotalaria ocholeuca, Dolichos lablab* and *Tephrozia vogelli* species
Boundary planting	Used mainly to mark boundaries (boundary markers). But can also be used to provide a protection from strong winds also a source of firewood, fodder, timber and fruits. Common species are *Senna spectabilis* (cassia), Ficus spp *Casuarina equisetifolia Leucaena leucacephala, Sesbania Sesban,* Eucalyptus *sp. Mimosa scabrella and Azadirachta indica*.
Improved fallowing, relay/rotational cropping	Improved fallowing is an attempt to improve traditional shifting cultivation to rejuvenate soil fertility instead of waiting for nature to vegetate, leguminious nitrogen fixing multipurpose trees and shrubs are planted on the field. Common trees/shrubs used are *Sesbania sesban, Crotalaria grahamiana, Crotalaria paulina, Crotalaria ochloleuca, Mucuna pruriens, Canavalia enziformiz, Dolichoz lablab, Tephrozia vogell, Gilricidia sepium, and Calliandra cathothyrus.* Relay or rotation cropping is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons for various benefits such as to avoid the build-up of pathogens and pests that often occur when one species is continuously cropped. The technology also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. A traditional component of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. It is one component of polyculture. Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants.
Fodder bank	Fast growing fodder species planted in a block on their own or in a mixture with fodder grasses for cut and carry. Common shrubs used are *Calliandra calothyrzus, Leucaena diversifolia, Leucaena leucacephala, Gliciridia sepium* and *Desmodium renzonii*

High valued fruit tree gardens/ orchards	High value tropical fruit tree orchards such as elite *Mangifera indica, Perzea Americana, citrus* (oranges), *Carica papaya, Psidium guajavaa, Passiflora adulis, Anona senegalensis, Anona cherimoya, Anona muricata* are common especially in warmer areas. High value fruit trees such as apples and pears are common especially in the Central highlands
Hedgerow/alley cropping	Closely planted lines of suitable trees and spaced about five metres apart – usually by direct seeding or transplanting from nurseries, The lines are placed across a slope within areas where crops or vegetables are grown. Only viable in high potential areas
Home gardens	Common in areas of high population density. Comon species include *Carica papaya. Mangifera indica, Passiflora adulis, Anona senegalensis, Anona heterophyllus Cyphomandra betacea, Ficus natalensis, Markhamia lutea, Maesopsis eminni*
Medicinal plant gardens	Common medicinal gardens include *Artemisia annua, Ricinus communis, Phtolacta dodecandra, Iboza multiflora, Alow vera,*
Seed banks/seed orchards	Mainly for afforestation programs for the supply of quality planting seeds, Some NGO's and farmer groups with support from research institutions have established seed orchards of mainly improved fruit trees to facilitate scaling up of agroforestry in different parts of Kenya.
Taungya system	Planting of cash or food crops between newly planted trees in a plantation. Farmers raise crops while the trees are still young. After 2-3 years, depending on the tree species and spacing the canopy closes and light demanding annual crops can no longer be planted. Farmers then transfer to other areas to repeat the process, provided there is mutual understanding between parties, it is said to be a viable practice for plantation establishment
Terrace stabilization/ contour hedges	Common in highland areas. Common tree/shrubs used are *Calliandra calothyrus, Leucaena leucacechala, Leucaena diversifolia*
Trees on cropland	Trees mainly found scattered in crop fields without any particular pattern Main practice in most part of the country. In Western Kenya, it is dominated by Jatropha-vanilla technology, banana-coffee and ficus practice
Trees on hillsides	Common in fragile ecosystems like hillsides of Eastern and Central Kenya. Helps stabilize the hillsides and prevent soil erosion. Common species are Eucalyptus and Cypress, Pines, Black wattle.
Trees on pastures and rangelands	Trees are either scattered randomly or arranged according to some systematic pattern on established pastures and rangelands. Common in areas of extensive grazing land. Common species include Acacia sp., Ficus sp, Euphobia sp
Windbreak and shelterbelts	Strips/belts of vegetation composed of trees, shrubs and vines to protect croplands from strong wind. They can provide protection of crops over a

	distance equivalent to 15-20 times the height of the trees in the windbreak. The can also help minimize wind erosion and reduce moisture loss.
Woodlots	Single tree species or a mixture established usually for firewood, poles and timber. Common tree species are Eucalyptus, Cassia, *Grevillea robusta, Cupressus lustanica*

Some technologies such as high value tropical fruit tree orchards (*Persea americana*, *Magnifera indica*, *Citrus*, *Psidium guajava*, *Carica papaya*, *Passiflora adulis*, *Anona cherimoya, Anona senegalensis* and *Anona muricata*) were reported to be common especially in low humid areas while, those of high value temperate fruit tree orchards such as pears and apples were said to be practiced in the cold highland areas especially in the Central region of Kenya.

Technologies such as fodder bank and woodlots were reported to be predominantly common in Central Kenya. But generally speaking, most of the technologies such as trees scattered on croplands, trees on pasture/rangeland and apiculture cut across the whole country. On the other hand other technologies need improvement because it was reported during the FGD that some farmers are still stuck with their traditional ways of doing things. Such technologies include apiculture and trees on cropland. In the case of trees on cropland, most farmers were said to just retain the trees scattered all over the farm and that rarely are these trees deliberately planted. This has an implication in that it makes tilling the land especially by ox-plough difficult. While, for the case of apiculture (a form of silvopastoral system where bees are considered as a mini-livestock), traditional methods of apiary technology are still very rampant in most parts of the country. Modern apiary technologies such the use of Kenya Top Bar Hives (KTBH) is yet to pick up.

Farmer's prioritization of the technologies during the FGD revealed very interesting patterns. Fruit tree gardens/orchards, home gardens, apiary (apiculture) and woodlots were ranked highly on the attributes of economic feasibility.

While, terrace stabilization/contour hedges, trees on hillsides, windbreaks and shelter belts, woodlots, home gardens, and trees on cropland technologies were ranked best in the aspect of environmental sustainability. Regarding social acceptability, home gardens, fruit tree gardens/ orchards, ornamental/avenue planting technologies top the list. In terms of ease of adoptability and with regards to gender parity, home gardens and fruit tree gardens/orchards were the two highly ranked technologies. Combining all the five criteria, home gardens; fruit tree gardens/orchards; trees on cropland; woodlots; apiary systems, apiary systems, terrace stabilization/contour hedges; improved fallowing, relay and rotational cropping; fodder banks; ornamental/avenue planting and trees on hillsides were the top ten highly scored technologies.

5.5 Prioritized agroforestry technologies according to five feasibility criteria

Farmers' prioritization of the agroforestry technologies revealed very interesting patterns with regards to five feasibility criteria (environmental sustainability, social acceptability, economic feasibility, ease of adoptability and gender parity). The outcome of farmers' scores reveals that fruit tree gardens/orchards, home gardens, woodlots, apiary (apiculture) were ranked highly on the attributes of economic feasibility.

On the other hand, home gardens, woodlots, trees on cropland, trees on hillsides, windbreaks /shelter belts and terrace stabilisation/contour hedges technologies were ranked best in the aspect of environmental sustainability. With regard to social acceptability, fruit tree gardens/orchards, home gardens, ornamental/avenue planting technologies top the list. While considering the ease of adoptability and the issue of gender parity, home gardens and fruit tree gardens/orchards were the two highly ranked technologies. Combining all the five criteria, fruit tree gardens/orchards; home gardens; woodlots; trees on cropland; terrace stabilisation/contour hedges; improved fallowing, relay and rotational cropping; fodder banks; apiary systems, ornamental/avenue planting and trees on hillsides were the top ten highly scored technologies, respectively.

Table 5.7 Prioritized agroforestry technologies according to five feasibility criteria

Agroforestry technology	Economic feasibility	Environmental sustainability	Social acceptability	Ease of adoptability	Gender parity	Total weighted score
High valued fruit tree gardens/orchards	9 (2.8)	7 (1.6)	8 (1.7)	8 (1.3)	9 (0.8)	8.2
Home gardens	9 (2.5)	8 (2.0)	7 (1.3)	8 (1.3)	8 (0.9)	8
Improved fallowing, relay/rotational cropping	7 (2.3)	8 (1.9)	7 (1.2)	6 (0.8	6 (0.6)	6.8
Woodlots	8 (2.1)	8 (2.0)	7 (1.0)	5 (0.9	5 (0.6)	6.6
Trees on cropland	8 (2.1)	7 (1.8)	6 (1.2)	6 (0.9)	6 (0.6)	6.6
Fodder banks	8 (2.2)	6 (i.8)	6 (1.2)	6 (0.8)	7 (0.8)	6.6
Medicinal plant gardens	6 (2.0)	5 (1.5)	8 (1.2)	6 (0.8)	6 (0.7)	6.2
Boundary planting	6 (2.0)	8 (1.5)	6 (1.1)	6 (0.9)	5 (0.7)	6.2
Trees on pastures and rangelands	7 (1.8)	7 (1.6)	6 (1.1)	6 (1.0)	5 (0.7)	6.2
Trees on hillsides	7 (1.8)	8 (1.5)	5 (1.0)	5 (0.9)	5 (0.8)	6
Terrace stabilization/ contour hedges	7 (1.7)	8 (1.4)	6 (1.0)	5 (0.9)	4 (1.0)	6
Apiary systems	8 (1.6)	6 (1.4)	6 (1.0)	5 (1.0)	4 (0.8)	5.8
Windbreak and shelterbelts	5 (1.6)	8 (1.5)	7 (1.0)	5 (0.9)	4 (0.8)	5.8

Seed banks	8 (1.5)	6 (1.3)	5 (0.9)	4 (0.9)	4 (0.8)	5.4
Taungya system	6 (1.4)	7 (1.3)	5 (0.9)	5 (0.9)	4 (0.9)	5.4
Hedgerow/alley cropping	6 (1.2)	7 (1.2)	4 (1.0)	5 (0.9)	4 (0.9)	5.2
Live fences	4 (1.2)	7 (1.0)	6 (1.1)	5 (1.0)	4 (0.9)	5.2
Biomass transfer	5 (1.1)	7 (1.0)	4 (1.0)	5 (p.8)	4 (1.0)	5

Figures: bracketed are the weighted rank scores. Those un-bracketed are the un-weighted rank scores

5.6 Prioritized agroforestry technologies according to the different ago-ecological zones

On the basis of agro ecological criteria, farmers prioritized agroforestry technologies according to different agro-ecological areas, which included low humid area, marginal areas (drylands) and humid highlands.

With reference to Kisumu County (humid/sub-humid lowlands, apiary (apicultural) systems, home gardens, boundary planting, Agrosilvofishery (aquaforestry), river bank/lakeshore/terrace stabilization, windbreaks and shelter belts, trees on farmland (e.g., Jatropha-vanilla and taungya technologies were the priority technologies according to the results from focus group discussions (Table 5.8). For humid highlands such as Central Kenya in Embu County trees on home gardens, fruit orchards (temperate), hillsides, terrace stabilization and contour hedges, woodlots, fodder bank hedgerows, and improved fallows were chosen as priority agroforestry technologies during the FGDS.

Table 5.8 Prioritized agroforestry technologies according to three agro–ecological zones

Agroecological zone	Priority agroforestry
Humid/Sub-humid lowlands - Western Region	Home gardens Boundary planting Trees on farmland e.g. Jatropha-vanilla, coffee-banana-ficus sp River bank/lakeshore/terrace stabilization Windbreaks and shelter belts Apiary Live fences
Tropical highlands	High valued fruit tree gardens/orchards Home gardens Boundary planting Woodlots Terrace stabilization and contour hedges Fruit orchards Taungya Fodder bank Hedgerows

	Windbreak and shelter belts Trees on hillsides Improved fallowing
Semi-arid dry lands - Eastern Region	High valued fruit tree gardens/orchards Home gardens Trees on pasture and rangelands Fodder bank Windbreak and shelter belts Boundary planting

FGD participants also placed apiary technology (apiculture); trees on pastures and rangelands; fodder banks; windbreaks and shelterbelts; live fences; fruit orchards (tropical) and taungya as priority technologies for the marginal drylands especially the semi-arid Machakos County.

6.0 Adoption of agroforestry technologies in Kenya

Agroforestry technologies have been extensively researched and introduced to smallholder farmers in Kenya for over three decades. Despite the research and extension effort over this period, not many farmers have adopted these technologies. The purpose of this section is to determine why agroforestry technologies are not being taken up by examining factors that influence the adoption of agroforestry practices. Based on review of 25 publications on agroforestry adoption in Kenya, statistical analysis show an association between adoption of both improved fallows and biomass transfer technologies with knowledge of the technology, availability of seed, and having the appropriate skills. In addition some household characteristics are found to be linked to the incidence of adoption. However, the strength of association between these variables is low, giving an indication that there might be other factors at play limiting agroforestry adoption. It is anticipated that these findings will point to other areas beyond the household and community level that need further exploration in order to understand factors limiting agroforestry adoption.

Assessment of adoption potential is a key element of a participatory, farmer-centred model of research and development. It improves the efficiency of the technology development and dissemination process, helps document progress made in disseminating new practices, provides farmer feedback for improving research and extension programmes, and helps to identify the policy and other factors contributing to successful technology development programmes as well as the constraints limiting the achievements (Franzel *et al.,* 2001). The main objective of the present study was to assess adoption potential of agroforestry technologies by farmers in Kenya and to suggest means to ameliorate and accelerate adoption.

6.1 Theoretical and conceptual framework on adoption

According to Rogers (1983, 1995), the adoption of an innovation goes through a decision-making process beginning with awareness, then the formation of positive or negative attitudes, and finally deciding whether to adopt the technology. Each stage of this process is influenced by various factors, including: household factors (socio-economic, resource base and outside contacts), community factors (access to extension, education, market, infrastructure, indigenous knowledge and ecological factors), and institutional factors (extension services, training and material support, through government and national/local NGOs). Building upon Rogers' theory, a host of studies on adoption of agricultural innovations, including agroforestry technologies, have been undertaken (Ajayi *et al.,* 2007; Ervin and Ervin, 1982; Lapar *et al.,* 1999; Napier *et al.,* 1991). The studies of agricultural innovations have found many influencing factors, varying from one place to another with variations in the agro ecological, socioeconomic and institutional settings in which farmers operate (Bekele and Drake, 2003). Rasul and Thapa (2004); Yila (2009), Yila and Thapa (2008) have grouped these factors into three levels: micro-level, meso-level and macro-level.

Macro-level factors, such as policies on land tenure, extension and credit, play an influential role (Beshah, 2003; Pender *et al.,* 2006; Rasul, 2003). Access to market centres facilitated by transportation facilities and the provision of market information and extension services, considered as meso-level factors, contributes to the promotion of agroforestry technologies by providing necessary technical information on available technologies and by linking agricultural producers to markets. The promotion of agroforestry technologies is only productive when the farmers can get satisfactory economic benefits from the resources invested by better links between agriculture and markets (Rasul and Thapa, 2004). Farmers' socio-economic characteristics and the biophysical characteristics of farmlands, considered as micro-level factors, also influence farmers' decisions (Bewket, 2007; Ervin and Ervin, 1982; Mbaga-Semgalawe and Folmer, 2000; Paudel and Thapa, 2004; Shiferaw and Holden, 1998).

Small farmers in developing countries are often unable to adopt new technologies effectively for reasons ranging from an inability to make financial investments to inadequate institutional structures for facilitating information flow and insecure land tenure (Scoones *et al.,* 1996). However, in Nigeria, Yila (2009) argued that there is a need to look at the adoption process through the eyes of farmers in order to effectively promote the use of new land management technologies. He reported that farmers had no accurate and useful knowledge about soil erosion and conservation. As such, they not only misunderstood what constituted conservation, but also failed to see the well-published dramatic instances of soil erosion. The farmers thus tended to believe the good practices rather than those introduced by government.

In a study on the Central highlands of Kenya, Muriuki *et al.,* (2013) revealed that a substantial number of factors influenced farmers' attitudes and perceptions regarding the nature and extent of agroforestry practices. Among these factors was age, years' operating the present farm, education, size of farm, type of farm, level of technical and financial assistance, and profitability of conservation practices.

In an earlier study in Central Kenya, Chitere (1985) pointed that the adoption of on-farm tree planting was influenced by land size. The author noted that farmers in Nyeri were reluctant to plant trees on their farms because trees shade on crops and their farms were small. Tree species, crops grown, farm size and local planting practices were found to influence agroforestry adoption in Western Kenya (Kimwe and Noordin, 1994). According to Tengnas (1994), most farmers in Kenya find it unacceptable and unattractive to invest in tree planting on land which is not confirmed legally as their). Related to land tenure is also tree tenure. Farmers who do not own the land tend to feel they cannot possibly own the trees hence lack the need to plant them. In Vihiga district, Kenya, women insisted on the issue of sorting out tree ownership before being persuaded to plant trees (Ipara, 1992). In Kitui secure tree and land tenure and a relative freedom to harvest trees and sell products were found to be an incentive for farmers to adopt tree planting (Makindi, 2002).

Certain traditional beliefs have also been found to be a factor in the adoption of agroforestry practices. In Kenya, among certain communities, women cannot plant trees because doing so is believed to be an act of ownership over land (Gichuki and Njoroge, 1989). In other communities, trees belong to men regardless of who plants them. In Western Kenya for example, there are distinct tree species for men and women (Kerkhof, 1992). Women are not allowed to plant certain tree species- it's believed if she does she becomes barren. Ipara (1992) noted that among communities that hold these beliefs and taboos, traditional land tenure and ownership rights are based on male patrilineage. Certain tree species are associated with certain beliefs and bad omen and therefore, should not be planted at all by community members even if they are beneficial in any way. It is further noted by Ipara (1992) that tree planting decisions in many communities is a domain of the male head of the household. However, the author also found out that female headed household had more land under trees than male headed households. This explains the role of women in society, which meant they get affected more in case of scarcity of forest resources (Mutoro, 1997). The study on community participation in wildlife conservation around Ol Donyo Sabuk National Park Machakos District Kenya, by Lelo (1994) found out that women were more crucial stakeholders in environmental management and conservation than did men. These studies clearly show that women cannot be ignored in the environmental conservation activities and if put on forefront, women achieve more than men. Nyerere (1988) also observed that less than half of the population couldn't develop the nation alone without women participation.

Fig. 6.1 presents a simple schematic framework for studying agroforestry technology adoption by farmers. This framework has been widely applied to investigate the adoption pattern of various agricultural technologies, especially the adoption of high yielding cereal varieties and related practices. Feder *et al.,* (1985), and Neupane *et al.,* (2002) have applied this framework for studying adoption of agroforestry in Nepal. The framework provided in Fig. 1 forms the basis for selecting relevant variables influencing agroforestry technology adoption.

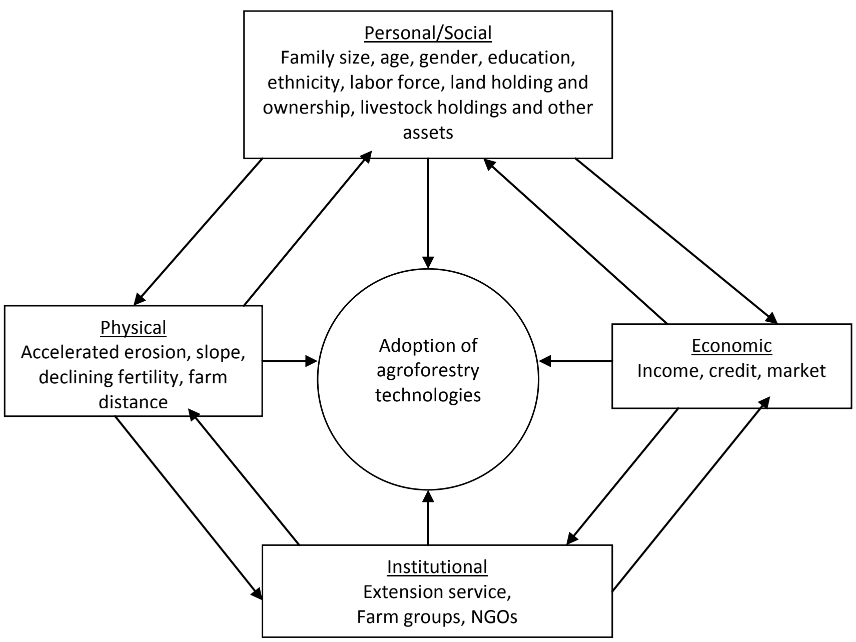

Fig.6.1: Agroforestry technology adoption framework

As noted earlier agroforestry management is a complex process involving the interplay of many factors and this explains why agroforestry practices vary from one place to another or from one farm household to another. These factors operate at various levels and affect farmers' agroforestry management decisions and thereby their behaviour (Rasul, 2003; Rasul *et. al.,* 2004; Paudel and Thapa, 2004).

6.2 Agroforestry adoption

The process of developing and disseminating agroforestry as a viable alternative for farmers under various ecological and socioeconomic conditions has become a challenging constraint to promote agroforestry. Moreover, as noted by Raintree (1983), no agroforestry technology, regardless of its ecological and economical soundness, will have significant impacts on land management, productivity and income unless it is adopted by a significant proportion of farmers. Similar to any other new technologies, agroforestry adoption is a complicated process that may be influenced by a number of factors, such as socioeconomic characteristics of farmers, access to and level of resources, provision of extension, infrastructure and market, and other institutional factors. Farm level studies can provide insights into key social and economic factors affecting farmer use and management of agroforestry practices and their effects on household resource base (Scherr, 1990). A sizable number of researches have been given to studying adoption of agroforestry technology in Kenya. Therefore, there is considerable empirical information to look why some farmers adopt agroforestry and others do not.

Rogers (2003) has categorized adopters into five including innovators, early adopters, early majority, late majority and laggards. This kind of classification is a problem to use in the situation where adoption has not reached 100 percent use (Rogers, 2003) as it does not include those that cannot be grouped within the five groups, the discontinuance and non-adopters. Therefore this study adapts Rogers' model but also looks at other studies conducted on agroforestry in Kenya to gain insights on levels of adoption and influencing factors (Marenya and Barrett, 2007; Muriuki *et al.,* 2014; Nyaga *et al.,* 2015; Onim, *et al.,* 1990; Place *et al.,* 2000; Shepherd *et al.,* 1997; Mogaka *et al.,* 2014; Noordin *et al.,* 2001; Jerneck and Olsson 2013; Pisaneli *et al.,* 2001; Lucas and Nwonwu 2000; Scherr, 1995; Scherr and Peter Mol, 1989; Wairore *et al.,* 2015; Njoroge *et al.,* 2011; Waswa, 2000; Wafuke, 2012; Oino and Mugure, 2013; Mugure *et al.,* 2013; Mandila et al., 2015.

6.3 Taking stock of agroforestry adoption studies in Kenya

Numerous empirical studies have been carried out to gain insights into the adoption of agroforestry in Kenya. In light of the number of empirical studies of agroforestry adoption published during the last three decades it is time to take stock and identify general determinants of agroforestry adoption in Kenya. To find the general patterns in agroforestry adoption, a comparison and combination of specific cases described and modeled in the published literature were undertaken.

It needs to be pointed that most of the recent adoption studies explain how different farmers, farms, and projects characteristics are correlated with past adoption behavior, based on binary choice regression models estimated from household surveys that represent a single snapshot in time. As several of these studies fail to link the empirical analysis to underlying theory and use only a few factors within regression models of adoption in limited geographic areas within the country, they do little to promote a general predictive understanding of farmers' adoption decisions. In general, it makes it difficult or inappropriate, to generalize from these adoption studies due various limitations; (a) time dimension considered, (b) sampled populations, (c) factors and variables included, and (d) the variation in technology or policy variables.

The following were therefore undertaken; (1) a review of the general adoption literature to identify the major determinants of technology adoption and (2) combination of information from 25 agroforestry adoption studies in a simple meta-analysis to evaluate the influence of general factors on agroforestry adoption. To my knowledge, this work represents the first meta-analysis of agroforestry adoption studies in Kenya. Table 6.1 presents a summary of the 25 agroforestry adoption studies used for the analysis.

Table 6. 1. Empirical studies of agroforestry adoption in Kenya

Authors	***Year***	***County***
Jerneck, A. and Olsson J. (2013)	2013	Kenya
Lucas and Nwonwu (2000)	2000	Kenya
Mandila, B. et al., (2015)	2015	Kenya
Marenya, P.P. and Barrett, C.B (2007)	2007	Kenya
Mogaka, V. *et al.,* (2014)	2014	Kenya
Mol, S. (1989)	2013	Kenya
Mugure, A., Oino, P.G. and Sorre, B.M. (2013)	2013	Kenya
Muriuki J., Kirumba, E. and Catacutan, D. (2014)	2014	Kenya
Njoroge,, E. *et al.,* (2011)	2011	Kenya
Noordin, Q. *et al.,* (2001).	2001	Kenya
Nyaga, J. *et al.,* (2015).	2015	Kenya
Oino, P. and Mugure, A. (2013).	2013	Kenya
Onim, J.F.M., Otieno, K. and Dzowela, B. (1990)	1990	Kenya
Otsuki, T and Ogo, T. (2009)	2009	Kenya
Pisaneli *et al.,* 2001	2001	Kenya
Place, F. *et al.,* (2000).	2000	Kenya
Scherr, S.J. (1995)	1995	Kenya
Shepherd, K.D. *et al.,* (1997)	1997	Kenya
Wafuke, S. 2012	2012	Kenya
Wairore J.N. *et al.,* (2015)	2015	Kenya
Waswa, S.I. (2000)	2000	Kenya

The review of adoption studies was restricted to published peer-reviewed publications. This was started with a set of 95 empirical studies on adoption of agricultural and forestry technology by smallholders farmers. This based on the assumption that the key features relevant to agroforestry adoption are common to both agriculture and forestry technology adoption. The review gave particular attention to the seminal survey by Feder *et al.,* (1985) and a recent study of land management by Yila and Thapa (2008). Finally, based on the criteria of (a) empirical analysis and (b) focus on agroforestry and related technology investments, the list was narrowed down to 25 studies of agroforestry and related technology investments. The empirical analysis was defined based on micro-economic studies that (a) used household survey data, (b) reported descriptive statistics, (c) presented empirical results of technology adoption.

In this study, I have considered five commonly used factors, namely, *farmer preferences, resource endowments, market incentives, bio-physical factors,* and *risk and uncertainty*. These five determinants provide a useful organizing framework for conceptual and empirical evaluations of agroforestry adoption. Each is briefly described below.

(1) *Preferences* are placeholders for the broad category of farmer specific influences such as risk tolerance, conservation attitude and intra-household homogeneity. Because farmer preference effects are difficult to measure explicitly, socio-demographic proxies such as age, gender, education, and social status are used instead. There may be some issues with whether these variables are good preference proxies. For example, education levels may also measure the opportunity cost of labor investments in agroforestry technology. Gender or the percentage of males may reflect the resource capacity of the household. Based on the signs of association we found in the literature, I believe that these are best interpreted as preference proxies. However, we also mention alternative interpretations when they are discernible. It is impossible to a *priori* determine the direction of the influence on adoption of this broad category.

(2) *Resource endowments* measure the resources available to the technology adopter for implementing the new technology. Examples of resource endowments include asset holdings such as land, labor, livestock and savings. Generally, resource endowments are likely to be positively correlated with the probability of adoption.

(3) *Market incentives* include factors related to explicitly lower costs and/ or higher benefits from technology adoption. This factor focuses on the explicitly economic determinants of adoption such as prices, availability of markets, transportation, and potential income losses or gains. Clearly, a factor that is expected to increase the net benefits associated with the technology is likely to be a positive influence on adoption.

(4) *Bio-physical factors* relate to influences on the physical production process associated with farming and/or forestry. Examples include soil quality, slope of farmland, and plot size. In general, poorer bio-physical production conditions (*e.g.* greater slope or potential for high erosion) create a positive incentive to adopt technologies that will alleviate these situations. However, it is also possible that some farms are of a quality that is below the threshold of useful investment.

For each paper, the text and the tables were reviewed to identify variables that fit our five categories of adoption influences—*preferences, resource endowments, market incentives, bio-*

physical factors, and risk and uncertainty. Numerous variables were identified within each of these broad groups and applied the vote-counting method to all. Thus for each study, category and variable, were determined whether there was a statistically positive or negative relationship with the adoption decision. Variables with statistically insignificant correlation were assigned a "0" label. Therefore, if a study did not report results for a particular variable, the cell was left blank.

The 25 papers on agroforestry technology adoption were analyzed to develop a meta-data set of specific variables within the five classes of technology adoption factors. Application of vote counting based meta-analysis to this data set provided a richer picture of agroforestry adoption that can be developed from a qualitative comparison of the individual study features and results (Table 6.2).

In this regard, the review highlights two kinds of meta-statistics on the empirical literature on agroforestry adoption: *inclusion* and *influence* of factors. It was established that 'preference proxies' and 'resource endowments' are most likely to be included in analyses of adoption, while 'bio-physical factors' are least likely to be included. Specifically, over 65% of the studies include 'education', 'labor endowment', 'plot size', and 'age'. Researchers often see them as critical determinants or (and) find them easier to measure.

Using the influence (significance) criteria, it was found that adoption is most often statistically correlated with the risk, bio-physical factors, and resource endowments categories. This result would be somewhat different if we measured significance conditional on whether the investigators included these factors to begin with. Considering specific variables, soil quality, plot size, extension and training, tenure, and assets exert the greatest statistical power; that is, when included they are statistically significant in the greatest number of cases.

Table 6.2 Results of vote-counting meta-analysis of determinants of agroforestry adoption (Full sample, 25 studies)

	Included	**Significant**		**Insignificant**	**Included %**	**Significant %**	**Significant %**
		Pos.	Neg.			(included studies)	(all studies)
Preference proxies					**47**	**47**	**20**
Education	26	9	3	16	80	39	39
Age	22	7	1	18	69	25	17
Gender	11	6	2	5	31	59	18
Resource Endowments					**42**	**66**	**24**
Labor	22	7	2	13	75	40	30
Income	19	10	3	8	57	60	34
Asset	13	12	1	2	38	91	35
Livestock	10	1	2	7	28	34	9

Credit/saving	3	3	0	1	7	98	7
Market incentives					**33**	**57**	**19**
Potential Income Gain	20	10	3	9	62	59	36
Distance to Market	7	1	5	3	25	76	20
Price	6	2	2	4	18	42	8
Risk and Uncertainty					**44**	**71**	**30**
Tenure	20	14	5	7	60	74	44
Experience	17	12	3	4	53	60	44
Membership	8	5	1	6	30	45	14
Bio-physical Factors					**38**	**81**	**28**
Plot size	20	8	6	8	67	66	45
Soil	14	9	3	3	40	82	34
Slope	11	7	2	4	33	71	23

Comparing the general determinants and specific variables in the 'included' and 'statistically influential' sets, it was found a far from perfect overlap. Before hedging to conclusions concerning the mismatch of attention and significance, some important caveats ought to be considered. First, as argued elsewhere (most poignantly by McCloskey and Ziliak, 1996), results reported in the published literature are heavily influenced by the bias against insignificance in scientific literature. In effect, investigators try very hard to find significance in their analyses and voluntarily or because of convention include only significant results in the published papers.

Second, claim cannot be that the set of adoption studies denotes a random and, therefore, unbiased set. The set may not represent the true population of studies in part because it involves a purposive search of the published and gray literature to find studies that satisfy predetermined compatibility criteria of topical content, empirical methods, analysis units, and variable measures. It similarly may not be random because the scientific literature is an evolving and organic occurrence, in which investigators are constantly building off previously published work that may have been published by their colleagues or by themselves. Third, while the direction of the correlation is unambiguous in most cases, statistical significance *per se* it may not be very useful criteria for variables such as plot size that have an equal number of positive and negative influences. Finally, statistical significance tells only a part of the story. It could not estimate the magnitude of the effects because of scarce details on the marginal probabilities of adoption.

The limits discussed above offer lessons for future research using more sophisticated types of meta-analyses. Consider a few other issues. Equal weights were assigned to all studies with no quality adjustments. It may be possible to conduct more discriminating analyses by developing quality-differentiated weights, based on publication source, sampling methods and size, and scientific rigor. Further, by collecting additional data, researchers could apply combined tests of significance and effect sizes. Finally, future work could include moderator variables and attempt meta-regressions with corrections for all sophisticated meta-analyses rely, however, on even more purposive data collection exercises that pay attention to information on marginal probabilities of adoption (i.e. how a specific variable changes the probability of adoption).

To sum, given the recent surge in interest and empirical research on agroforestry adoption, it is time to examine this growing literature and take stock of what we have learned. I took the first step by reviewing 95 general agroforestry adoption studies and conducted a simple meta-analysis of 25 agroforestry adoption studies in Kenya.

It was found that preferences and resource endowments are the most common factors studied while market incentives, risk and uncertainty and bio-physical factors are examined less frequently. However, adoption behavior is most likely to be influenced by risk, bio-physical, and resource factors. Specifically, the review suggests that credit, savings, prices, market constraints, and plot characteristics are potentially important determinants of adoption behavior that have not been studied adequately. We hope researchers will take on the challenge of measuring these factors and variables to include in future studies.

6.4 Impact of adoption of agroforestry practices on the status of land in Kenya

Having examined the agroforestry practices adopted by the farmers, it is sensible to ask the question as to how these practices have impacted on the status of the lands. This section presents the findings of the analysis of the status of land based on the farmers' experiences and perceptions.

Although recognizing that assessing the status of land should be based on a set of indicators, determining such indicators could be a complicated task, as the condition of the lands at a given place and time is an outcome of complex interactions of biophysical and socio-economic environments that vary from one place to other (Bindraban *et al.,* 2000). There have been no well-defined indicators for assessing the status of land resources applicable to all areas (Dumanski and Pieri, 2000). However, in this study, I have considered three commonly used indicators, namely, soil erosion, soil fertility and crop yield.

Soil erosion

Soil erosion is a commonly accepted indicator of the status of land (Napier *et al.,* 1991; Shiferaw and Holden 2001). In the study area, the severity of soil erosion was assessed from the farmers' perspective. Although the severity of erosion is a qualitative assessment that does not specify the amount of soil being removed from a particular area, still it is very useful to understand the condition of the farmlands. Based on the farmers' experiences, this type of assessment could also serve as basis for mastering strong public participation in land conservation programs.

Nearly 75 per cent of the farmers in the FGDs acknowledged that their farmlands are undergoing soil erosion, despite an array of agroforestry practices that they have adopted, hence soil erosion is the biggest problem that results in the decline in the soil fertility on both lowland and upland farms. As for the intensity of the soil erosion, nearly 80 per cent farmers mentioned that it is 'severe'. The farmers considered erosion to be severe when visible signs such as rills and gullies are formed in their fields. This assessment reconfirms the findings of previous studies, which indicated that extensive areas of the Kenya highlands are undergoing accelerated soil erosion (Muriuki, 2014). Majority of the farmers interviewed in the FGDs had also witnessed an increasing trend in the severity of soil erosion over the past 5 years. On the other hand, only a few of the respondents believed that soil erosion had become less and less severe over the same period, while the rest of the respondents replied that they did not observe any change. Most of the farmers who mentioned that the rate of erosion had been increasing were from the villages of Central region where most farm plots are situated on steep slopes.

Soil fertility

As discussed above, the farmers in the study area are using both organic and inorganic fertilizers to maintain soil fertility and crop yield. However, majority of farmers during the focus group discussion mentioned that soil fertility is declining, which could be partly attributed to the on-going severe soil erosion. Nevertheless, questions relating to soil fertility always attract spontaneous outcry from the farmers about the extent to which the fertility of their farmlands is declining. Thus, the farmers often use such expressions as 'the land is tired or exhausted' and 'the land is old' to indicate the poor status of the soil fertility. This qualitative assessment of the farmers has been confirmed by scientific studies which indicated that the levels of plant nutrients in the soils of Western Kenya are low and that deficiencies in nitrogen and phosphorus in the soil are quite common (Place *et al*., 2002).

Crop y~~-y~~ield

The impact of soil erosion and nutrients depletion could be manifested in the crop yield (Dumanski and Pieri, 2000). Thus, crop yield is a very useful indicator of the land's condition, and is easily understood by concerned stakeholders (Bindraban *et al*., 2000). All farmers in the study were unanimous in explaining that fertile land produces more crops than infertile lands. Nearly all farmers confirmed that there was a trend of declining yield of most crops produced in their farmlands. The results showed a declining trend of all staple crops except for maize, the highest decline in the yield was that of sorghum with a net negative change of 6 per cent within a rather short period of 5 years. Millet and rice had also experienced decline in yield at the same rate.

6.5 Conditions affecting agroforestry technology and knowledge transfer

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The literature review conducted by this study responded to this by identifying and analyzing past experiences, mechanisms and conditions that have enabled knowledge and agroforestry technology adoption by smallholder farmers within the three agro-ecological zones and elsewhere in Kenya. The fieldwork conducted in the three zones added to the academic review through significant insights on the range of agroforestry technologies selected by farmers and researchers, and their accessibility within and beyond. The fieldwork deliberately sought the differing perspectives of project staff, NGOs, the private sector, government officials and women and men farmers.

6.5.1 Public policies and institutions

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The literature review emphasizes the need for an over-arching enabling environment for agroforestry where political will and leadership is backed up by strategies, policies, regulations and resources that allow pluralistic research, extension and entrepreneurship to flourish together to the benefit of smallholder farmers in agroforestry. Three key aspects of this enabling environment relevant to agroforestry are: a) land tenure arrangements that provide the security for men and women farmers to invest in the long-term agroforestry systems on their land; b) mainstreamed government support for agroforestry, and c) unbridling the marketing constraints on agroforestry products (middle men, transportation, preservation etc.)

6.5.2 Resources (ecology, climate, land, capital and human resources)

Agroforestry systems span a huge range of ecologies as trees and shrubs are versatile plants capable of growing from warm temperate to tropical, and from semi-arid to humid conditions. The range of agroforestry technologies interventions promoted by projects in Kenya also reflects the ecological range from semi-arid through to sub-humid, from neutral to acid soils, from sands to clay and from low through mid to high altitude. It is recognizable that in all the three regions populations are growing very fast and land is becoming a limiting factor to sustainable land-based livelihoods, requiring radical solutions. Agroforestry and the consequent changes in farming systems could be among radical adaptation to both land scarcity and the changes that are likely due to climate change (higher temperatures and more frequent droughts and floods). Most of the projects examined are aimed at 'smallholder farmers', however many of the promoted technologies by projects require cash for take up as well as long term investment. It is worthy to point out that agroforestry technology such as fertilizer tree are unlikely to increase crop yields or soil fertility within one or two seasons. If the transition from conventional to agroforestry technology is not supported financially through other measures, then only with sufficient resources will benefit, further exacerbating existing social inequalities.

As observed smallholder farmers in Kenya are both women and men, with some households being female-headed on a temporary or permanent basis. During the fieldwork, gender was explored in relation to the appropriateness, accessibility and uptake of technologies for both women and men. When questioned, many interviewees commented that practices such as fodder bank were 'gender neutral'. Two projects staff admitted that they were not well-versed in gender issues. Gender issues are explored

Gender issues explored during the study revealed that far from being gender neutral, agroforestry technology adoption has strong gender aspects. These include changing labor loads for men and women, the potential change in tasks for women and children implied a change in land use from seasonal planting of arable crops to long term agroforestry have varying consequence on gender.

Furthermore, preference for certain varieties and technologies can also vary between genders, with women tending to select technologies for domestic use and men for cash sale. A study to inform the Sustainable Intensification of Maize–Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) programme reveals that 70% of the customers of *Kilimo Salama (*a crop insurance project in Kenya) are women. This implies that women are more risk averse than men.

In general, however most of the projects visited have not addressed gender in a comprehensive manner, they have assumed that gender is covered if women are involved in participatory meetings and invited to dissemination events. Gender training for most of the agroforestry projects was carried out in the early stages of the project; however, repeat training may be necessary that explains how gender can be applied to specific situation. Improved understanding of gender issues in institutions will result in increased inclusion of women in the research and development stages, therefore improving out-scaling and spillover as these new technologies will already be targeted to women farmers.

6.5.3 Agroforestry value chain actors and organizations

Kenyan agroforestry smallholder farms range from semi-subsistence to those operating on fully commercial basis. As farm families transition from one to another, access roads, communications, and the availability and reliability of inputs and market information become increasingly important, also education levels and connectivity of the farmers themselves. All are aspects of the conditions required for scaling out agroforestry technologies that require the application of new information, materials and skills and penetration into new markets. Although savings and credit cooperative societies (SACCOs) have increased in several of the study regions, access to affordable credit for those with limited collateral is a major problem for farmers wishing to adopt technologies requiring cash for materials or equipment

The role of the private sector in providing inputs at the start of the value chain was noted during the study. Other value chain actors are involved with processing, storage, transport and marketing of crop products. To date most of the projects visited has hardly considered these, as the traditional research thinking is often focused only on production. As the project progresses and involves itself more in genuine multi-stakeholder innovation platforms, there is need0 it should expand the range of value-chain actors for which it provides technologies and knowledge products because the faster and smoother the flow of products along the value chain, the better this will be for the producers. Table 6.3 provides a summary of the constraints and enabling factors that farmers classified as most significant during the FGDs.

Table 6.3 Conditions that enable or act as bottlenecks to scaling-out and spillover of agricultural technologies

Conditions	Enabling factors, conditions, requirements and mechanisms	Bottlenecks, barriers and unfavorable conditions
Political conditions	•Investment from governments or donors • Policies for technologies mainstreamed across government departments • Interest shown from political figures • Security of land tenure	• Reduction of donor assistance • Lack of political will • Lack of land rights
Institutional conditions	• Timeliness of information provided to farmers • Policies placing extension within the poverty reduction agenda • Improved monitoring of agricultural extension impacts • Access to information through mobile phones and radios • Involvement in farmer groups	• Recommendations from extension agencies inconsistent with farmers' objectives • Conflicting advice given to farmers • Low motivation and accountability of extension staff • Networks not encouraged • Exclusion of the private sector
Ecological and biophysical conditions	• Adaptive testing and substantial modification of promising varieties to differing agro-ecological zones • Farmers adapting technologies themselves • Awareness of soil degradation • Adoption best in areas of high potential	'One size fits all' or ''magic bullet'' approach to technology adoption and diffusion
Social and human conditions	• Use of female extension workers to target women farmers • Dissemination materials and inputs suitable for women • Time saving agricultural technologies	• Women under-represented in research and governance systems • Women most often ignored by external agencies • HIV/AIDS affecting labor requirements • Migration depleting farm workforce
Economic and market conditions	• Improved interest from farmers in selling cash crops • Access to credit and financial services • Input provision alongside advice and technical support	• High transport costs due to poor rural roads • Price plunges when local markets are unable to absorb surplus output • Shortage or inaccessibility of seeds

6.6 Barriers to adoption of agroforestry

Several barriers to adoption of agroforestry were identified by farmers during the FGDs. The fundamental barrier to adoption of agroforestry practices pointed by farmers is lack of socio-economic acceptance. The limited success of some past agroforestry programs in Kenya can be traced to the lack of up-front participation and buy-in by the very group the programs were developed for -- the farmers. Consequently, these programs have repeatedly demonstrated that farmers are reluctant to adopt agroforestry practices. Specific barriers to adoption of agroforestry as pointed by farmers during FGD are:

- Trees are perceived to take land out of production, so there is a net loss of cropland yields.
- Agroforestry practices are perceived to create havens for insect, disease, and weed pests.
- There is a lack of information, understanding, and appreciation of the product and non-product benefits of agroforestry.
- Farmers perceive that the costs of agroforestry and other conservation practices outweigh the benefits. Costs include inconvenience and maintenance.
- Landowners and other stakeholders have not been adequately involved in shaping agroforestry practices and programs, so there is limited buy-in or ownership by the groups they are intended to serve.
- Farmers are reluctant to put trees back into the landscape, after they have historically gone through a lot of effort to remove them. According a an elderly farmer in Machakos he asserted "We have developed systems and perceptions based on the belief that we need to keep trees in woodlots away from productive agricultural lands".
- Modem farming has acquired such a short-term outlook, it is hard to understand, value, and accept the long-term benefits of any land-use practice. Lenders, and other driving forces, emphasize a short-term cash flow.
- There is a lack of technical information and technical assistance for agroforestry practices. Often, technical assistance providers are either not familiar with agroforestry practices, have misconceptions, perceive that the practices will introduce problems, or prefer to promote other practices that are easier to design, unless the landowner requests an agroforestry practice.

6.7 The way forward on adoption of agroforestry

Farmers in the study area have adopted a range of agroforestry technologies, though the range of adoption varies from one household to another for several reasons. Based on the findings we conclude that three factors, namely, the extension service, agricultural labor force and seriousness of soil erosion have a significant positive impact on the adoption of agroforestry technologies, while one factor, out-migration, has a negative impact. However, in some instances, the income accruing from off-farm activities by farm household members who have migrated to other areas can help farmers to afford the cost of implementing a technology, thereby increasing the adoption overall. When confronted with labour shortages, farmers pay more attention to less labour intensive technologies than high labor intensive technology. Overall, the extension service provided by government and other institutions plays the most important role in promoting agroforestry technologies in the study areas. Results of studies carried out elsewhere (Adesina and Baidu-Forson, 1995; Bewket, 2007) indicates that farmer-to-farmer extension can play an important role in the promotion of agricultural innovations including agroforestry technologies.

However, so far the Kenyan government has not paid much attention to the promotion of technologies through such extension. The Kenyan government is pursuing a policy goal of sustainable management of agricultural land. In view of the findings of this study, the government should focus on improving the capability and effectiveness of the extension service which has been acting as a catalyst for promoting relevant agroforestry technologies. In view of a shortage of extension workers and the convincing role of farmer-to-farmer extension in other areas (Adesina & Baidu-Forson, 1995; Bewket, 2007), the extension agency should promote appropriate agroforestry technologies through innovative methods of farmer-to-farmer extension services so as to gain more effective results. Instead of spreading their resources and efforts thinly, thereby producing ineffective results, the extension agencies should make strategic interventions to support farmers to adopt agroforestry technologies.

Regarding the appropriateness of any agroforestry technology under consideration, the potential economic benefit is an important factor to be considered. Another important factor is the labor requirement. Since the farmers have been increasingly confronted with labor shortages arising from competing demands for household labor and out-migration of some of their household members, amongst other things such as cost effectiveness and technical suitability, the labor requirement for carrying out any agroforestry practices whether they be indigenous or introduced. Because there is an increasing trend of rural–urban migration in all developing countries, it is plausible to anticipate the same in the study area and other rural areas of Kenya.

Therefore, in the future, farmers are unlikely to keep maintaining the highly labor-intensive practices even if they are indigenous. Farmers are likely to adopt technologies that are relatively less labor intensive, but provide higher returns to the resources involved including land and labor. However, farmers may be able to afford the labor-intensive technologies if the financial returns from their application are attractive. The current tendency is to pay more attention to farm plots undergoing serious soil erosion due primarily to the requirement of a lot of labor for the proper management of all farm plots. For the same reason, farmers are also paying more attention to the management of irrigated farms which are more productive than the upland farms. Promotion of less labor-intensive but more remunerative technologies would enable them to manage all of their farm plots in an effective way.

6.7.1 Public-Private Partnerships (PPP) as a strategy for sustainable agroforestry and adoption

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A great deal of the discussions with farmers during the field work focused on business: How to link smallholders to markets? How to make agroforestry profitable? How to engage major corporations? How to guarantee social and environmental sustainability while making money?

A consistent message was that farmers can't do it alone, especially if they're also growing food for their families. Thus, building successful agroforestry systems requires scientific expertise, business savvy and access to markets, robust policies and infrastructure, and NGO support to advocate for farmers and help with training and facilitation. It's a team effort, and it takes a lot of resources.

The frequent question that arose during discussion with farmers is can public-private partnerships help bring these elements together, especially in Kenya? The answer I think is yes as already, there are several prominent examples in agroforestry, such as the Connected Farmer Alliance (CFA) a public-private partnership among the U.S. Agency for International Development (USAID), Vodafone and TechnoServe that aims to increase the productivity, incomes and resilience of 500,000 smallholder farmers, including 150,000 women, in Kenya, Mozambique and Tanzania. By developing sustainable business models that serve the interests of a broad range of private sector stakeholders, the program seeks to prove the commercial viability of mobile solutions for smallholder farmers. The program also aims to increase revenues for agribusinesses and agricultural value chain service providers.

PPPs have been widely used in development to attract private-sector investment, reduce financial costs for governments, and bring in tools and expertise from the business world. Given that agroforestry projects often require long-term investments in planting trees, PPPs are particularly appealing as a way to reduce the financial risks for farmers.

With regards to CFA, farmers raised several important questions about the nature of PPPs and the kinds of actors needed for success. Can a PPP work if only smaller businesses or less powerful actors than USAID are involved? On the other hand, can a PPP be a true partnership if one partner is so much larger and more powerful than the others? And if a partnership is only made possible by aid funds, can it be truly sustainable once the money is spent?

A sustainable model of PPP that can be attained is when the partners are more or less equal. Indeed, most studies on PPPs consider the relationship between actors and their willingness to compromise to be key factors in a partnership's success. Risks and power have to be equitably shared, and strong, transparent and accountable systems have to be put in place to protect all the partners' interests. Overall, at the end of the day, the goal of a farmer and the private sector is to generate income. The private sector has the ability to bear the risks and lift up levels of incomes substantially, because it is not in the interest of private sector to work with unsuccessful partners.

7.0 Conclusions and recommendations

7.1 Conclusion

For more than 30 years there has been both concerted national and international effort to promote agroforestry in various parts Kenya, This study was undertaken at field sites of the agroforestry projects.

Overall the study showed that while a number of agroforestry programmes and projects have been implemented across the three counties, adoption of agroforestry practices still remains low for various reasons, including limited knowledge of and capacity in CSA, lack of coordination among agroforestry stakeholders, lack of finance for agroforestry investments both at farmer and at national level, and underdeveloped input and output markets for agroforestry.

This scoping study describes the state of agroforestry in Kenya. The policy of the government of Kenya related to agroforestry, as illustrated in this study, is found in a series of national, regional and continental policy blueprints, demonstrating commitment to mainstreaming adoption goals into planning processes and outlining potential measures for achieving them.

Many Kenya farmers today, have great expectations from agroforestry. Yet, if current efforts to understand, develop and disseminate agroforestry technologies/practices are to have any hope of meeting even a reasonable proportion of current expectations, its deployment, as a newly organized branch of applied science, must take place within a certain context. It was therefore, clear from the findings that certain agroforestry technologies for instance fruit tree gardening, ~~homegardens~~home gardens, woodlots and apiary/apiculture will be easily taken-up because of their economic feasibility or financial profitability. Raintree (1983) also underscored the importance of economic feasibility as a criterion to selection of agroforestry technologies. He emphasized the need of going beyond qualitative functional specifications to quantify and evaluate the relative economic advantage of different agroforestry alternatives. This will give agroforestry technologies a fair chance of being adopted. There is no doubt that because of the galloping poverty in Kenya, farmers will always first look at economic feasibility of either enterprises or technologies they would like to adopt.

- Kenya has a number of adequate policies and strategies pertinent to agroforestry. What remains to be done is creating awareness about the policies as well as promoting their implementation at all levels, for example through mainstreaming of the policies into agricultural extension and the development of national agroforestry implementation manuals.
- In Kenya there are numerous projects and programmes that are conducting and promoting agroforestry practices and technologies. However, these programmes and projects are

being implemented in a fragmented project-based manner, which poses a threat to the sustainability of these initiatives.

- The current policies, strategies and laws related to agroforestry and sustainable agriculture are adequate. However, they are not adequately incorporated into extension guidelines and manuals (and the extension system as a whole) in a way that the great majority of the rural farming population could understand and participate in their implementation. For this reason adoption of practices such as conservation agriculture remains relatively low.
- Key stakeholders involved in promoting agroforestry can be grouped according to four broad categories – government; development agencies (including international and local organizations, NGOs and CBOs); research and academic institutions; and the private sector.
- There is a need to ensure that these institutions, organizations and departments coordinate their efforts and conduct their work in a manner that adds value to one another rather than duplicating or being in conflict with one another
- There is a lack of adequate research findings on agroforestry in Kenya for the various agro-ecological zones, soil types, rainfall patterns, farming systems, as well as temperature and moisture ranges. Hence there is a need to support more research projects on agroforestry, particularly action research and field-based research.
- There is a lack of common understanding on the content of agroforestry in different parts of the country among the agroforestry implementing public, NGOs and private sector organizations. At the moment there is no organization responsible for the promotion and technical support of agroforestry at all levels. Agroforestry is not incorporated in the annual action plans of the agricultural offices.
- So far efforts to promote agroforestry practices have shown some encouraging results at grassroots level. There are districts where farmers have adopted some of the components of agroforestry practices such as fodder bank, hedgerow, shelter break as well as other climate-smart practices such water harvesting. However, documentation and data on adoption rates are lacking at district, county and national level.
- There is a wealth of knowledge held by farmers on traditional agroforestry methods that can be useful in supporting the up scaling of agroforestry across the country. These practices need to be studied, documented and shared.

7.1.1 The impact of BvAT, PELUM Kenya, ICRAF, KEFRI and other institutions on agroforestry

Compared to the lifespan of ~~some~~ many trees, BvAT, PELUM Kenya, ICRAF, KEFRI and many other organizations promoting agroforestry are not old in their establishment in Kenya. However, the question that may arise is what has been the impact of these organizations on the livelihoods of smallholders in Kenya and in creating more sustainable and productive landscapes? It is important to grasp that the science and knowledge promoted by these organization traditionally has 'an indirect relationship' with impact on the ground.

Still, it is clear that these organizations have played major roles in introducing new methods for managing trees on farm in Kenya. Starting with some improved agroforestry technologies, like fertilizer trees that increase crop yields and fodder shrubs that are used by thousands of farmers in Kenya. It is important to note that fertilizer tree planting practices were not there before, so it is obvious to see these organizations' role and how their research indicates that farmers are maintaining their use in many areas where they were introduced. For instance smallholder dairy-farmers who adopt fodder trees produce more milk, and for poor farmers in Kenya – who cannot afford fertilizer – planting fertilizer trees provides a useful alternative to boost crop yields.

In addition, these organizations are contributing to domesticating high value wild trees to become cash crops, enabling farmers to earn an income from them. Examples include *Allanblackia*, used for high value oil in food products, previously wild fruit species such as bush mango, *Ziziphus* and medicinal plants such as *Warburgia*. Furthermore, these organizations' role has also been instrumental in developing a wide range of methods for improved land management, such as soil quality and land degradation assessment, carbon measurement and payment for ecosystem services models.

On the other hand assessing the effects of these organizations' research on policy change and training and extension systems is even more difficult. Needless to say, the language of agroforestry is increasingly getting into national and international strategies and policies." Furthermore, these organizations also contribute many technical background papers on topics ranging from improved water management using agroforestry principles and techniques to ecoagriculture and to climate change (carbon measurements and systems to reduce deforestation and degradation: REDD, REALU).

7.1.2 Gaps in agroforestry research and development in Kenya

It was easy to note from the thorough review of literature on agroforestry in Kenya that much research efforts in agroforestry research in Kenya have so far been dominated by descriptive (survey and stock-taking type) and observational (what happens when something is done in a particular manner as opposed to why and how things happen the way they do) studies, with only a few process-oriented studies. Consequently, the results of most agroforestry research efforts are location specific, with only limited possibility of extrapolating them to situations other than the place of investigation. Furthermore, according to Wekesa *et al.,* 2011 the methods used in agroforestry research in Kenya are taken directly from other related land-use disciplines such as agriculture, forestry, and range science; in some cases, this may pose methodological challenges. Little wonder, then, that calls for strengthening research at every front are a common feature of most agroforestry publications. Thus, the identified knowledge gaps emanating from the publications I reviewed can be summarized as follows:

- Linkage between AFS and poverty reduction in Kenya. How do AFS help the rural poor to build productive assets and to reduce their vulnerability to external shocks? Insights into this question will help governments and development organizations to better design and target their interventions.
- There's a lot of knowledge lacking about agroforestry characteristics, diversity and status. Are they under threat? Are they widespread? How do their traits vary among populations?
- Understanding the factors that drive change and influence adoption behaviour (household decision-making) on managing privately-owned trees. (What motivates farmers to stewardship towards trees)
- Sustainability (long-term studies and impacts) Impacts of agroforestry on farm households
- Valuation of non-market goods and services produced by agroforestry systems
- Assessing how regular management and maintenance efforts can help reduce risks of tree loss, and how to incentivize such efforts
- Evaluating how to make agroforestry resilient in a changing climate
- Assessing costs and benefits of protecting trees already in place versus planting more trees (relative value for air quality? storm management? water quality?)
- Conducting anthropologic and economic analysis of different types of agroforestry practices. (Why do some agroforestry programs work more effectively than others?)
- How climate change will affect Kenyan forest ecosystems, their composition, productivity and carbon sequestration potential and how it will interact with biotic (insect and pathogen pests) and abiotic factors (drought, fires, etc.);
- How can human intervention mediate the adaptation of forests to environmental change and prevent ecosystem and landscape degradation.

- **Gaps for scaling up agroforestry project interventions**

The current agroforestry interventions are evidence that Kenya has potential to advance in natural resources management. From consultations and FGDs, the major gap was limited capacity in scaling up of agroforestry project activities. Therefore gaps for intervention were identified as barriers and capacity gaps in up-scaling of ongoing agroforestry initiatives and or starting new ones. About 95% of the farmers indicated that they face a lot of challenges in scaling up agroforestry interventions. The major barriers to scaling up agroforestry interventions were mentioned as:

i. Limited trained manpower and lack of field equipment
ii. Inadequate funding
iii. Land shortage and land fragmentation
iv. Poor accessibility and inadequate transport facilities
v. Poor management of trans-boundary natural resources
vi. High cost of agroforestry inputs
vii. Negative attitudes among communities
viii. Limited capacity of local governments to carry out agroforestry initiatives

ix. Limitations in identifying, developing and implementing appropriate sustainable NRM initiatives
x. Transport facilitation and logistics hampers mobility of extension workers and district staff to the field to train and sensitize farmers.

From literature, other barriers to scaling up of sustainable agroforestry include:

a. Limited capacity of local governments and county to carryout agroforestry initiatives;
b. Institutional capacity of CSOs, NGOs, SMEs and government agencies to mainstream climate change challenges in NRM;
c. Lack of or limited incentives to scaling up initiatives of agroforestry
d. Vulnerable communities;
e. Limitations in identifying, developing and implementing appropriate sustainable agroforestry initiatives;

- **Knowledge gaps and research priorities**

The key knowledge gaps identified during the study fall into three domains:

i. *Developing more productive agroforestry systems* that are sustainable and resilient to change (both climate-related and others), and that retain and enhance the provision of ecosystem services including carbon sequestration.
ii. Building *resilient agroforestry communities* capable of adapting to change.
iii. *Institutional and other mechanisms* for promoting uptake of sustainable agroforestry production systems, and for ensuring that the links between agriculture, environment and climate change are acknowledged.

Across all these research domains, there are three important priorities. The first is that research should build from the national knowledge base to provide locally specific solutions by optimizing existing techniques or refine information for particular agro-ecological zones or production systems. A considerable body of knowledge already exists from previous development programs in the country and regions but one of the lessons from past experience is that although there are common themes and problems across the region, physical and cultural diversity is such that there are rarely “blanket” solutions. Scaling up and spilling out agroforestry will require an understanding of regional diversity. This emphasizes the need to engage in, and build competence of, national research agencies and institutes as they are best positioned to carry out detailed local research and trials.

The second is that research should be adaptive, with a strong emphasis on monitoring and evaluation. New developments in information technology, physical and institutional infrastructure and the economic context mean that concepts and possibilities for agroforestry and rural development are changing rapidly. As an example, planting of eucalyptus for poles promoted in many parts of Kenya in the 1980s, is now seen as an environmental issue rather than an option for promoting livelihoods. Ongoing adaptive research is essential to meet the needs of evolving communities.

The third priority is to ensure that the implications of research for policy and decision making are properly understood and that information is relevant and accessible at national, county and local scales. Policy dialogue networks such as African Centre for Technological and Policy Studies (ACTPS) and Swedish International Agricultural Network Initiative (SIANI) can play an important role in mediating and translating technical information for non-technical audiences, and in assisting stakeholders to analyze the policy significance of emerging knowledge.

7.2 Constraints to agroforestry adoption in Kenya

In Kenya the adoption of agroforestry practices is hampered by a general lack of awareness, understanding and confidence on the part of farmers and technical/extension workers as to the principles and viability of some agroforestry practices compared with conventional practices, as well as a lack of government policy thrust to drive the countrywide promotion and adoption of agroforestry. Other constraints are described below.

- At times there is a lack of quality agricultural inputs, particularly in rural communities where quality agrochemicals, farm implements and equipment, seeds, tree seedlings and other necessary inputs for the adoption of agroforestry practices are either not readily available or are unaffordable. In many cases, inputs and implements of low quality are used, resulting in sub-optimal results which ultimately do not favor the promotion of agroforestry practices.
- Small farm sizes, lack of available labour and limited access to seedlings and planting materials were noted as challenges hampering some agroforestry practices, in particular farm fodder production. These have a direct influence on the extent of adoption of specific fodder crops and the area put under fodder crop production by farmers. These factors need to be considered when promoting agroforestry practices involving fodder production.
- Small plot sizes moreover have an influence on practices such as agroforestry, as a farmer with a small plot of land may not be able to plant many trees within the farm but may rather prefer to plant trees on the farm boundaries so as to reduce tree-crop competition for resources. Research into appropriate tree species for small farm sizes would be useful.
- A lack of general and technical knowledge on agroforestry practices is another challenge among farmers. For example, in agroforestry some farmers have cited challenges of poor seed germination as well as seedling damage by pests and diseases. With proper training on nursery management, these challenges can be overcome. Knowledge and adoption of practices such as alley farming is also low and households require technical capacity building and financial support to implement such practices successfully
- While Kenya has a good agricultural extension network, it is often hampered by a lack of financial capacity. The extension system itself needs to build capacity in agroforestry to enable extension workers to provide the required support to farmers.
- As with other countries in the sub-Saharan Africa, many of the projects related to agroforestry in Kenya are being implemented in a fragmented manner, with few linkages with one another. This type of implementation arrangement is unsustainable in the long run

and does not have the intended large-scale impact on adoption of practices and the national contribution agroforestry. The relatively short to medium-length duration of these projects also does not promote long-term sustainability and wide-scale adoption.

- Many appropriate policy frameworks exist for wide-scale implementation of agroforestry; however, one of the main challenges is the availability of sufficient funding. In Kenya the funds required to implement the programme are estimated at as high as US$40 billion.
- While agroforestry is now a commonly used term among agricultural development practitioners across the world, there is a lack of integration of agroforestry into tertiary education curriculums across Kenya.
- In addition, the level of awareness and knowledge about agroforestry among the broad public, including media practitioners, is low. Institutional coordination on agroforestry is still lacking, despite the presence of a number of agroforestry related policies, programmes and plans.

7.3 Untapped opportunities for agroforestry promotion in Kenya

There are a number of opportunities for the promotion of agroforestry technologies and practices in Kenya. As with the challenges, the main pull factor for adoption of agroforestry practices relates to issues of direct socio-economic benefit for the farmers, including improved food security, improved incomes, alternative energy sources (in the case of biogas) as well as improved availability of fuelwood and construction material (in the case of agroforestry). Untapped opportunities to support the up scaling of agroforestry systems in Kenya include the following:

- Devolution of national government functions provides an opportunity for the integration of agroforestry into county level plans, programmes and policies.
- Some counties governments have embarked on the promotion of integrated watershed management as part of the County Integrated Development Plan (CIDP) to improve agricultural productivity, with major emphasis on avoiding open and uncontrolled grazing. This provides a good opportunity for large-scale implementation and promotion of agroforestry practices
- Collective farmer actions, for example integrated savings and lending's and shared community resources, provide opportunities for joint resource mobilization and implementation of agroforestry practices such as community seed production and community forestry.
- There is a strong base of human capital in the agricultural sector, including extension workers, development workers and private sector stakeholders. Kenya's extension service has been estimated to have over 5, 400 staff members across the country, thus providing a base from which agroforestry extension services can be provided to smallholder farmers in different parts of the country. This is complemented by a number of well-equipped training

and demonstration centers that can be used to train and demonstrate agroforestry practices and principles.

- Kenya has a well-developed and distributed research infrastructure covering all agro-ecological zones in the country. This is complemented by the presence of a large number of international research organizations such as ICRAF and CIMMYT, who have regional offices and are conducting research in many parts of the country. This provides an opportunity for large-scale research on agroforestry practices in different parts of the country.
- Kenya's policy-making environment and receptive policy-makers are conducive to the formulation and implementation of agroforestry policies and strategies in the country.
- Local knowledge on agroforestry at grassroots level can be tapped and utilized to support adoption of improved practices.
- There is huge potential to engage Kenya's youth in agroforestry, particularly in the production of high-value fruit trees. The youth are also open to new technologies and are likely to adopt innovative agroforestry practices quicker than the elderly.
- Kenya has a wide range of communication technologies that can be used to pass on the message of agroforestry to a wider audience. Examples are the 'Shamba Shape Up' TV programme (aired by Citizen TV every Sunday at 2 p.m.) and the 'Seeds of Gold' newspaper pullout in national print media every Saturday, which provide advice on improving agricultural production.
- Many international organizations, development partners, research organizations and donors are becoming involved in agroforestry and are indicating their willingness to support Kenya's agroforestry initiatives.
- Carbon markets bring opportunities for carbon trading, especially for smallholder farmers who would like to invest in forestry-related activities.

7. 42 Recommendations

Based on the research findings, the following recommendations are made:

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- For effective agroforestry promotion, adequate mechanisms are needed for generating, capturing and disseminating knowledge and information through the use of effective processes and institutional arrangements. Sources of knowledge on agroforestry include scientific research and indigenous knowledge. After knowledge has been created and sourced, it needs to be disseminated to users to support adoption of agroforestry practices.
- For agroforestry knowledge dissemination a comprehensive capacity-development approach for all stakeholders that builds on a sound assessment of needs is required. In this regard, within the diversified extension service delivery, there is a need to build the capacity

of all agroforestry-implementing organizations, with major emphasis on the extension directorate of the MoA and integration of agroforestry into the country's extension package. It is through the extension system that the technologies reach the wider community.

- To stimulate adoption, efforts should be made to improve the level of education of prospective farmers as well as current farmers since education was found to have a positive influence on adoption. The land reform efforts by government will also go a long way towards enabling farmers to adopt agroforestry practices as the area of land was found to have a positive influence on adoption.

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- It is recommended that development partners promoting agroforestry should target younger farmers since they are more likely to adopt than older farmers to achieve positive results.

- The agroforestry technology promotion process has to be documented at all levels of implementation so as to undertake evidence-based promotion and up scaling of the technologies. Documentation would provide a good basis for those involved in the implementation of agroforestry to attain knowledge and methodologies, which could then be used and applied for influencing policy-makers and for developing networks for the promotion of best practices.

- In areas where agroforestry technology has not yet been popularized, demonstrations have to be given at farmers' training centres (FTCs) and on farmers' fields. In this regard extension materials such as leaflets and brochures and organizing experience sharing visits and farmers' field days are crucial.

- Agricultural research institutions should invest in agroforestry demonstration sites across the country to show location-specific good practices in agroforestry that can be easily adopted by farmers. This can be complemented by the establishment of community-based resource centres where communities can access information on various agroforestry technologies and practices.

- Agroforestry needs to be mainstreamed into core government strategies, guidelines, manuals and annual action plans. In this regard the experience of the SIMLESA Programme is a good lesson for integrating agroforestry technologies into project and programme implementation manuals. Priority needs to be given to agroforestry practices that bring productivity gains, enhance resilience and reduce emissions.

- Agroforestry has to be integrated into tertiary level education, including TVET colleges and universities, so as to develop a large number of professionals with an in-depth knowledge of the subject.

- Universities and tertiary-level education institutions need to be supported to develop agroforestry curriculum and training courses so as to enhance the knowledge of graduates in this area. This can be initiated by first conducting an assessment of knowledge, status and uptake of agroforestry in the tertiary education curriculum at national and sub-regional level.

- The agroforestry value chains need to be evaluated and strengthened in order to enable access to key inputs and equipment needed as well as enabling the sale of agroforestry produce.

- Value chain development for agroforestry inputs and outputs such as seedlings, chemicals and equipment as well as for processing, use and sales of agroforestry products is needed across the country. Specific agroforestry value chain studies for key agroforestry practices and key agroforestry commodities is required and would assist in identifying constraints and enabling factors for improvement of the agroforestry value chain.

- More action research on key agroforestry practices is needed, particularly with the aim of testing context and agro-ecological-specific practices. Research already available must be shared and scaled-up.

- More thorough and systematic research is required to assess the effectiveness of agroforestry technologies interventions in all sectors. Long term monitoring of agroforestry interventions is required to establish which are most successful and cost effective. Given such monitoring must be undertaken over a multi-annual time scale it could be the responsibility of a central body, for example, the Kenya Forestry Research Institute. Currently it is extremely difficult to establish the long-term success rates of the plethora of agroforestry technologies on livelihood diversification programmes that have been implemented over several decades in Kenya. Logging all projects on a central database for review in future years would enhance understanding of the type of interventions, or critical factors in their implementation, that worked to sustainably build agroforestry.

- Agroforestry stakeholders need to continue to work together and ensure coordination of agroforestry activities at national and sub-regional level. This will help reduce duplication and support effectiveness and sustainability of agroforestry programmes.

- There is a need for promotion of diversified agroforestry technologies/practices. Whether, on associated river basins; humid highlands; marginal areas; buffer zones; urban/peri-urban areas, diversified agroforestry technologies may be the most appropriate form of land use where land tenure constraints or an unfavorable political economy make it imperative for small landholders, in trying to reduce risks, in order to satisfy most of their basic needs directly from the land resources under their control.

- There is also need for revision of government policies to enhance and encourage the development of agroforestry technologies in ways that are economically appropriate for the farmers. These policies should include long-term development strategies; national and regional program plans and structures, financial incentives (such as loans and

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Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5" subsidies) and establishment of agroforestry technologies demonstration sites in the different regions within the country.

- The lack of household capital is preventing many smallholders from undertaking effective economic planning. Farmers are selling produce when they need money, rather than at the time of optimal price. Thus, establishment of micro-loan schemes where farmers borrow against the commodity could give these farmers the opportunity to retain their produce until the best price is available therefore maximizing returns. This could also provide some bargaining power against middlemen.

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- The role of village/community leaders can be critical for the uptake of new agroforestry technology. During the field visit the influence of these leaders was observed in two villages. In the first village in Embu the leader had a clear vision taking an active interest in the community's development. This resulted in the adoption of fodder trees technology and subsequently the village having an improved well-being and livelihood. In the second village this vision seems to be lacking and as result the living standards of the community were much less including the existence of sanitation issues. It's believed that future projects should encourage village enterprise through working with the village/community leaders. This could be achieved field visits where these leaders travel to successful villages.

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- The role of middlemen is crucial in determining the price of farm produce. It was observed how three middle men competing to buy mango from the same farmers resulted in an increased price. Alternatively, it was also observed when a single middleman was present the price of the produce was substantially deflated. Thus, an investigation into sources of influence which lead to middlemen operating and mechanisms to encourage competition could create a more robust market reflecting the real cost of agroforestry produce.

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- In reviewing the agroforestry projects it is worth noting that some consideration of the socio-cultural aspects are critical to success, yet their complexity has meant that they are often overlooked with bio-physical aspects taking more precedence. Some other considerations identified during the review of projects are: a) a focus toward needs oriented participatory training; b) a need for strong partnerships and collaborations; and c) project planning should be broad, inclusive and flexible.

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- Furthermore, there is urgent need for consolidation of scientific and technological innovations in agroforestry through intensification of on-farm testing with farmers. This would be a positive step towards up-scaling the candidate technologies. It is also very important to develop agroforestry education at different levels. Farmers should be given sufficient information on systems to help them make informed decisions on the best and most sustainable land use options for their farms. This is best done through a technology transfer process involving demonstration plots, publications, leaflets or

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5" web–driven "toolboxes" to help the farmer decide on the best option, taking into account individual circumstances, profitability and best practice.

- There is need to clarify collective / contextual understanding of agroforestry. Ultimately, if communities are to achieve good adoption of relevant agroforestry technologies, there needs to be a clearer understanding by all parties as to what this means. Even accepting that agroforestry is a dynamic process rather than a fixed end state, targets and indicators can, and must, be developed to monitor the impact of agroforestry activities.

- Adequate resources and capacity must be committed to building relevant agroforestry systems. Short-term interventions, with no provision for long-term operations and maintenance, are unsustainable. Value for money can be justified for many agroforestry interventions, but these will rapidly become a waste of money if they are not part of a longer-term plan of support that is founded on participatory approaches.

- In addition, spending on and investment in agroforestry areas needs to increase significantly, both in the short and the long term. Building agroforestry systems is not cheap and will be expensive in the short term. Governments and donors need to recognize that a sustained and significant cash injection is required to address the inequalities in basic service provision and other development investment. At a minimum the inherent bias in development programming outside of drought prone areas need to be addressed so that funding is reprogrammed to the underserved areas.

- Lastly, one of the key issues relates to financing –while the governments must make every effort to ensure sufficient budgetary allocation for the development of agroforestry, attention also needs to be given to identifying investments outside of government through bi- and multilateral development financing sources that target the same, or related, activities.

Overall many strides are being made in Kenya in terms of agroforestry adoption and promotion and the counties involved in the study should be commended for the efforts being undertaken. However, a lot still needs to be done and support from all stakeholders as well as international, regional and national partners is called upon to transform the agroforestry systems in the country that contribute to national food security by sustainably increasing productivity and incomes; building resilience and adapting to climate change; and developing opportunities for reducing greenhouse gas emissions compared with expected trends. The clear message emanating from this report is that more work needs to be done to promote the realization of benefits of agroforestry at a broader country level in Kenya in the fields of research, policy and education.

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Appendices

Appendix A: Glossary of terms

Adoption: Beneficiaries choosing to put a particular output or cluster of outputs into practice, e.g. following a technical recommendation or use of a new technology after the same output has been taken up and disseminated by a target institution.

Afforestation: establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest. Afforestation implies a transformation from non-forest to forests.

Agroforestry: The deliberate use of woody perennials (trees, shrubs, palms, bamboos) on the same land management unit as agricultural crops, pastures, and animals. This may consist of a mixed spatial arrangement in the same place at the same time, or a sequence over time.

Agroforestry practice: Denotes a *distinctive arrangement of components* in space and time. Although hundreds of agroforestry systems have been recorded, they all consist of about 20 distinct agroforestry practices. In other words, the same or similar practices are found in various systems in different situations (Nair, 1993). Table 5.1 lists the most common agroforestry practices that constitute the diverse agroforestry systems throughout the tropics and their main characteristics. It may be noted that both the systems and the practices are known by similar names; but the systems are (or ought to be) related to the specific locality or the region where they exist, or other descriptive characteristics that are specific to it.

Agroforestry system: a specific local example of a practice, characterized by environment, plant species and their arrangement, management, and socioeconomic functioning.

Agroforestry technology: In other words this refers to an innovation or improvement, usually through scientific intervention, to either modify an existing system or practice, or develop a new one. Such technologies are often distinctly different from the existing systems/practices; so they can easily be distinguished and characterized.

Alley-cropping: Cultivation of annual crops between rows of trees or hedgerows. Sometimes called hedgerow intercropping.

Boundary planting: Lines of multipurpose trees or shrubs planted along borderlines and boundaries dividing properties or land uses.

Carbon sequestration: process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils; the sink of carbon sequestration in forests and wood products helps to offset sources of carbon dioxide to the atmosphere, such as deforestation, forest fires, and fossil fuel emissions.

Civil society: groups acting voluntarily in their capacity as citizens to advance common goals and agendas. These include both formally registered organizations and non-registered, loosely organized cause-oriented groups.

Climate change: a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Community-based forest management: management of forest lands and forest resources by or with local people, whether for commercial and non-commercial purposes.

Contour planting Rows of trees or shrubs planted along the contour of the field.

Contract farming: agricultural production carried out according to an agreement between a buyer and farmers, which establishes conditions for the production and marketing of a farm product or products.

Deforestation: conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold.

Environmentally friendly: terms used to refer to goods and services, laws, guidelines and policies claimed to inflict minimal or no harm on the environment.
Farm forestry: system where growing trees for timber, fuelwood or poles is carried out on farmland, in small woodlots or in boundary planting.

Home garden A complex collection of woody and herbaceous plants deliberately grown in small plots in or near home compounds, often associated with the production of small domestic animals.

Institutions: customs, behavioral patterns and regulations that define forest-related access, rights and duties, benefit-sharing and decision making.

Intercropping: cultivation of two or more crops simultaneously on the same field with or without a row arrangement (row intercropping or mixed intercropping); can also refer to the growing of two or more crops on the same field with the planting of the second one after the first has already completed development (relay cropping).

Landscape: a composite land area made of a cluster of interacting ecosystems that is repeated in similar form.

Live fence posts: Use of living trees, rather than dead posts, as fence posts. In Central America these are usually used to support barbed wire fencing. The fence posts may also be managed for fuelwood or poles.

Mitigation: overcoming the causes of climate change through activities leading to a reduction in the emission of greenhouse gases or removing them from the atmosphere: for instance, through carbon sequestration by trees and soil.

Multi-purpose trees or shrubs (MPTs): A woody perennial grown to provide more than one product or service.

Multipurpose forestry: any practice of forestry that fulfills two or more objectives of management, whether products, services or other benefits.

Natural resource management: Responsible and broad based management of the land, water, forest and biological resources, including genes needed to sustain agricultural productivity and avert degradation of potential productivity.

Parkland: open land with scattered groups of trees, which is temporarily or permanently cultivated and/or used for grazing.
Participation: involvement of citizens and stakeholders in decision-making, either directly or through legitimate intermediaries representing their interests.

Payments for environmental services (PES): voluntary transactions whereby a defined environmental service – or a land use likely to secure that service – is bought by a buyer from a provider, on the condition that the provider secures provision of the service.

Private sector: encompasses for-profit business entities that are not owned or operated by the government.

Scaling up: The process whereby more quality benefits are availed to more people, over a wider geographical area, more quickly, more equitably and more sustainably. In general, it involves engaging with more and/ or higher level institutions.

Scaling-out: is the geographical spread and expansion to more people and communities within the same sector or stakeholder groups. This is also known as horizontal scaling-up (Gündel et al. 2001).

Scaling-down: is another form of geographical spread and involves increasing participation through decentralization of accountabilities and responsibilities by breaking down large programmes into smaller programmes and projects (Gündel *et al.* 2001).

Spillover: describes the act of scaling-up, scaling-out and scaling-down across country borders. Internal spillover will be used to describe technology and knowledge transfer across the three regions of regions of Central, Eastern, and Western Kenya External spillover will be used to describe technology and knowledge transfer beyond the three participating regions.

Shifting cultivation: a system of cultivation in which a plot of land is cleared and cultivated for a short period of time, then abandoned and allowed to revert to producing its normal vegetation while the cultivator moves on to another plot.

Silvopastoral: any agroforestry system which includes grazing and animals.

Shrub: Woody perennial plant, generally more than 0.5 meters and less than 5 meters in height at maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 meters and 7 meters.

Stakeholders: any individuals or groups who are directly or indirectly affected by, or interested in, a given resource and have a stake on it.

Taungya: A system in which new forest plantations are established together with food and cash crops, which continue to be intercropped until shaded out by the maturing plantation.

Technology: Any one or combinations of tools, equipment, genetic material and breeds, farming and herding practices, gathering practices, laboratory techniques, models, etc., and the knowledge and skills needed to use them. In the agroforestry project, a technology may be simply a new variety, a maize–legume production system, a practice, or a combination of practices such as conservation agriculture (CA). In some cases an innovation such as a package or combination of technologies will also be classed as a technology. An important part of technology definition is the reference to knowledge and skills needed.

Tenure: agreement(s) held by individuals or groups, recognized by legal status and/or customary practice, regarding the rights and duties of ownership, holding, access and/or usage of a particular land unit or the resources therein.

Tree: A woody perennial with a single main stem, or in the case of coppice with several stems, having a more or less definite crown.

Trees intercropped with annual crops: Closely spaced trees planted or maintained in cropland for their products or their positive effects on associated crop production (for example, nitrogen fixation or microclimate improvement)

Windbreak Strips of trees or shrubs planted to protect fields, homes, canals or other areas from wind and blowing soil or sand.

Woodlot: Stands of trees planted and managed to produce various tree products, associated plants or services.

Woody fallow: Fallow is land resting from cropping, which maybe grazed or left unused, often colonized by natural vegetation. For woody fallows, the fallow is left uncultivated for sufficient time that woody plants come to predominate; - fanners may enrich, manage, or harvest from this woody fallow.

Appendix B: Benefits of adopting agroforestry technologies

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Participant's farmers in all the three agro ecological zones were asked to report on the perceived benefits of adopting agroforestry technologies. Table bellows the partiscipant farmers response

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Benefits of AF	Remarks
Improves water quality	Trees in agroforestry practices catch, store and release water. Trees break the force of falling rain. In an area with trees, rainwater flows slowly into the ground where it is stored as groundwater. Later, the water flows out as springs and streams. By trapping and absorbing water, the trees reduce flooding. By storing and releasing water, the trees reduce the effects of drought.
Soil conservation and fertility amelioration	Trees in agroforestry practices break the force of rain and wind and protect the soil from erosion. Less erosion means richer soil for farming. It also means less silt in rivers, dams and the sea. Leaves from trees and micro-organisms from soils under trees enrich the soils around them by providing organic matter.
Improves wildlife habitat	Agroforestry helps to conserve and protect natural resources by, for example, mitigating non-point source pollution and creating wildlife habitat. Provide shelter/habitat for wildlife
Increases biodiversity	While modifying natural vegetation for their productive use, farmers develop and maintain agroforestry systems that make substantial contributions to biodiversity in multi-functional landscapes.
Provides shade for livestock	
Increase financial security	Increase in levels of farm incomes due to improved and sustained productivity.
Diversifies production	Crop diversity and reduced risk. Reduction in incidence of total crop failure, common to single-cropping or monoculture system, Help sustain steady and reliable production to meet market demands
Provision of non-wood products:	Many useful products come from trees. Among these are medicines, fibers for making ropes, gums and resins, seeds for ornaments, bush meat, fruits and honey from tree flowers.
Timber provision:	Trees in agroforestry practices produce wood and poles for houses, furniture, fences, telephone and electricity lines, paper, tools and works of art. Certain special trees are used to make products for religious or social ceremonies. Some indigenous trees produce very beautiful wood.

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Air quality and environmental services:	Trees in agroforestry practices help to moderate the climate. Near forests, hot days are less hot and cold nights less cold than in open areas. Trees absorb carbon dioxide, a gas that is produced by animals and burning fuels. By storing carbon dioxide, trees help to regulate the gases in the atmosphere around the earth.

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Appendix B: Checklist for Focus Group Discussions

A. Farmer group identification

Name of group…………….
Number of members: male………., female…………youth…………
Date of formation………………..
Group goal, mission, vision………………………………

B. Farmer group knowledge of agroforestry principles and concepts

1. How did you come to know about agroforestry? What does agroforestry mean to you?
2. What does it take to 'learn' agroforestry, both individually and collectively (activities, processes, etc.)?
3. What are your roles and responsibilities in implementing the agroforestry project?
4. Who are your partners and what are their roles and responsibilities?
5. What agroforestry technologies and practices have you learned and adopted?
6. What agroforestry technologies and practices have you learnt BUT NOT adopted? Why?

C. Group benefit/effects as a result of practicing or adopting agroforestry

a. What have been your benefits and fears about agroforestry? (household, group and community benefits and fears)
b. What benefits do you hope to achieve from agroforestry in future, for example in 5 to 10 years' time?
c. What changes have occurred within and around the group as a result of practising agroforestry
d. What general changes have occurred that were not planned?
e. What are the unintended or unexpected benefits or changes?
f. What are your fears or perceived threats about agroforestry?
g. What are the key obstacles, challenges and way forward for agroforestry in

h. What are the entry points and pathways that lead to large-scale adoption of agroforestry? Are some more effective than others?
i. Have large-scale farmers a comparative advantage in adopting agroforestry? What advantages and why? Under what conditions can agroforestry work for smallholders and resource-poor households?
j. What are the key lessons learned in scaling up adoption? Do's and don'ts, and why.

D. Agroforestry continuity and sustainability

1. What opportunities exist within the group or community for continuity of agroforestry initiatives?
2. What organizations and institutions exist in the community that has potential for further promoting?
3. How can agroforestry initiatives be scaled out to the entire community?
4. What will be your roles and responsibility?
5.

6. Constraints

1. What are some of the main problems you experience in your farm/garden?

7. Government/NGO Outreach

1. Have you ever attended any trainings or workshops offered by the government or NGO's on farming/gardening?
2. Have you tried anything new or different on your land that your neighbor's haven't tried?

Narrative Walk

In addition to the focus group discussion I have designed a qualitative method called 'narrative walks' to explore spatial, physical, temporal and social conditions of agroforestry adoption in the study area/group

In the company of field assistant from the area, we will walk with peasant farmers through their landscape and life worlds to observe and discuss our impressions through dialogue while learning directly from them about their socio-ecological endowment.

Such in situ dialogues often have many advantages, as it establishes the respondent as 'knower' of the agro-ecological landscape and compensates for asymmetry in interviewing. It allows also for documentation in notes, diaries, drawings, photos and maps. It offers opportunities for rich field interactions and discovery while generating a context-based empirical material to be continuously validated in oral and visual checks linking 'what you see' with 'what you hear'. By probing deeper I could uncover, clarify and confirm a range of data to be directly coded, sorted and verified. Although narrative walks can be time consuming for respondents, however, and challenging in conditions of strong wind, rain or scorching sun.

Besides a predetermined narrative walk guide, I will have context bound questions for every field site. Inspired by direct landscape observations commented by peasant farmers and field assistants, I will intermittently posed open, structured and clear-cut follow-up questions seeking in depth answers. The generic questions could be as follows:

- Biophysical, socio-economic and institutional environment of agroforestry work in the area
- Trajectory of related work in the selected region, site, project
- Overview of the agroforestry adaptation and diffusion process in the area
- Agroforestry impacts in the area
- Present gaps and challenges in agroforestry work

Appendix C: Questions - Key Informants Interview

1. Name of Respondent: ……
2. Institution/ministry/organization ……………………………………………………………………………………………
3. Phone Number: ……
4. Email: ……
5. What are the main activities of your institution/ministry/organization?
………
………
………

6. What role does your institution/ ministry/organization play that is related to Agroforestry or Food Security?
………
………
………

7. What successes has your institution experienced in Agroforestry?
………
………
………

8. What are the constraints faced by your institution in implementing or promoting Agroforestry? How can these be overcome?
………
………
………

Constraints	Possible solutions

9. Based on the Agroforestry definition provided above, what are the current AGROFORESTRY related policies in the country that is relevant to your activities?
………
………
………

10. What are current on-going Agroforestry development and research programme initiatives in the country?
………
………
………

11. What are the major gaps in Agroforestry policies and programmes?
………
………
………

12. What (can be done) is needed to ensure that Agroforestry policies are improved in terms of relevance, equity and effectiveness?
………
………
………

13. In your opinion, how effective have Agroforestry activities and policies been?
………
………
………

14. How have the Agroforestry activities had an impact on gender equality and social equity taking into cognizance the role of women and youth?
………
………
………

15. What are the key challenges to implementing Agroforestry t in the country? How can these challenges be overcome?

Key challenge to implementing Agroforestry	Possible solution

16. What opportunities remain untapped in agroforestry, and why?
……
……
……

Untapped opportunity	Reasons why still untapped

Appendix D: List of key informants consulted

Name	Project/ Program/ Initiative	Organization	Acronym
Jonathan Muriuiki		World Agroforestry Centre	ICRAF
Danyell Odhiambo		World Agroforestry Centre	ICRAF
Oscar Murithi		World Agroforestry Centre	ICRAF
Walter Adongo		World Agroforestry Centre	ICRAF
Silas Muthuri		World Agroforestry Centre	ICRAF
Vincent Oeba		African Forest Forum	AFF
Gituanja Gachie		Community Action for Nature	
Andrew Ochieng		Environment Expert/ Independent	

Appendix E: List of validation workshop participants held 31 March 2016 at

Serial No:	Names	Organization / Programme	Email address
1	David Amudavi	BvAT	damudavi@biovisionafricantrust.org
2	Sammy Carsan	ICRAF	S.Carsan@cgiar.org
3	Othniel Yila	SEI	othnielyila@sei-international.org
4	Joyce Chege	ICRAF-SD3	jochege@cgiar.org
5	Jantor Ndalo	ICRAF-SD3	j.ndalo@cgiar.org
6	Joan Simari	ICRAF-SD3	JSimam@cgiar.org
7	Kipruto Muthemba	AOCC-SD3	s.muthemba@cgiar.org
8	John Innocent	ICRAF-SD3	i.john@cgiar.org
9	Agnes Gachuiri	ICRAF-SD3	a.gachuiri@cgiar.org
10	Gerald Moloa	Cropcare	gerald@Cropcare.co.ke
11	Pauline Mundia	BvAT	pmundia@biovisionafricantrust.org
12	Hudson Shiraku	BvAT	hshiraku@biovisionafricantrust.org
13	Ludy Keino	ICRAF	l.keino@cgiar.org
14	Agnes Were	ICRAF	a.were@cgiar.org
15	Simon Kangethe	ICRAF	S.Kangethe@cgiar.com
16	Urbanus Kinuthia	ICRAF-SD3	muthaiurbanus@gmail.com
17	Geoffery Abour	ICRAF-SD3	G.abuor@cgair.com

18	Zakayo Kinyanjui	ICRAF-SD3	z.kinyonjui@cgiar.org
19	Alice Muchugi	ICRAF-SD3	a.muchugi@cgiar.org
20	Changeh Janice	BvAT- Intern	janiceghems@yahoo.com
21	Betty Tuei	Egerton university	tueibc@yahoo.com
22	Samuel Muthemba	ICRAF	S.Muthemba@cgiar.org
23	Phiona		
24	Samuel Manthi	ICRISAT	S.Manthi@cgiar.org
25	Edna		
26	Alice Muchugi	ICRAF	a.muchugi@cgiar.org
27	Prasad Hendre	ICRAF	P.Hendre@cgiar.org

Group name	Province	County	Sub-county	Division	Location	Sub-location	Village	Original Membership	Current Membership	Activities
Toben Gaa	Rift Valley	Kericho	Kipkelion West	Chilchila	Siwot	Siwot	Tuiyabei	45	48	Tree planting- timber, medicinal, fruits Soil conservation, VSLA, Fodder banks Local poultry production, Coffee, sugarcane, maize, beans and banana growing, Dairy cows
Ochoria Greener Globe	Nyanza	Kisumu	Muhoroni	Muhoroni	Koru	Fort-tenan	Kahawa	20	19	Tree planting- timber, medicinal, fruits Soil conservation, VSLA, Fodder banks Local poultry production, fish farming, maize, beans and banana growing,
Kyanda women group	Eastern	Machakos	Machakos	Central	Mua	Kyanda	Kyanda	26	18	Agroforestry-crops (maize beans, cowpeas, pigeon peas, horticultural crops) trees - *gravellea robusta, magnifera indica, carica papaya, persia americana, citrus sinensis)* table banking (merry go round), cereal banking, local poultry farming, local cattle rearing, agroforestry
Mua Horticulture	Eastern	Machakos	Kangundo	Kangundo East	Kivaani	Miu	Mua			Agroforestry Table banking (Merry go round) Cereal banking local poultry farming soil conservation

Biovision Africa Trust (BvAT)
C/O ICIPE,
P.O. Box 30772-00100
Duduville Kasarani,
Off Thika Road
Nairobi, Kenya