Review of the Status of Agroforestry Practices in Kenya.

Background study for preparation of Kenya National Agroforestry Strategy (2020 – 2030)

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LIST OF ACRONYMS AND ABBREVIATIONS

AFRENA	- Agroforestry Research Networks for Africa
ASALs	- Arid and semi-arid lands
BGF	- Better Globe Forestry
CAFNET	- Coffee Agroforestry Network
CAWT	- Conservation Agriculture with Trees
CIDA	- Canadian International Development Agency
COSOFAP	- Consortium for Scaling up Options for increasing Farm Productivity
DANIDA	- Danish International Development Agency
DryDev	- Drylands Development Program
EADD	- East Africa Dairy Development
EU	- European Union
FAO	- Food and Agriculture Organization of the United Nations
FF-SPAK	- Farm Forestry Smallholder Producers Association of Kenya
GBM	- Green Belt Movement
ICRAF	- International Centre for Research in Agroforestry (also World Agroforestry)
IMARA	- Integrated Management of Natural Resources for Resilience in Arid and Semi-Arid Lands
ITF	- International Tree Foundation
KALRO	- Kenya Agricultural and Livestock Research Organization
KARI	- Kenya Agricultural Research Institute (presently part of KALRO)
KEFRI	- Kenya Forestry Research Institute
KEPHIS	- Kenya Plant Health Inspectorate Service
KFS	- Kenya Forests Service
MICCA	- Mitigation of Climate Change in Agriculture
MoALFC	- Ministry of Agriculture, Livestock, Fisheries and Cooperatives
MoEF	- Ministry of Environment and Forestry
NAFRP	- National Agroforestry Research Project
NGOs	- Non-governmental organizations
PELIS	- Plantation Establishment and Livelihood Improvement Scheme
PES	- Payment for Ecosystem Services
RRC	- Rural Resource Centre
SDC	- Swiss Agency for Development and Co-operation
SDG	- Sustainable Development Goals
SIDA	- Swedish International Development Agency
VSLA	- Village Savings and Loaning Associations

1.0 Introduction

Agroforestry is defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm- and rangeland, diversifies and sustains smallholder production for increased social, economic, and environmental benefits (Leakey, 2017). Agroforestry as a science and farming practice combines both agriculture and forestry techniques to build more robust, productive, resilient and diverse agro-ecological profiles (Stiebert *et al.,* 2012). Agroforestry is promoted to achieve a sustainable productive agroecosystem that has potential to improve resilience of farmers over time by mitigating deforestation and land degradation, addressing climate change and its variability, increasing farm productivity, enhancing households' access to diverse wood and non-wood products at times of the year, diversifying household's livelihood sources and increasing their income and food security situation and thus, alleviating poverty (FAO, 2013). The practice of agroforestry seeks to optimize the interaction between woody and non-woody components in order to achieve higher productivity, sustainability and diversity of products from the land (Kilewe et al., 1989).

Agroforestry is an age-old land use practice (Degar &Tewari, 2016) that has evolved over time since middle ages when it defined traditional agriculture as mixed tree-crop slash-and-burn farming. The science of agroforestry commenced with the formation of formal institutions in the 1970s (Nair & Garrity, 2012), mainly signified by the establishment of the International Council for Research in Agroforestry (ICRAF; also known as World Agroforestry), in 1977[1]. ICRAF became the focal point of organized global efforts to develop these traditional forms of land use while addressing some of the land-management problems that were often exacerbated by developments in commercial agriculture and forestry. Persistent livelihood challenges such as shortage of fuelwood, timber and construction materials, land degradation and deforestation caused by rising human population as well as climate change, among other factors, have directed the over four-decades of agroforestry research and development globally (van Noordwijk *et al.,* 2018). Since 1980s, a wide range of agroforestry technologies have been experimented with and adopted by farmers (Nair & Garrity, 2012), while the academic aspects of the discipline have shaped up to tens of higher learning institutions offering courses in agroforestry across the world. There has also been increased investment in promotion of tropical agroforestry by various organizations including governments, the donor community, community-based and non-governmental organizations, with different development and environment goals (Scherr, 1995).

There is common understanding that agroforestry has made a positive impact in livelihoods and landscapes in Kenya and across the world but it is important to demonstrate the impact of agroforestry in empirical terms. The role of agroforestry is not always adequately acknowledged in development policies and practices perhaps because of difficult-to-measure and diverse pathways through which the practice affects people's lives (Dawson *et al.,* 2013). This gap could be attributed to the unlikelihood of a single methodology or metric to fully capture the multiple, system level

[1] ICRAF was originally set up as a "nucleus" in 1977 in Amsterdam, the Netherlands, and later moved to its permanent headquarters in Nairobi, Kenya, in 1978. In 1991 it joined CGIAR (formerly the Consultative Group on International Agricultural Research) to conduct strategic research on agroforestry throughout the tropics, changing its name from Council to Centre. In 2002, it was renamed as the World Agroforestry Centre, but retained its original acronym (ICRAF). Today, it is called World Agroforestry but still retains ICRAF as its acronym.

impacts associated with adoption of agroforestry technologies. The Sustainable Development Goals (SDGs), defined by the international community to guide research, practice and policy efforts until 2030 and key Kenya's development goals can be a departure point. Agroforestry contributes to several SDGs but significantly: i) SDG 1 - End extreme poverty in all forms; ii) SDG 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture; iii) SDG 13 - Take urgent action to combat climate change and its impacts; iv) SDG 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss; and, Partnerships for the goals. Agroforestry also moderately contributes to: SDG 3 – Good health; SDG 6 – Clean water; SDG 7 – Clean energy; SDG 8 – Decent work; and, SDG 10 – Reduced inequalities; among others.

One of the oldest and most remarkable form of traditional agroforestry in Kenya is the *shamba* system (a form of *taungya*) where people were allowed to cultivate annual food crops on gazetted forest land while tending tree saplings on behalf of the government forestry department (Witcomb & Dorward, 2009). This form of land use was introduced during colonial times with an aim to provide farmers with livelihood and subsistence needs as they help the government to re-establish industrial forest plantations (Kagombe & Gitonga, 2005). Abuse of the system subsequently led to its subsequent banning in 1987 and again in 2004 following environmental activism, however, a variant of the system known as Plantation Establishment and Livelihood Improvement Scheme (PELIS) was later introduced in 2007. PELIS allows forest adjacent communities, through their Community Forest Users' Associations (CFAs), to cultivate crops during the early stages of forest plantation establishment until tree canopy closes before being re-allocated new sites, as part of Participatory Forest Management (PFM) (Witcomb & Dorward, 2009). Agroforestry has now been more broadly shaped as a land use approach in Kenya building upon decades of research and promotion across the country. Kenya has at least seven universities offering agroforestry either as a diploma or degree course or as a unit in one of the degree courses, which further reveals how significantly the discipline has grown in the past four decades.

This review elucidates some of the key impacts of agroforestry and attempts to build an understanding on various agroforestry initiatives implemented in the past and at present in Kenya and point out what has worked well and potential constraints to scaling. It seeks to show evidence of piloting and adoption of practices across diverse regions in the country, link to national and international targets that agroforestry interventions have shown potential to address and the opportunities for scaling up agroforestry in the country.

2. Framing the impact of agroforestry in Kenya within broad development challenges

2.1 Agroforestry for land and biodiversity improvement

The main challenge facing smallholder agricultural production in Kenya is low soil productivity occasioned by continuous cropping over time, with low or no addition of inorganic fertilizers. Agroforestry is considered a low-cost approach to replenishing soil fertility that is technically feasible and socially acceptable to smallholder farmers especially those with limited resource endowment (Mango & Hebinck, 2016). Reduction of soil erosion, combating land degradation and soil fertility improvement were among the key goals of promotion of agroforestry in Kenya in the early years of research (Tengnas, 1994).

Early investment in research in agroforestry for management was undertaken through the Agroforestry Research Networks for Africa (AFRENA) programme soil improvement flagship hosted at Maseno Regional Agro-forestry Research Centre in Western Kenya (AFRENA, 1996, 1997, 1998). The ICRAF 2008 annual report indicated that there was conclusive evidence from the various studies conducted at the site (as well as others) that agroforestry can reverse the decline in soil productivity and substantially increase crop yields. Agroforestry technologies such as improved short-duration fallows, green manure biomass transfer, hedgerows and intercropping with fertilizer trees produced substantial improvement in soil fertility in western and even central Kenya (Mango & Hebinck, 2016; Mugwe *et al.,* 2004).

> ***For example****, improved short duration fallows were considered an attractive option to farmers because they accelerated the process of soil rehabilitation (Sjogren et al., 2010), doubled maize yields and were a source of firewood for households (Place et al., 2004), among other benefits. Where improved fallow species were combined with micro-dose of inorganic fertilizer, the maize yield was even more compared to non-fertilized maize farms (Micheni et al. 2002; Maithya et al., 2006; Shisanya et al., 2009). Combining Tithonia diversifolia biomass with rock phosphate on soils low in phosphorus proved to be an effective way of restoring soil fertility (Jama et al. 2000), and results showed an increase in yields of maize and other high-value crops such as tomatoes, kale and French beans (Franzel et al., 2008).*

Additional to soil fertility improvement agroforestry benefited through decline of striga weed infestation and reduction in soil erosion. Striga (commonly known as witchweed) is a genus of parasitic plants that attacks cereals and severely stunts them, a phenomenon closely associated with nitrogen deficient soils. Studies in western Kenya showed that introduction of improved fallows remarkably declined infestation by the weed (Kiwia *et al.,* 2009; Sjogren *et al.,* 2010). Similarly, agroforestry is a very effective control of soil loss through surface run-off especially on steep slopes (Kinama *et al.,* 2007) aiding rehabilitation of degraded rangelands (Droppelmann & Berliner, 2003).

In terms of biodiversity, agroforestry has the potential to conserve tree genetic resources (Kehlenbeck *et al.,* 2010). Agroforestry presents landowners (whether of private, communal or public land) with the possibility to introduce new tree species in an area and exploit untapped niches for specific tree production. This is because trees can grow in different locations including boundaries, terraces or intercropped in food crops, pasturelands, riverine and hills among, many other niches.

Land productivity improvement by agroforestry technologies involves some trade-offs that may impact negatively on the farmers, if not properly factored in design, however. These include cases where exotic tree species grown excessively replace indigenous species leading to low tree species diversity on landscapes. Studies such as Kehlenbeck *et al.* (2010) have reported low tree diversity and dominance of exotic tree species especially in the humid highlands. For example, Eucalyptus and *Grevillea robusta* have replaced many indigenous species as the most common tree species in farms in western Kenya (Henry *et al.,* 2009; Wanjira, 2019) and central Kenya (Njuguna *et al.,* 2014). This calls for a more pragmatic and holistic approach to realize the objective of improving biodiversity by increased diversity of tree species and other components that is paramount in building multifunctional landscapes through agroforestry.

2.2 Agroforestry for food and nutritional security

Food and nutritional security is a major motivating factor for agroforestry adoption by farmers (Mbow *et al.,* 2013; De Souza *et al.,* 2012). Agroforestry contributes to food and nutritional security through 1) the direct provision of tree foods such as fruits and leafy vegetables and by supporting staple crop production; (2) by providing rich and nutritious fodder for livestock; (3) by providing energy for proper processing and cooking of food such as charcoal and firewood; and (4) by supporting various ecosystem services such as pollination that are essential for the production of some food plants (Jamnandas *et al.,* 2013; Dawson *et al.*, 2013).

With different species of exotic and indigenous fruit and nut trees promoted under agroforestry, farmers have access to fresh fruit throughout the year (ICRAF, 2008) which are a major source of vitamins and minerals. Example of fruits and nuts common to Kenya humid and ASALs include *Mangifera indica* (mango), *Citrus sinensis* (orange tree), *Persea americana* (avocado), *Tamarindus indica*, *Adansonia digitata* (baobab), *Syzygium cuminii,* Macadamia nuts, Cashew nuts among many other fruit and nut tree species that can grow under agroforestry. To better incorporate fruits into local food systems while addressing the challenge of seasonal availability, ICRAF has developed a methodology based on "fruit tree portfolios" that selects socio-ecologically suitable and nutritionally important fruit tree species for farm production, to meet local consumption needs (McMullin et al, 2019).

Studies have shown that fodder trees when fed to dairy cattle, can significantly increase milk yields (Franzel & Wambugu,2007) enabling households to have more milk, an important source of proteins especially for children, for consumption and surplus for sales. According to Place et al., (2009), 1kg of dry matter equivalent of *Calliandra calothyrsus* twigs increased milk production by 0.6 kg-0.8 kg per day per cow and the butterfat content was also slightly higher when cattle were fed with fodder. Sale of tree products also provide smallholders with additional income which then allows them to be able to purchase food types not produced in the farm thereby improving household food diversity. Better access to cooking fuel also gives households more flexibility in term of what they can cook and eat, including foods with better nutritional profiles that require more energy to cook (Dawson *et al.,* 2013).

2.3. Agroforestry for income and livelihood improvement

In most rural households, incomes are seasonal in relation to the farming cycle (David, 1997), and therefore farmers are vulnerable and exposed when they wholly rely on their small farms for their livelihoods and sustenance. Agroforestry can raise the income levels of rural households by providing profitable market products or enabling the household to obtain products that they would otherwise buy (Jamnandas *et al.,* 2013; Dawson *et al.,* 2013). Agroforestry systems provide opportunities for participation in various enterprises like tree nurseries, timber production and sale, fruit, fodder, fuelwood sale and any other product that can be commercialized. The trees serve as a 'savings account' and 'safety-net' and in some ways act as rural insurance system for the poor smallholder farming families who are highly vulnerable and subject to unexpected expenditures (Kallio, 2013). Income may also increase because of increased production in other agricultural enterprises supported by agroforestry, which enables households to sell the surplus.

Short-term leguminous trees such as *Calliandra calothyrsus*, *Leucaena trichandra and Leucaena pallida* were introduced into farms in early 1991 as livestock fodder in Embu jointly by ICRAF, Kenya Agricultural Research Institute (KARI)[2] and Kenya Forestry Research Institute (KEFRI), under the National Agroforestry Research Project (NAFRP), sustainably raised the income level of small-scale dairy farmers (Franzel & Wambugu, 2007; Place *et al.,* 2009; NAFRP, 1993). Farmers who participated in on-farm trials with *Calliandra* fodder in Embu earned an additional US$98-US$ 124 per year from their dairy enterprises after the second year compared to farmers who did not (Franzel *et al.,* 2003a). The increase in income was attributed to adoption of *Calliandra* fodder as a substitute/supplement to commercial feeds (Franzel & Wambugu, 2007; Franzel *et al.,* 2003a), and innovations within the dairy value chains that increased farmers' income. Similar observations were reported in an agroforestry project in Kaptumo, Nandi County (Wambugu *et al.,* 2014). Wider adoption of fodder shrubs has also evolution of networks of small-scale seed dealers to support fodder shrub seed creating an additional revenue stream for adopting farmers, seed dealers and nursery operators (Dawson *et al.,* 2013; Wambugu *et al.,* 2011).

2.4. Agroforestry for ecosystem services, climate change and livelihoods

Climate change is a major threat to a huge proportion of the farming populations in developing countries including Kenya, given they mainly derive their livelihoods from agriculture (Verchot *et al.,* 2004). Yields from rain-fed agriculture have been projected to drop by half by 2020 and net revenue from crops is expected to fall by 90% by 2100 as a result of climate change (UNFCC, 2007) while the adaptive capacity of smallholder farmers is critically low (Bryan et al., 2013). Agroforestry is however capable of buffering farmers against climate extremes (Thorlakson & Neufeldt, 2012), while performing wider services that directly support local production (Leakey, 2010). These include soil, spring, stream and watershed protection; animal and plant biodiversity conservation; and carbon sequestration and storage, all of which ultimately affect food and nutritional security (Garrity, 2004). In smallholder agroforestry in the tropics, potential carbon sequestration rates have been estimated to range from 1.5 to 3.5 Mg C ha^{-1} yr^{-1}(Montagnini & Nair, 2004). Therefore, encouraging individual farmers to preserve and reinforce functions that extend beyond their farms by payments for ecosystem services such as carbon credits (Roshetko *et al.* 2007) and selling

[2] KARI is now defunct and known as the Kenya Agricultural & Livestock Research Organization (KALRO), established in 2013 as a merger of KARI, Coffee Research Foundation, Tea Research Foundation and the Kenya Sugar Research Foundation

carbon credits may provide another source of income for farmers, diversifying their agricultural portfolio and mitigate against climate change through GHGs emission reduction.

Agriculture in Kenya is mostly rain-fed making farmers vulnerable to any variability in rainfall and temperature patterns (Jamnandas *et al.,* 2013). **A number of studies have therefore investigated the role of agroforestry in** buffering farmers against adverse impacts of climate change **in the country. Thorlakson and Neufeldt (2012)** found that farmers involved in agroforestry had better standards of living than those not engaging in the practice because of improved farm productivity, increased off-farm incomes and better environmental conditions of their farms. This outcome helped reduce their vulnerability to climate-related changes. FAO's Mitigation of Climate Change in Agriculture (MICCA) Program in Kaptumo, Nandi County showed potential to create a net sink of -775 542 to -663689 tonnes of CO_2 eq when farmers practice agroforestry combined with improved farming and livestock practices compared to -304627 CO_2 eq when dairy production was the main focus (Jönsson, 2012).

In semi-arid Machakos, **a study by Lott *et al.* (2009)** concluded that trees had the potential to buffer understory crops against extremes of temperature by reducing incident radiation. Another study in the area reported higher soil moisture retention under conservation agriculture with trees (CAWT; where *Gliricidia sepium* and *Calliandra calothyrsus* were intercropped with maize) than under conventional agriculture (ICRAF, 2015). This implies potential to extend the growing season of maize, and possibly other crops during periods of moisture stress by incorporating selected agroforestry trees on farm.

2.5 Gender aspects in agroforestry adoption and impact

The success of agroforestry greatly depends on its adoption particularly by rural women (Gladwin *et al.,* 2002). Agroforestry is beneficial to women farmers in several ways. They can access tree products such as fuelwood, herbs, fodder and vegetables among others within their farms rather than traveling to forests, making it cheaper and less time consuming. The time saved can be invested in productive activities (Kiptot & Franzel, 2011; Thorlakson & Neufeldt, 2012) and subsequently improve incomes and livelihoods. It is therefore important to underscore that agroforestry practices and scaling should consider the gender and cultural perspective to address any gender related cultural constraints that may hinder its uptake.

Despite accounting for most of the labour required in agricultural and food production systems as well as being key agents in managing natural resources, women may be disadvantaged in taking up proven agroforestry technologies due to socio-cultural and economic factors (Mugure *et al.,* 2013; Ndiritu *et al.,* 2014). Such factors may include restricted rights to plant and manage trees, due to insecure land and tree tenure (Mugure *et al.,* 2013; Kiptot & Franzel, 2011), poor access to knowledge on new technologies and poor access to seeds or seedlings (Gladwin *et al.,* 2002). They are usually unable to afford high-cost technologies due to cash constraints and may prefer low-input agroforestry (Dawson *et al.,* 2013), an important factor in agroforestry adoption by women, especially in poor rural settings.

Kiptot & Franzel (2011) found that projects introducing new agroforestry technologies gained high participation from women when the enterprises involved were more attractive to women, and when projects worked through existing women's groups. Land rights have also been seen to be less significant constraints in some cases. For instance, in some communities, widows or women whose husbands are working away from home have freedom to make decision that relates to land use including tree planting (Kiptot & Franzel, 2012). The Green Belt Movement has also implemented programs on-farm tree planting with a primary focus on empowering women (find it here). This is a pointer to possibility that focusing on women group may help in agroforestry scaling and achieving sustainability in the long-term. Women manage significantly more tree species on farmlands than men since they aim to primarily meet subsistence needs over and above commercial goals (Scherr, 1995).

Women have been as actively involved as men in the various agroforestry practices in Kenya including production of fodder shrubs, woodlot establishment, and soil fertility improvement. However, Kiptot & Franzel (2011) recorded that the area of fodder shrubs and the number of trees grown by female-headed households is approximately half that grown by male-headed households. In western Kenya, Place *et al.* (2004) found that more women than men trialed with improved fallow and biomass transfer systems, while in central Kenya, men and women jointly managed *G. robusta* for poles and fuelwood respectively (Kiptot & Franzel, 2011).

3. Agroforestry development and initiatives in Kenya

3.1 Past Agroforestry Initiatives

The establishment of ICRAF in Nairobi in Kenya in 1978 was critical in Kenya's agroforestry history because the institution took the lead in identifying and coordinating scientific methods in the development of agroforestry in Kenya and beyond. Several development partners including Canadian International Development Agency (CIDA), Swedish International Development Agency (SIDA), Danish International Development Agency (DANIDA), FORD Foundation and Swiss Agency for Development and Co-operation (SDC) were instrumental in providing funds that were initially invested in agroforestry research and development in the country.

In November 1980, ICRAF co-organized the first congress on agroforestry in Kenya entitled the *Kenya National Seminar on Agroforestry* with the University of Nairobi and supported by the national ministries of Agriculture and Livestock Development and Environment and Natural Resources (Buck, 1981). The conference was the first major meeting in Kenya aiming to encourage an exchange of views and experience on agroforestry. A broad set of recommendations from the conference included the establishment of a coordinating committee to help promote and sustain agroforestry activities among all government and non-governmental organizations. A *Second National Seminar on Agroforestry* was held in Nairobi in 1988 to review and highlight the development and performance of agroforestry in the country since the original conference (Kilewe *et al.,* 1989). By this time, a few organizations including CARE-Kenya, ICRAF, Vi Agroforestry and government departments in the ministries of Environment and Natural Resources, Agriculture and Energy were already involved in promotion of agroforestry (Tengnas, 1994).

A second development on agroforestry research and development in Kenya in 1980 was the setting up of an ICRAF field station in Machakos on a 40-acre land donated by the Kenya Government to demonstrate agroforestry technologies for extension personnel, policy makers and researchers. Technologies demonstrated on the land included; (i) multi-purpose tree species establishment; (ii) agroforestry technologies such as woodlots comprising of *Grevillea robusta* and *Gliricidia sepium*, boundary planting, live fences, soil conservation with trees, alley cropping, windbreaks and fodder banks; and (iii) experimental designs for in-depth agroforestry research studies. Following closely was the inception of a project dubbed "the Dryland Agroforestry Research Project (DARP)" In 1983/84 to develop agroforestry technologies for semi-arid areas in Kenya. The collaborative project between KEFRI, the National Dryland Farming Systems Research Station (NDFSRS) of KARI, ICRAF, and Machakos Integrated Development Project (MIDP) was initiated in Kakuyuni, a semi-arid area of Machakos district (currently known as Machakos County). The project aimed to develop agroforestry technologies to address challenges the in the semi-arid areas related to (i) soil erosion and degradation of grazing land, (ii) decline in soil fertility, (iii) dry-season fodder shortage, (iv) poor cash flow for farmers, and (v) shortage of tree products (timber, poles, firewood) constraints (Tengnas, 1994).

KEFRI, KARI and ICRAF actively collaborated and participated in setting up the *collaborative research programme in the highlands and mid-lowlands of Eastern and Central Africa* spearheaded by AFRENA between mid-1980s to late 1990s. The goal was to develop appropriate agroforestry technologies sub humid areas with high population density, small farm sizes and intensive land use system as well as strengthen national capabilities to carry out agroforestry research. Focusing mainly on the western and central Kenya regions, this collaboration brought together researchers and scientists from KARI, ICRAF and KEFRI under the AFRENA network in Kenya (Tengnas, 1994). The Maseno Research Centre was consequently established in 1987 to develop agroforestry technologies appropriate to western Kenya region with a goal of addressing problems of declining soil fertility, soil erosion, inadequate fuel wood and fodder supplies in the region (Tengnas, 1994). Later, in 1991, the National Agroforestry Research Project (NAFRP) was initiated in Embu under the same collaboration to test on-farm agroforestry technologies in the coffee-dairy-based land use system of the central highlands (Tengnas, 1994; NAFRP, 1993; Minae & Nyamai, 1988).

The establishment of research stations in Machakos, Maseno and Embu was critical in facilitating research and dissemination of agroforestry technologies to address a foreseen household energy crisis, livestock fodder shortages, declining soil health and land degradation in the country (Tengnas, 1994). Building on this development, programs such as Kenya Woodfuel and Agroforestry Program (KWAP) and the CARE Agroforestry project were started. KWAP operated in Busia, Kisii, Kakamega and Siaya districts[3] in western Kenya between 1990 and 1997 while CARE-Kenya implemented the CARE Agroforestry project in Siaya district from 1988 to 1998. Both projects applied community-based approaches to disseminate agroforestry practices mainly with the aim of providing the community with alternative sources of household fuelwood (Tengnas, 1994; Noordin *et al.,* 2002).

Between 1997 and 2004, more than 100 organizations including ICRAF, KEFRI, and KARI piloted scaling of agroforestry practices to improve soil fertility in 23 districts of western Kenya (ICRAF,

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[3] The Constitution of Kenya 2010 converted all the former Districts that had been gazetted in 1996 to counties. First Schedule under article 6(1) of the Constitution of Kenya 2010 has the lists of the 47 counties making up Kenya.

2011) under a program called Consortium for Scaling up Options for increasing Farm Productivity (COSOFAP). The consortium brought together 60 partners that were active in western Kenya to develop and disseminate options for improving farm productivity, including agroforestry (focusing on two technologies namely, improved fallow systems and biomass transfer) (Njui *et al.,* 2003). Candidate technologies were jointly tested through groups that already existed at community level. These early agroforestry efforts that had quick results in order to stimulate community interest in investment in trees with long-term benefits.

Efforts to intercrop legume trees within croplands so as to improve land productivity have been sustained by various projects to present day. In 2011, Evergreen Agriculture project funded by EC/IFAD and implemented by ICRAF in collaboration with ACT and KENDAT piloted the importance of high value agroforestry trees and nitrogen fixing trees in what was referred to as the CAWT approach. The technology was successfully piloted in Machakos, Siaya and Bungoma Counties, the approach showed excellent complementarity and better yield than sites without agroforestry trees (Ref?). The project also piloted development of a Rural Resource Centre (RRC) in Machakos that served two main purposes: (i) a hub 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 on agroforestry; and (ii) a collection point and marketing center for tree products, notably, quality seeds and seedlings, medicinal plant products and fruits among others (Yila, 2015)

Beyond the provision of livelihood and environmental services, farmers' interest in establishing trees for income generation was raised by the introduction of the fast-growing *Eucalyptus spp*. The species may be incompatible with crops, but farmers are attracted by the possibility of selling timber and poles within a short duration. Research efforts are therefore geared towards identifying *Eucalyptus* provenances that would be more ecologically benign as well as identify other multipurpose tree species that would help farmers produce more marketable products while boosting provision of ecosystem services. Bamboo is a great candidate for such trials aiming to promote its local use in households and small-scale enterprises (Gauli *et al.,* 2018; Kibwage *et al.,* 2013), while promotion of fodder shrubs has served the same objective as elucidated earlier (Wambugu *et al.,* 2011; Place *et al.,* 2009). The East Africa Dairy Development (EADD) Project is the latest fodder shrub scaling project in Kenya. The project was implemented between 2008-2013 in nine counties of rift valley and Central Kenya regions aiming to support dairy farmers with better livestock feeds and improved participation in a robust dairy value chain that benefits all industry stakeholders. The project promoted a variety of foliage species including Calliandra, Lablab, Lucerne, Desmodium, Sesbania, Mucuna and Leucaena (Sikumba, 2013; Wambugu *et al.,* 2014).

Increased awareness and interest in climate change towards the end of the 20th century saw broadened scope of agroforestry research and development activities to consider the role that agroforestry would play in adaptation and mitigation. As a result, several climate change mitigation and adaptation focused projects have been implemented in the country. Some of the most recent ones include the Western Kenya Ecosystem Management Project executed by KARI and ICRAF between 2006-2010 throughout the Nzoia, Yala and Nyando basins (Shames *et al.,* 2012), and the Agroforestry for Livelihood Enhancement (AGRILIVE) Project (2008-2011) by CARE Kenya and ICRAF in lower and mid-Nyando (Shames *et al.,* 2012; Shames & Onyango, 2012). In 2011 three projects were launched in western Kenya building on the above. CARE-Kenya and the CGIAR Climate Change, Agriculture and Food Security (CCAFS) programme initiated '*the CARE Sustaining Agriculture through Climate Change (SACC)* project' targeting 100,000 households to explore how carbon financing could enhance farm productivity and make farmers more resilient to climate change (ICRAF, 2012). Vi Agroforestry, introduced the Kenya Agriculture Carbon Project with the aim of restoring degraded agricultural land and increasing farmers' resilience to climate change. Besides increased food security for 30,000 participating farmers, the Vi Agroforestry project developed a method to estimate the potential for carbon storage especially in soils when farmers adopt Sustainable Agriculture Land Management (SALM) practices[4]. The third project, MICCA was launched by FAO aiming at building the capacity of smallholder dairy farmers on climate-smart agricultural practices and simultaneously increase farm productivity, household income and ecosystem resilience within dairy farming systems in Kenya (Osumba & Rioux, 2015).

Agroforestry has also been directly adopted in restoration of degraded gazetted forests through PELIS as stated in the introduction. This program is common in tropical forested areas in central Kenya, parts of rift valley and western Kenya. Through this program, Kenya Forest Service (KFS), in collaboration with other partners, builds the capacity of CFA members and farmers on tree nursery establishment, tree planting and management skills. The approach is thus improving the livelihoods of forest adjacent communities by providing more arable land and food (Odwori, 2017; Odwori *et al.,* 2013). Odwori *et al.,* (2013) concluded that PELIS contributed an annual total average of up to 3 million bags of potatoes from an average of up to 2000 hectares of arable land in the forest zones the study investigated.

Coffee and tea agroforests is another important practice in the country that has seen farmers integrate different tree species as shade trees in coffee farms and along the field boundaries of cash crop fields. A recent project, Coffee AgroForestry Network (CAFNET) project financed by the European Union between 2007-2010[5] aimed at creating a network of actors who wish to promote agroforestry-based shade coffee growing by strengthening and promoting environmental services and economic value of forest coffee in Central America, East Africa and India. In Kenya, CAFNET project was implemented around Aberdare ecosystem particularly, in Nyeri and Muranga Counties by ICRAF and CIRAD as the key implementers. One of the key lessons from the project was that farmers are interested in diversifying production from their coffee farms to include fruits, timber, firewood and other tree products as a response to fluctuating coffee prices (Lamond *et al.,* 2019).

Use of biomass energy in industrial agriculture has seen KTDA and other tea firms established and manage their own woodlots over decades to provide fuelwood for tea curing (Carsan & Holding, 2006). Similarly British American Tobacco (BAT) has invested heavily in tree planting to provide fuelwood for tobacco curing[6], mainly in Meru and Migori counties where eucalyptus woodlots have been promoted over years.

The story of BAT Kenya on tree planting with communities- *Since its establishment in 1978, BAT Kenya has integrated afforestation as one of the key components of their*

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[4] https://viagroforestry.org/projects/kacp/
[5] https://afrique-orientale-australe.cirad.fr/en/research-in-partnership/projects-completed-in-2010/cafnet
[6] http://www.batkenya.com/group/sites/BAT_B4ALXZ.nsf/vwPagesWebLive/DOB4AMC3?opendocument

environmental sustainability programme. For example, BAT Kenya have planted over 300,000 trees in Agongo hills, Migori and have identified 25 nature conservation sites for rehabilitation including eight dams, eight rivers and six hilltops in the county for rehabilitation through afforestation. They also collaborated with key stakeholders in the country to plant trees in local communities and have participated in various national / global initiatives such as the World Environment Day and the National Tree Planting day. BAT annual tree planting target is 1.5 million trees. Since establishment, BAT has planted over 50 million trees with farmers and various community stakeholders.

3.2 Current agroforestry initiatives in the country

Over time, the number of organizations involved in agroforestry work in Kenya has increased tremendously and agroforestry interventions are now being promoted across different agro-ecological zones in the country by various organizations. This section delves into projects and programmes that are ongoing regardless of the length of time it has been implemented by the specific organizations.

Green Belt Movement (GBM), whose program activities can be traced back to 1977, has an extensive tree planting programme that targets mainly areas around Kenya's major water towers such as Mt. Kenya, Aberdares Ranges, Mau Complex forests, Mt. Elgon and Cherangani Hills. The organization has trained and empowered thousands of women and youths through on-farm tree planting over decades. To date, about 5,000 tree nurseries have been established providing quality tree seedlings for income generation and own planting[7], especially in Mt. Kenya, Rift Valley and western Kenya regions while about about 51 million seedlings have been planted with farmers both within forests and on farmlands. The organization promotes on farm tree growing for the provision of fuelwood to rural households and as source of income besides tree nurseries, bamboo growing and bee keeping (GBM Annual Report 2013).

Two private sector organizations, **Better Globe Forestry (BGF) Ltd**[8] and **KOMAZA** are spearheading Initiatives for timber production through farm forestry in south eastern and coastal regions. Since 2004, **BGF** has been promoting woodlots of dryland timber with *Melia Volkensii* and *Melia azedarach* being their candidate tree species in eastern (especially Kitui county) and coastal Kenya. The organization promotes the two species both from livelihood and business model perspective and has since attracted many farmers into their program. Since 2015, BGF has introduced contract farming for M. volkensii as an agroforestry practice and farmers are provided with free seedlings, technical training, and a guaranteed market once the trees mature upon signing the contract[9]. The same year (2015), BGF initiated a 10-year Green Initiative Challenge (GIC) programme targeting 1000 schools in the Seven Forks area (Machakos, Embu, and Kitui counties) that has so far reached

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[7] Gregory, R. (2017). Kenya- The Green Belt Movement: Our Stories. *The Eco Tipping Points Projects.* Link: http://www.ecotippingpoints.org/our-stories/indepth/kenya-tree-planting.html

[8] The Information was retrieved from Better Globe forestry Ltd website. Link: http://www.betterglobeforestry.com/pages/about-us.html

[9] http://www.betterglobeforestry.com/pages/seven.html

500 and planted 150,000 seedlings of *Melia volkensii, Terminalia brownii* and *Mangifera indica* were planted with survival rates of 60-65%[10]. In Kilifi county, coastal region, **KOMAZA** is promoting *M. volkensii* and hybrid eucalyptus (*E. grandis x E. camaldulensis),* from South Africa to help farmers develop environmentally sustainable livelihoods and reforest degraded ecosystems[11]. The hybrid exhibits the fast-growth and straightness of *E. grandis* and the drought-resistant trait of *E. camaldulensis*[12]. Since the KOMAZA program started, 2 million trees have been planted with over 6,000 farmers reached[13].

Farm forestry, specifically defined as planting trees in farmlands away from gazetted government forests particularly for timber, poles and other essential wood products with a commercial objective, is now promoted by national producer organizations in Kenya [10]. They include Farm Forestry Smallholder Producers Association of Kenya (FF-SPAK) and Kenya Tree Growers Association (KETGA)[14]. FF SPAK is an umbrella that was registered in 2013 with a mission to strengthen the capacity of member organizations to improve farm forestry producers' livelihoods. Their work also involves lobbying and advocating for better policy environment and secure markets for member association's tree products.[15] (Chisika *et al.,* 2019). FFSPAK has received support from FAO Kenya which has resourced the organization's efforts to strengthen capacities of affiliate associations and to organize other farm forestry producers into more associations. FF-SPAK currently works in about 15 counties across the country. FFSPAK's work complements Kenya KFS's efforts in promoting farm forestry through its Forest Farm and Dryland Forestry Program. KFS has developed planting and management guides[16] for farmers to boost production of for timber, poles and fuel wood in the country.

Several other Non-governmental organizations (NGOs) especially World Vision Kenya, ADRA Kenya and CARITAS have strongly promoted agroforestry initiatives for landscape restoration in the country since the last decade. World Vision has promoted is Farmer Managed Natural Regeneration (FMNR)[17] as both a land use practice and land restoration approach aimed at bringing back trees on the landscape. FMNR is being promoted as a cost-effective approach to revegetating and reversing land degradation in the ASALs since it does not rely on tree planting. The projects in the country that promotes FMNR include East Africa FMNR Project (2013 – 2017), Food for Today and Tomorrow (FTT) Project, Dryland Development (DryDev) Program(2013-2019), Regreening Africa Project (2017-2022), Central Rift FMNR Scale Up (CRIFSUP) Project (2018-2021),

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[10] http://www.betterglobeforestry.com/pages/gic.html

[11] http://www.komaza.com/environment

[12] The Information was retrieved from KOMAZA

[13] http://www.komaza.com/company

[14] Kenya Forest Service. Forest Status Report; Kenya Forest Service: Nairobi, Kenya, 2018; Available online: www.kenyaforestservice.org (accessed on 23 April 2020).

[15] FFSPAK affiliate association members include Western Tree Planters Association (WTPA), Meru Farm Forestry Producers Association (MEFFPA), and Kisii Tree Planters Association (KTPA), South Coast Forest Owners Association (SCOFOA), Central Highlands Tree Growers Association (CHTGA), Community Food and Environment Group (COFEG), Nakuru Smallholder Timber Association (NASTA), and North Coast Farm Forestry Association (NCFFA)

[16] KFS (2009). A Guide to On-Farm Eucalyptus Growing in Kenya. Available online http://www.kenyaforestservice.org/documents/Eucalyptus%20guidelines%20%20Final%202.pdf (accessed on 23 April 2020)

[17] FMNR is the systematic regrowth and management of trees and shrubs from felled tree stumps, sprouting root systems or seeds, or in woody thickets. It can also be broadly defined as the practice of actively restoring, managing and protecting non-planted trees and shrubs in agricultural landscapes, communal lands and rangelands to combat poverty and hunger by increasing food, fodder and wood production as wells as resilience to climate extremes.

and Integrated Management of Natural Resources for Resilience in Arid and Semi-Arid Lands (IMARA) project (2018-2021). In most of these projects, enrichment planting with high value tree species particularly fruit trees which has quickly been embraced by farmers especially grafted mango, avocado and pawpaw.

International Tree Foundation (ITF) is working in the Mt. Kenya Region, specifically in Embu and Meru counties, to plant native trees on degraded forest sites and both native and on farms through agroforestry and PELIS[18]. Working with two local partner organisations which are also working with 34 women and self-help groups and in close cooperation with KFS, ITF has a target to plant 20 million trees in the country and has developed three pillars to anchor the tree planting target. These include: (i) forest restoration targeting to reforest 20,000 ha; (ii) agroforestry with a target of 50, 000 rural households planting trees in their farms; and, (iii) engaging the next generation "school children" through a campaign dubbed ' *My 20 Trees and Me – Growing up Together'.* ITF ITF is also collaborating with TreeSisters, which is currently building the capacity of women on tree growing, providing them with seedlings and helping them set tree nurseries as a livelihood source in the watershed of Mt. Kenya especially South-East Mt. Kenya, Northern slopes of Mt. Kenya and lower Imenti areas[19]. In addition, ITF tree planting campaign is also targeting the other four Kenya's major water towers as well as Kakamega Forest and their immediate surrounding communities.

[18] https://internationaltreefoundation.org/20milliontrees/

[19] Cayet-Boisrobert, L. and Kurzweg-Swaffield, W. (blog). How Women and Togetherness are Re-robing Mount Kenya in Green. Link: https://treesisters.org/blog/how-women-and-togetherness-are-re-robing-mount-kenya-in-green.

4. What has been successful and what has not - What are the constraints for adoption and scaling?

Table 1. What has work and constraints for agroforestry adoption and scaling

What has been successful?	Reasons for Success	Potential Constraints
Farm forestry particularly woodlots	- **Set it and forget it" investment:** After preparing land, planting seedlings, and occasional early weeding, trees continue to grow without needing further work, so farmers can invest time in other productive endeavours as their trees mature. - Fast growth and demand for timber and poles. -**Income diversification and opportunity to fight poverty**- Farmers see on-farm tree planting as an opportunity to diversify household income sources and thus serves as safety- nets and insurance scheme for smallholder farmers (Sikuku et al., 2014). - Secured land tenure in some areas (Appia & Pappinen, 2010) - **Available markets for forest products** (poles, timber, firewood, etc)- attributed to growth of urban areas, real estate development and fuelwood as a primary source of energy for larger population (Dewees, 1995). - **Technological advancement** in improving the quality of woodlot tree species like eucalyptus and **availability of variety of woodlot species and even hybrids**. Other fast-growing woodlot species, apart from eucalypts include *Acacia polyacantha, Acacia xanthophloea, Acacia mearnsii, Melia volkensii* among others. - Favourable policy environment that calls for community and private sector participation in forest management (Forest Act 2005) and advocating for at least 10% tree cover on farmlands (Constitution of Kenya 2010, Kenya's Vision 2030, Agricultural (Farm Forestry) Rules, 2009, Forest conservation and management Act 2016 etc.	-**Inadequate incentives to enhance production of wood and wood products** in the private sector e.g. policy and regulatory incentives (security of land and resource tenure), technical capacity (through training), fiscal and economic incentives (including tax breaks, concessional loans, etc.), and enhanced extension services (Mathu & Ngethe, 2011). - **Lack of quality germplasm -** the available planting materials cannot satisfy the growing market demand in sufficient quantity and quality -**Lack of appropriate inventory tools to assess volume of wood biomass on farmlands** - this has led to over-exploitation of tree resources from farmlands. -**Undervaluation:** Farm-based tree products are often undervalued to the extent that they do not capture their true worth among other competing farm products. - **Lack of market information** to guide farmer's decisions when planting trees. Failure to target any particular end-user at planting makes farmers price takers with low returns. - **Inadequate access to credit facilities** by farmers due to inadequate accounting of farm tree enterprises as commercial entities with long gestation periods and poor contracting. -High cost of tree establishment -Lack of knowledge of adapted tree species for specific regions especially ASALs (Tefera *et al.,* 2001). - Growing preference for alternative poles such as steel in the building and construction industry and concrete for

		conveyance poles attributed to high timber prices may ultimately reduce demand volumes. - Poor species-site and niche marching (Nyambati & Oballa, 2002)
Improved fallows in western Kenya (Short duration)	-Large farm sizes thus farmers could practice fallow system. -Short period for land recovery as opposed to natural fallow system -Declining soil fertility or poor soils and associated low crop yield coupled with high poverty index and expensive farm inputs (Pisanelli *et al.,* 2008; Place *et al.,* 2004). -Financially attractive to poor households with little cash available to buy inorganic input (Place *et al.,* 2004) - Low risk of failure in supplying nutrients to the farm (because of its extensive rooting systems), while offering by-products such as firewood depending on fallow species, density, fallow duration and size of the area planted (Jama *et al.,* 2008). -**Co-designing** of the practice together with farmers enhanced their receptiveness to it (Swinkels *et al.,* 2002).	- Sub-optimal or lack of extension services and poor coordination among NGOs promoting similar practice seems to have slowed down agroforestry scaling (Pisanelli *et al.,* 2008) - Land sizes have shrunk over time due to high population growth thus improved fallows are not feasible with small scale farmers who are currently the majority (Pisanelli *et al.,* 2008). - Soil fertility improvement alone is not incentivizing enough for adoption if the practice does not provide other tangible economic benefits (Kiptot, 2007). - Improved fallows are a complex technology with marginal superiority which is not good enough for scaling hence needs clarity in terms of how the basic mechanism works in local context for pioneer farmers to disseminate it to other farmers (Kiptot, 2007).
Homestead planting	-Provide shade in the compound -Windbreaker thus protecting houses from strong winds -Fast access to fruits and other tree products. - buying seedlings in small numbers every rainy season by poorly resourced farmers encourages consistent planting. -Land tenure right (static land ownership).	-Declining land sizes likely to reduce the space allocated to home compounds which then reduces tree planting space
Coffee and tea agroforests	- **Specific crops** such as Coffee, tea and bananas require partial shading for improved yield quality. - Common shade species such as *Grevillea robusta* (Wangui, 2012) provides households with valuable tree products such as fuelwood; mulch and serves as windbreak for the coffee crop. -**Good policy and market environment** for coffee and tea farming which are key agricultural exports for the country making farmers to continue maintaining the agroforests.	-Loss of coffee and tea farms to real estate development like in the case of Kiambu County. This is attributed to the failing coffee markets as opposed to return from real estate.

Fruit tree growing e.g. Mango and avocado, and Paw paw.	- Nutritional benefits for households - A thriving fruit growing systems **which is attributed to well-established fruits market within and outside** the country like in EU (Dannenberg & Nduru, 2012; Ajayi *et al.,* 2012). -Intensive research on fruit trees especially Mango has availed several suitable cultivars to farming communities in several agroecological zones (Njuguna et al., 2006). -Certified/registered fruit tree nurseries across the country-certified/quality cultivar (Griesbach, 2003).	- Flooded markets leading to post harvest losses besides demoralizing farmers (Röckle *et al.,* 2019)- capacity gaps on post-harvest management and value addition through processing. -Lack of incentives to farmers e.g. insurance, credit facility -Lack of cultivars suitable to some agroecological zones for fruits preferred in the markets -Weak extension system (Röckle *et al.,* 2019) -Institutional failures such as lack of policies to guide pricing, quality control, standardisation and certification for certain commodities especially macadamia nuts derails growth in the value chain (Murioga *et al.,* 2016).
Boundary planting/ windbreaks	- Does not interfere with cropping - Ability to provide valuable products to farmers such as firewood, poles, timber as well as mulch and windbreak - Inadequate land for practices such as woodlots leading to farmers' preference for boundary planting (Githiomi *et al.,* 2012). - Need for clear land demarcation and soil erosion prevention as promoted in early 1990s (Mandila *et al.,* 2015)	- Information gap on the right tree species for boundary planting- farmers. -Boundary conflicts and ecological trade-offs that spill over to neighbours
Fodder trees	-The huge demand among farmers for fodder shrubs, mainly because of saving on cash to purchase feeds, and savings on land and labour. - Paradigm shift from relying on commercial feeds to integrating affordable and nutrient-rich plant legume in dairy production system providing equal results. -Milk market is fairly developed to attract innovations and adoption of feed production system that is pocket friendly to rural smallholder dairy farmers (Dawson *et al.,* 2013). -Dissemination through farmer groups instead of individual farmers economises on scarce training skills and transport facilities. -The strong partnership between researchers, extensionists, and farmers in scaling projects has facilitates the flow of information across the innovation spectrum (Wambugu et al., 2001).	-Poor fodder tree seedling production and distribution system- this can be addressed by promoting functional and sustainable community-based seed production and distribution systems. - Attack of fodder trees by pests and diseases. Low variety of tested species and varieties presenting risk of failure should successful ones be decimated by pests and or pathogens - Lack of extension materials customized or written in simple language that farmers can read, understand and put to practice in their own context. - Poor extension services at county level due to poor funding. This will likely hamper scaling of fodder trees.

Rural Resource centre (RRC)	- Rural resource centres served as a one-stop-shop for agroforestry dissemination i.e. tree nursery, demos and community learning platform -It has mostly been supported by projects	-Management cost of the RRC is project dependent. -Not self-sustaining without support from the project or local government and so have often collapsed at the end of project cycle. There is need to contextualize the approach to meet specific demands of communities while identifying sustainability levers.
Adopting Consortium and Alliance as an agroforestry scaling model Successful Examples where this has worked or is working: DryDev Programme, COSOFAP, IMARA, Regreening Africa Project etc.	-Synergy of efforts among consortium partners working in projects minimizes duplication and fragmentation of efforts of the various organizations (Kindt *et al.,* 2005). Partnerships and close linkage with government departments has proved to be critically important for the success of projects. This include linkage between the country programme teams and the respective government departments and staff (DryDev Report 2019). - Setting up interactive learning sites where partners and farmers share their experiences, demonstrate ongoing activities and learning of farmers and extension agents takes place. - A joint funding for consortium projects supplemented by co-funding from member organizations enabled each partner in the consortium to undertake a specific deliverable. -Effective management of the project (in 23 districts in western Kenya) attributed to creation of 3 sub-regional coordinating committees-which reported to- an overall regional coordinating committee that is backstopped by a secretariat hosted by the World Agroforestry Centre (ICRAF). - Empowerment of farmers and consortium partners - Developing strong links with high-level decision makers in the government which then makes it easy to advocate for improved natural resource and agriculture policies (Ndufa *et al.,* 2005). - Partnerships with Micro-financial institutions (MFIs) has helped leverage the much-needed services that have strongly enhanced the beneficial effects of project interventions (DryDev Report 2019) -Contextualization of options to local contexts has proved important in increasing chances of success in very poor communities (DryDev Report 2019)	- Secretariat remained unfunded making knowledge sharing and exit strategy for the project poorly handled. - Staff turnover on critical positions and subsequent changes lowers the performance in the projects. This is both staff from the implementing organizations and key contact staffs from the government department/ministry closely involved in the project. This requires additional efforts and resource to induct the new staffs so that they can continue to support implementation of project activities and to ensure annual targets are reached (DryDev Report 2019). NB- It will also be important to study and understand other partnership arrangements such as Alliances particularly on the successes, challenges or opportunities that they pose to agroforestry scaling in the country.

	Communication: - Effective communication methods employed by country teams has helped to raise the visibility of the programme and increase the demands for programme support (DryDev Report 2019). - Use of modern tele-conference facilities (such as Skype) and social media platforms (such as Whatsapp) has greatly enhanced the linkage and closeness of the programme staff in the consortium. Meetings, sharing experiences and ideas has been made easier saving long-hour of traveling and costs to meetings.	
Agroforestry Dissemination through community groups approach	- Use of existing community organizational structures to disseminate agroforestry technologies accelerates and enhances impacts. The groups include a mix of community sub-groups — men and women of all ages, ethnicity, and degrees of wealth who have different needs, constraints and opportunities. - Capacity development on leadership and technical approaches to improve organizational performance e.g. technical aspects of agroforestry, group dynamics and team building, cooperation and trust among members, record keeping, leadership skills, M&E of projects and proposal writings. - **Encouraging all community involvement and ownership of the project**- this has built a strong sense of ownership in projects and has enhanced full participation of all community members and groups across all levels of the project implementation.	- Group formed with anticipation of political gains are most likely to fail. - Lack of adequate funds for groups to conduct their activities likely to lead a state of inactivity in the group. Nevertheless, integrating rural financing innovations such as VSLA to groups and building their capacity to participate lucratively in value chains contextually tailored to fit the opportunities and constraints of particular places and target groups could reverse this (Devaux *et al.,* 2018) - Attitude of hanging on leadership even when the term of office has ended is likely to kill such committees.

5. Evidenced agroforestry practice by each region and context of practice – what is the status of practice

This section focuses on various agroforestry practices that are evident in various regions[20] of the country and the context in which they have been practiced. This section also underscores the close link that exists between agroforestry practices adopted in various regions of Kenya and thus it is difficult to find a region-specific practice. This section therefore reviewed agroforestry practices in the country under three categories i.e. Humid highlands, (ii) humid lowlands and (iii) ASALs of Kenya. In all the regions where agroforestry practices are evidenced, their uptake by farmers have been linked to:

1. The **profitability** of the agroforestry practice. This includes factors such as high profitability of the tree crop enterprise, high base crop or livestock production volumes (translating to marketable surplus), and high opportunity cost of labor (Franzel *et al.,* 2001).
2. The **acceptability** of the agroforestry practice by farmers. This includes factors such as perception on integrating trees in farmlands for any particular objective, economic importance of annual cropping, wealth level, gender and access to on- or off-farm income (Franzel *et al.,* 2001).
3. The **feasibility** of the agroforestry practice. This includes factors such as labor constraints, institutional support and farmers experience with tree nurseries (Franzel *et al.,* 2001).

5.1. Humid highlands

The region covers areas with minimum altitude of 1980 m above sea level and minimum annual rainfall of 1000mm. This includes all humid agroclimatic zones I to II (Appendix I) in Mt Kenya region, Rift valley region and western Kenya. For example, Nyandarua, Kiambu, Muranga, Kirinyaga, parts of Nyeri, parts of Embu, Meru, Kericho, Uasin Gishu, Nandi Hills, Mau catchments, Bungoma and immediate surroundings of Mt. Elgon, Kakamega forest catchments, Trans-Nzoia, Kisii highlands among others. Diverse agroforestry practices have been adopted in the region and have been an important source of livelihoods for many households. Some of these are as shown in Table 2:

Table 2. Evidenced agroforestry practices in the humid highlands zones

Agroforestry practices in the area	Dominant tree species	Main uses	Source literature
Boundary planting	Fodder shrubs e.g. *Trema orientalis, Morus alba, Calliandra calothyrsus, Leucaena spp.* etc. Exotic timber species: *Grevillea robusta, Eucalyptus spp*, Indigenous species: *Acacia abyssinica, Olea europaea, Ficus*	Farm boundary demarcation, livestock feeds, Timber, poles, fuelwood, generating income etc.	Roothaert *et al.,* (2003) Franzel *et al.,* (2003a) Carsan & Holding, (2006). Place *et al.,* (2009) Oeba *et al.,* (2012) Nyaga *et al.,* (2015) Dawson *et al.,* (2014)

[20] Regions in the context of this review clusters counties that share similar agro-ecological range and other geographical attributes mainly humid highlands, humid lowlands and ASALs

	thonningii, Brachylaena hutchinsii, Allophylus abyssinicus, Vitex keniensis and Prunus africana		Rotich & Chepkemboi, 2017 Wawira & Thenya, (2017) Chisika *et al.,* (2019)
Homestead planting	Fruit trees esp. *Persea americana, Syzygium cuminii, Mangifera indica, Citrus sinensis, Psidium guajava* etc. Timber and fuelwood species e.g. *G. robusta, Eucalyptus spp, Cupressus lusitanica* and indigenous trees such as A*cacia abyssinica, Olea europaena, Ficus thonningii, Brachylaena hutchinsii, Allophylus abyssinicus, Vitex keniensis and Prunus africana* Herbal trees e.g. *Moringa oleifera,* Neem tree, *Prunus africana, Waburgia ugandensis* etc.	Fruits, medicinal value, timber and fuelwood.	Muriuki, (2011) Wawira, (2016) Githiomi *et al.,* (2012) Rotich *et al.,* (2017) Wawira & Thenya, (2017) Nyaga *et al.,* (2015)
Coffee and tea agroforests	*G. robusta, Croton spp, Cordia abyssinica* and indigenous tree species	Shade trees for coffee and tea Fuelwood	Tengnas, (1994) Carsan & Holding, (2006) Elliot, (2009) Githiomi *et al.,* (2012) Imo *et al.,* (2012) Lamond *et al.,* (2019) Carsan *et al.,* (2013)
Alley cropping/Strip planting along contours,	*Calliandra calothyrsus, Leucaena spp, Leucaena spp, Mimoca scabrella etc.*	Soil protection and improvement, livestock feed, timber, fuelwood.	Angima *et al.,* (2002) Rotich & Chepkemboi, (2017) Mutegi *et al.,* (2008) Franzel *et al.,* (2003b)
Woodlots	*Eucalyptus spp., Grevillea robusta, Podocarpus spp., Cupressus lusitanica, Acacia mearnsii etc.*	Timber, poles (both electricity transmission and construction poles), charcoal, fuelwood etc.	Carsan & Holding, (2006) Githiomi *et al.,* (2012) Nyaga *et al.,* (2015) Rotich & Chepkemboi, (2017) Chisika *et al.,* (2019) Kenya Forest Service
Scattered trees in croplands	Mainly fruit trees such as *Mangifera indica, Persea americana* and indigenous tree species such as *Markhamia lutea, Sesbania sesban, Croton macrostachyus, Albizia coriaria, Acacia abyssinica, Olea europaena, Ficus thonningii, Brachylaena hutchinsii, Allophylus abyssinicus, Vitex keniensis and Prunus africana* among others.	Household nutrition, income generation, construction materials, shade soil fertility improvement etc.	Dannenberg & Nduru, (2012) Mbaka *et al.,* (2010) Nyaga *et al.,* (2015) Wawira & Thenya, (2017) Röckle *et al.,* (2019) Murioga *et al.,* (2016)

Live fences (BVAT, 2006)	*Cupressus lusitanica, Calliandra calothyrsus, Leucaena spp, Dovyalis caffra*	Homestead/farm protection, fodder for livestock, fuelwood	Githiomi *et al.,* (2012)
Trees in Pasturelands	*Cordia abyssinica, Prunus africana Erythrina tomentosa, Leucaena spp, Calliandra calothyrsus, Sesbania sesban, etc.*	Fodder, medicinal value, fuelwood	Imo *et al.,* (2012)
Riverbank/lakeshore/terrace stabilization	Mostly indigenous species such as *Acacia abyssinica, Olea europaena, Ficus thonningii, Brachylaena hutchinsii, Allophylus abyssinicus, Vitex keniensis and Prunus africana* and fruit tree species	Land/riverbank protection and conservation, food (fruits)	Masibo *et al.,* (2018 Wawira & Thenya, (2017)

Context of agroforestry practice in the humid highlands

Agroforestry practices in the humid highlands have been practiced in the following context:

1. **Thriving dairy sector and expensive livestock feeds** particularly dairy meals push dairy farmers with limited resource endowment to adopt low-cost agroforestry innovations and technologies that boost milk production such as fodder shrubs. Several projects targeting the dairy value chain development and/or promotion of fodder shrubs have also been implemented in the area.
2. **Farming systems** that have coffee and tea as the main cash crop and income earner for households. The two cash crops, coffee especially, perform well under partial shading allowing integration of shade trees such as *Grevillea robusta* and other indigenous tree species within the farming system. Some projects have also been implemented to improve productivity of the farming system.
3. **Deforestation** mainly driven by demand for fuelwood and construction materials as well as alternative sources of livelihood as population in the region increases. The depressed ecosystem functionality and concerns about climate change attracts many projects by government, NGOs, governmental organizations and even the communities geared towards restoration and thus intensified tree planting campaigns.
4. **Small land sizes and good tree planting culture.** the region has the highest population density in the country with majority of the counties having over 350 persons per Km^2 (KNBS, 2019). The average land size in the area is 1.2 ha but with high potential for agriculture making farmers invest in high value marketable crops. Some of these crops are not shade-tolerant thereby limiting tree planting to farm boundary and at low density (in case of big canopy trees like *Grevillea robusta*). The area around Mt. Kenya has a very positive culture of tree planting and tends to deviate from only boundary planting to a high tree cover on farms including in croplands.
5. **High rates of urbanization** causing land use change from agriculture to real estate**.** Kiambu county is one of the best examples where massive conversion of coffee farms into real estate development has been witnessed. This conversation may pose as a barrier to scaling

and make agroforestry unattractive as poor landowners are bought off from peri-urban fringes unless value chain innovations create a niche for urban and peri-urban agroforestry.

5.2 Humid lowland zones

The zone covers areas with an altitude ranging 900-1800m above sea level and annual rainfall ranging 950-1500 mm. These areas include most parts of western Kenya, part of rift valley (parts of Bomet, Nandi and Elgeyo Marakwet) and parts of coastal region such as Migori, Homa Bay, Kisumu, Siaya, Vihiga, Busia, parts of Kakamega, parts of Bomet, Nakuru among others. The target zones fall under agroclimatic zone III-IV (Appendix I) and boast of diverse agroforestry practices which have been also source of livelihoods for many households in the region. Literature review of agroforestry practices in the region identifies the following agroforestry practices (table 3):

Table 3. Evidenced agroforestry practices in humid lowlands

Evidenced agroforestry practices in the area	Preferred tree species	Main uses	Literature reviewed
Farm forestry (particularly woodlots).	*Eucalyptus spp, Grevillea robusta, Casuarina lusitanica*	Timber, poles, fuelwood	Sikuku *et al.,* (2014) Odhiambo, (2010) Appiah & Pappinen, (2010) Nyambati & Oballa, (2002) Imo *et al.,* (2012) Reppin *et al.,* (2020)
Boundary planting	*Eucalyptus Spp, Grevillea robusta, Casuarina lusitanica*	Farm boundary demarcation, timber, poles, and fuelwood, aesthetics, shade	Mugure & Oino, (2013) Odhiambo, (2010) Imo *et al.,* (2012) Henry *et al.,* (2009) Wanjira, (2019) Reppin *et al.,* (2020)
Scattered trees in croplands	*Markhamia lutea, Grevillea robusta, Mangifera indica, Psidium guajava, Persea americana, Syzygium cuminii* and other indigenous species	Shade, timber/poles, fuelwood, fruits/nutritional diversity, soil fertility	Henry *et al.,* (2009) Kindt *et al.,* (2006) Imo *et al.,* (2012) Reppin *et al.,* (2020) Wanjira, (2019)
Improved fallows	*Tephrosia vogelii, T. candida, Crotolaria grahamiana, Sesbania sesban and Crotolaria paulina* etc.	Soil fertility improvement	Kiptot *et al.,* (2007) Amadalo & Jama, (2003) Pisanelli *et al.,* (2008) Jama *et al.,* (2008) Kiptot, (2007) Kiwia *et al.,* (2009) Swinkels *et al.,* (2002)
Fruit orchards	*Mangifera indica, Citrus sinensis, Citrus lemona, Persea americana, Syzygium cuminii,* Macadamia nuts etc.	Nutritional diversity, income generation	Odhiambo (2010) Mugure & Oino, (2013) Ekesa *et al.,* (2009) George *et al.,* (2018) Mbaka *et al.,* (2010)

Alley cropping/Hedge row intercropping,	*Calliandra calothyrsus, Gliricidia sepium, Leucaena spp, Tithonia diversifolia, Acanthus pubescens*	Soil protection and improvement, livestock feeds,	Odhiambo (2010) Mugure & Oino, (2013) Imo & Tammer, (2000) Radersma *et al.,* (2004) Kinama *et al.,* (2007) Henry *et al.,* (2009)
Homestead planting	Fruit trees such as *M. indica, Citrus lemona, C. sinensis*, *Psidium guajava, Syzygium cuminii* etc. Timber trees e.g. *G. robusta, Eucalyptus spp, Podocarpus spp*, *Casuarina equisetifolia* etc. Shade/ornamental trees e.g. *Croton Megalocarpus, Spathodea campanulata*, bottle brush etc.	Fruit, timber and fuelwood provision, shade, aesthetics etc.	Imo & Tammer, (2000) Scher, (1997) Henry *et al.,* (2009) Reppin *et al.,* (2020)
Riverbank/lakeshore /terrace stabilization	Mostly indigenous and fruit tree species	Land/riverbank protection and conservation, Livestock fodder, Fuelwood provision, Food (fruit)	Mugure & Oino, (2013) Wanjira, (2019)
Live fences	*C. lusitanica, Thevetia peruviana, etc.*	Farm/homestead fencing	Mugure & Oino, (2013) Odhiambo, (2010)

The context of agroforestry practice in the humid lowlands

Agroforestry practices in the humid lowlands have been practiced in the following context:

1. **Declining soil fertility** in areas such as western Kenya. Agroforestry technologies promoted in the area from early 1990s through to 2000s such as short-rotation improved fallows targeted to reverse declining soil fertility and increase crop yields. Nevertheless, the uptake of agroforestry for soil fertility improvement has elusive and soil fertility problems still persist (Kiptot, 2007; Place *et al.,* 2009). The business case for agroforestry technologies that can integrate perfectly well in the crop farming system and bolster soil fertility still needs to be elucidated.
2. **Shortage of fuelwood and construction materials**. The high demand of wood in the construction industry and the continued use of fuelwood as the primary energy source for almost 90% of the rural households (MENR, 2016) is a major driver for agroforestry uptake. Fuelwood is a major cause of natural resource degradation (MENR, 2016) making on-farm tree planting necessary have an additional benefit of land restoration and mitigating against climate change (Mbow *et al.,* 2014; Jerneck & Olsson, 2013; Dawson *et al.,* 2013).

3. **Shrinking land sizes and shortage of livestock forage.** The average land holding in these areas stands at 2.5 acres (Holden *et al.,* 2010) with most of it under crop cultivation which leaves little or no plot for livestock grazing. Stall feeding of livestock is gaining prominence with main basal feeds coming from crop residues, natural grass and napier grass. Fodder shrubs such as calliandra can be planted the farm boundary, as live fence, soil conservation structures or as hedgerow to boost productivity.

5.3 Arid and semi-arid lands (ASALs) of Kenya

The arid and semi-arid areas (ASALs) cover the largest part (about 80%), of the total land mass in the country, mainly lower eastern counties (Kitui, Makueni and parts of Machakos), north Eastern Counties (Isiolo, Marsabit, Mandera, Wajir and Garissa), part of north (Turkana, Elgeyo Marakwet, Samburu, Laikipia), Central rift (Baringo County, parts of Nakuru County such as Naivasha, Gilgil, Rongai and Bahati sub-counties) and south rift (Narok and Kajiado) counties, coastal region (Kilifi, Tana River, Lamu, Kwale and Mombasa) and pockets of areas in Western Kenya region. These areas fall under agroecological zones IV-VII, receiving annual rainfall of 150-600mm and often experience long period of droughts and hunger. The main livelihood activities include livestock keeping with intermittent rainfall favouring crop cultivation. The common agroforestry practices are shown in Table 4.

Table 4. Evidenced agroforestry practices in the ASALs

Evidenced agroforestry practices in the area	Most preferred tree species	Main uses	Literature reviewed
Boundary Planting/Live fence	*Euphorbia tirucalli, Cassia siamea, Melia volkensii, leucaena spp, Croton megalocarpus, Cupressus lusitanica and Grevillea robusta*	Farm boundary demarcation, soil erosion control, protection from intrusion into farms and homes, wind breaks, fuelwood, construction poles and timber, aesthetic values etc.	Kariuki *et al.,* (2012) Mandila *et al.,* (2015)
Fruit orchards	Exotic fruit trees e.g. *M. indica, Carica papaya,* etc. Indigenous fruit trees *e.g. Tamarindus indica, S. cuminii, Lannea stuhlmanni, Sclerocarya birrea, Adansonia digitata* etc.	Household nutrition, income generation	Tomasini, (2012) Muok *et al.,* (2000) Kehlenbeck *et al.,* (2013) Mbaka *et al.,* (2010)
Farm Forestry (specifically woodlots)	*Melia volkensii, Eucalyptus camaldulensis, Azadirachta*	Timber, construction poles and posts	Komaza, Better Globe Forestry website

	indica, Senna siamea, Acacia species	fuelwood, medicinal value, gum and resins	KFS KEFRI Mandila *et al.,* (2015)
Homestead planting	*Cassia siamea, Melia Volkensii, Melia Azedarach, Acacia spp, Balanites aegyptiaca, Mangifera indica etc.*	Shade, windbreak, fruits for household nutrition	Muluki *et al.,* (2016)
Scattered trees in croplands	*Grevillea robusta and Terminalia brownie.*	preventing soil erosions, providing shade to crops, animals and herders during hot seasons	Mandila *et al.,* (2015)
Home-garden	*Croton megalocarpus, Mangifera indica* (grafted), *Passiflora edulis*	Fuelwood, fruits	Mandila *et al.,* (2015)
Alley cropping/Hedgerow cropping	*Leucaena spp, Acacia saligna, Calliandra calothyrsus, Sesbania sesban, Passiflora edulis*	Soil improvement, soil structure protection and stabilization, livestock fodder, fuelwood, food (fruit)	Lehman *et al.,* (1999) Droppelmann *et al.,* (2000) Henry *et al.,* (2009) Kariuki, (2012) Mandila *et al.,* (2015)
Fodder banks	*Sesbania sesban, Croton megalocarpus* and *Dombeya cosanii* planted in Napier grass farm	provide fodder during dry seasons, improve land productivity	Mandila *et al.,* (2015
Farmer Managed Natural Regeneration (FMNR)	*Acacia spp, B. aegyptiaca* among other indigenous tree species	fuelwood, pasture for livestock, construction materials, trees of medicinal value, restoration of degraded land	Barrow & Mlenge, (2004) DryDev Project Report[21] FMNR hub[22] IMARA Project report CRIFSUP Project Report Regreening Africa Project Report (Kenya)
Parkland agroforestry systems (Trees scattered in ASAL rangelands inclusive of other approaches such as enclosures)	Native grass regenerated alongside *Acacia tortilis, Acacia reficiens, Acacia senegal, Acacia nubica, Salvadora persica* and *Zizyphus mauritiana, Fruit trees, Melia volkensii*	Livestock forage (fodder and pasture), Rehabilitation of degraded rangeland, food (fruit) fo pastoralists households	Verdoodt *et al.,* (2011) Kigomo & Muturi , (2013) Mureithi *et al.,* (2014) Wariore *et al.,* (2015)

Context of agroforestry practice in the ASALs

Agroforestry practices in the humid lowlands have been practiced in the following context:

[21] https://drydev.org/where-we-work/kenya/
[22] https://fmnrhub.com.au/projects/fmnr-east-africa-kenya/#.XmkQZ0pRVPY

1. **Livelihood and Resilience strategies.** ASALs are basically harsh for any meaningful rainfed agriculture implying intensified competition for agricultural water. For efficiency, tree planting targets high value tree species such as timber and fruit trees whose products can be sold for family income generation may. The trees may not establish well under low moisture level but are watered since their establishment improves the resilience of farmers against climatic challenges.
2. **Land degradation and loss of pasture** associated with livestock husbandry with overstocking**.** Livestock offers the most promising enterprise but pasture degeneration leads to conflicts among communities and human-wildlife conflicts in areas with wildlife protection. Sustainable rangeland management approaches such as FMNR and sustainable grazing management have shown potential to foster regeneration land restoration (Cheche *et al.,* 2015). Agroforestry scaling should be encompassed within sustainable rangeland management and grassroots institutional innovations for purposes of peace building and conflict reduction.
3. **Largescale farming with mechanization -** The land size in semi-arid areas is still very extensive and affords large scale farming such as of wheat farmers such as in Narok County. In such farming system, agroforestry is seen to be in conflict with mechanization and thus presenting an uptake barrier (Mandila et al., 2015). Agroforestry initiatives should target right tree species selection and proper design of tree-crop configuration to fit the context.

6. National and International targets addressed by Agroforestry

This section looks at policy, legislation and international commitments that agroforestry practice has shown potential to contribute to. A few targets have been presented in the table below with an in-depth analysis of policy can be found in the *Kenya Agroforestry policy review* by World Agroforestry (Mumina & Bourne, 2020) and *Analysis of Policy on Agroforestry in Kenya* by Vi Agroforestry (Katothya, 2020).

Table 5. National and international targets addressed by agroforestry scaling

National and international targets.	Description
Kenya Constitution 2010	Requires that at least 10% tree cover to be achieved and maintained on all the land area of Kenya.
Agriculture Act 2012	Requires that agricultural landowners and occupiers to establish and maintain a minimum of 10% tree cover. Identifies agroforestry as one of the agricultural activities it regulates.
Environmental Management and Coordination Act No. 8 of 1999 (Revised Ed. 2018)	Encourages planting of trees and woodlots by individual land users, institutions and community groups. It sets a target of 10% land holdings under trees, citing Farm Forestry Rules of 2009.
County Government Act, 2012	Emphasizes on maintaining a viable system of green and open spaces for a functioning eco-system and work towards the achievement and maintenance of a tree cover of at least 10% of the land area of Kenya

Sessional Paper No. 3 of 2016 on National Climate Change Framework Policy	Focuses on appropriate mechanisms to enhance climate resilience and adaptive capacity, and the transition to low carbon growth
The 2030 Agenda for Sustainable Development Goals (SDGs)	SDGs related to landscape restoration initiatives include: - SDG 1. End poverty in all its forms everywhere (Target 1.5) - SDG 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture (Targets 2.1, 2.2, 2.3 and 2.4) - SDG 6. Ensure availability and sustainable management of water and sanitation for all (Target 6.6) - SDG 12. Ensure sustainable consumption and production patterns (Target 12.2) - SDG 13. Take urgent action to combat climate change and its impacts (Target 13.1) SDG 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (Target 15.1, 15.2, 15.3, 15.5, 15.6)
Africa Landscape Restoration Initiative (AFR100)	Africa has committed under Bonn Challenge to restore 100 million hectares by 2030. Kenya has under AFR100 has committed to restore 5.1 million ha by 2030.
The UN Convention on Biological Diversity (CBD)	- Advocates and champions for conservation and maintenance of genes, species and ecosystems, with a view of sustainable management and use of biological resources for the benefit of humanity. - Commits to 20 Aichi targets by 2020[23] of which FMNR can give significant contribution to Targets 1, 4, 5, 7, 14 and 150

7. Incentives and opportunities for agroforestry development in Kenya.

7.1. Incentives for Agroforestry Development in Kenya

Research and Extension -For close to four decades a lot of investment has been put on agroforestry research especially in humid areas of Kenya. These include research on ecosystem goods and services associated with agroforestry such as soil fertility, nitrogen fixation and carbon storage, payment for ecosystem services (PES) (Nzyoka, 2012), water and soil conservation aspects; tree-crop interaction and planting configuration; social-economic aspects; gender and social inclusion; policy environment. The research in agroforestry is bolstered by the country's rich capacity in agroforestry through her several research institutions with a pool of professional that can help promote and test agroforestry technologies in the country's difference contexts and regions. These include KEFRI, KALRO, ICRAF, Vi Agroforestry, KFS and Kenya Universities. Institutionalizing a central coordination organ within the national government Ministry of Agriculture, Livestock, Fisheries and Co-operative and cascading the same to county level for purposes of cross-learning

[23] https://www.cbd.int/sp/targets/

and synergy among different stakeholders; and investing in strengthening of agroforestry extension right to the county level can immensely contribute to its scaling in the country.

Education and training -From early 1980s through to late 1990s, agroforestry could only be found immersed in other education programmes such as forestry, environmental studies, natural resources, agriculture and other related disciplines. This limited deeper research, knowledge and training in agroforestry. Nevertheless, greater milestone has been made in the last three decades that saw agroforestry curriculum developed (Kilewe et al., 1989), through the initiatives of African Network for AgroForestry Education (ANAFE) in collaboration with education stakeholders in the country. Today, several universities in the country are offering a degree course in Agroforestry thereby continues to produce more professionals that are able to steer agroforestry at various scales including through private sectors. Some of these University include University of Eldoret, Kenyatta University, University of Kabianga, Maasai Mara University, University of Embu, South Eastern Kenya University among others. The national government Ministry of Agriculture, Livestock, Fisheries and Co-operative can build synergy with the mentioned universities to research on a context- fit agroforestry innovations and a gender-sensitive extension model that fits the regional context where the universities are located.

Certification of tree nurseries - KEPHIS working closely with KALRO and KEFRI is undertaking certification of tree nurseries in the country. This is done to ensure that nursery practitioners adhere to standards for production of high-quality germplasm. Majority of the certified tree nurseries raise grafted fruit seedlings such as mango, avocado, passion, citrus among others. About 100 tree nurseries have been certified by KEPHIS across the country[24]. This is a great incentive towards ensuring that only highly quality tree germplasm is available for planting. The national government MoALFC and Ministry of Environment and Forestry (MoEF) in collaboration with KEPHIS, KFS and KEFRI should intensify efforts to develop a database of all tree nurseries across the country and develop the capacity of nursery operators on good tree nursery practices before certification. Where certification costs are prohibitive quality-declared guidelines for tree seedling production can be developed jointly by MoALFC and MoEF and extended to operators through advisory services at both ministries.

Existence of adequate institutional framework for scaling up agroforestry - Several policies, legislation and international agreements put a lot of emphasis on environment and climate change wherein agroforestry is anticipated to play an important role (see Table 5). A specific instrument to mainstream agroforestry investment in the government investment framework however misses, thereby denying the country the chance to massively derive the benefits elucidated in this paper.

Formation of agroforestry related associations - These act as the farmers' voice and support agroforestry extension, value chain development and agroforestry financing. These include: Farm

[24] https://www.farmlinkkenya.com/list-of-kephis-certfied-nurseries/

Forestry Smallholder Producers Association of Kenya (FF-SPAK), Agroforestry Association of Kenya, Avocado Smallholders Associations, grape growers' association of Kenya among others.

Climate finance - For developing countries, such as Kenya, where impacts of climate change are severe, climate finance remains critical to catalyse actions towards mitigation and adaptation. Farmers can be incentivized to increase and maintain sufficient tree cover on their farms through agroforestry practices listed above. Effective financial and technical support is required to realize greater success as many poor farmers will be motivated to invest in tree establishment due to financial benefits attached to the practice. Some of these funds include Green Climate Fund (GCF), Carbon Credit schemes, climate adaptation funds, green bonds and climate change trust funds at national and subnational level (Odhengo *et al.,* 2019) among others. Such incentives contribute to economic well-being of poor households whose source of livelihood could otherwise be affected by climate change effects.

7.2 Disincentives to Agroforestry Development

Institutional coordination for scaling up agroforestry technologies - Though adequate institutional mechanisms to promote agroforestry exist, there is low coordination among the various actors and stakeholders that promote agroforestry in Kenya. This has seen agroforestry activities being carried in isolation by actors and institutions sometimes in the same geographical area. The findings from agroforestry research end up not benefiting the community after the project comes to an end especially where there is inadequate involvement of community groups that may be very active at grassroots level. Most importantly, agroforestry has been perceived to lie within the MoEF due to the ministry's rich forestry repository but farmlands where agroforestry is practiced are the domain of the MoALFC. A joint coordinating mechanism between the two ministries is needed to steer agroforestry programme implementation in the country. The same should be anchored in the national agroforestry strategy and cascaded to county level.

Marketing constraints - Marketing agroforestry products such as timber, fruits, fodder and others are different from marketing agricultural commodities because of their diverse nature. Most often agricultural products are subject to government rules and regulations and even drastic measures to salvage farmers from unexpected low market environment that lead to losses. For instance, bail outs and/or price stabilization interventions for products usually done by the government on milk, tea, coffee, rice to name a few, which has influenced market conduct, performance and even structure. On the contrary, agroforestry products such as fruits, timber, poles and charcoal that sometimes suffer imperfect and inefficient marketing systems have attracted little or hardly government supports to say the least. For example, introduction of concrete transmission poles, led to massive losses on investment to farmers who established woodlots to supply transmission poles (Rotich & Chepkemboi, 2017; Ojanji, 2016). This has reduced farmers' profit margin, thereby influencing their land use decisions on adoption of a particular agroforestry practice.

Research bias - Most agroforestry research in Kenya seems inclined more towards biophysical with less investment in important aspects such as agroforestry product market development, innovative finance for agroforestry enterprises and clear analysis of the economic and social feasibility of agroforestry systems. There is a gap on best-fit agroforestry technologies for the rangelands.

Policy issues and gaps - Analysis of policies and legislations showed that the policy environment in Kenya is encouraging for agroforestry scaling. Similarly, the international agreements that Kenya has ratified such as SDGs, NDC, AFR100 among others in which agroforestry can play a central role. Nevertheless, lack of a specific policy, strategy and implementation framework or action plan for agroforestry implementation and development has been the missing link to successful agroforestry scaling and value chain development.

Short-project life cycle - Most agroforestry interventions in the country had short life cycle with no provision for long-term operations and maintenance thus making them 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 (Yila, 2015).

7.3 Opportunities for agroforestry Development in Kenya

Enabling policy environment - The analysis of existing policies, legislations, Kenya's Vision 2030, International commitments and agreements ratified by the country all shows that agroforestry can play a central role. There are also more opportunities at county level due to the fact that forestry and agriculture is a devolved function of the county government according to the 2010 Constitution of Kenya (MEF,2019).

Institutional Frameworks - The ministry of Environment and Forestry has been developing several strategies such as the one to attain 10% tree cover on all Kenya dry land masses. The strategy also emphasizes on production of high-quality tree seedlings, improved seed production, rehabilitation of degraded lands, implementing the Agriculture (Farm Forestry) Rules 2009, greening schools and other institutions of learning among others (MEF, 2019). The National Agroforestry Strategy for Kenya should focus on building context specific and actionable strategies for agricultural lands across all the seven Kenya's agro-climatic zones (Annex I).

Value chain development - Agroforestry contributes to a wide range of value chains that can fit every context of our seven agro-climatic zones though still underdeveloped. Developing tree-based value chains is a good entry point for fast adoption and scaling of agroforestry technologies in the country. The potential products for development include timber, poles, word carvings, fruits, fodder, medicinal, honey production, gums, resins, fibre among others. Developing vibrant value chains around these products will go along-way in sustaining agroforestry practices while addressing economic needs of poor farmers. The ministry of agriculture has shown a keen interest in developing fruit value chains. Similarly, the farmers' associations mentioned above (6.1.5) among others have been working to develop their respective value chains. Synergy among different actors will accelerate adoption and scaling of agroforestry technologies.

Land Restoration programmes and projects in the country - Agroforestry scaling can take advantage of the landscape restoration programs in the country. According to the MoEF ROAM taskforce report, AFR100 has recognized the of agroforestry has potential to restore degraded croplands with a target of 1.9 out of the 5.1 million ha of land committed by Kenya under the AFR100 initiative (Figure 1). Trees are a key entry point in the other restoration approaches as well. The preparation of the AFR100 implementation framework is underway, with MoALFC and MoEF as key players, providing an opportunity for agroforestry promotion to stand out. Partners are also implementing several land restoration projects which develop several approaches for scaling out and can be adopted. Such projects include Regreening Africa - Kenya and sister projects implemented by World Vision Kenya where FMNR is being promoted as a key restoration approach, Green Belt Movement tree planting programs across the country, and Kenya Climate Smart Agriculture Project (KCSAP) being implemented by the MoALFC, among others.

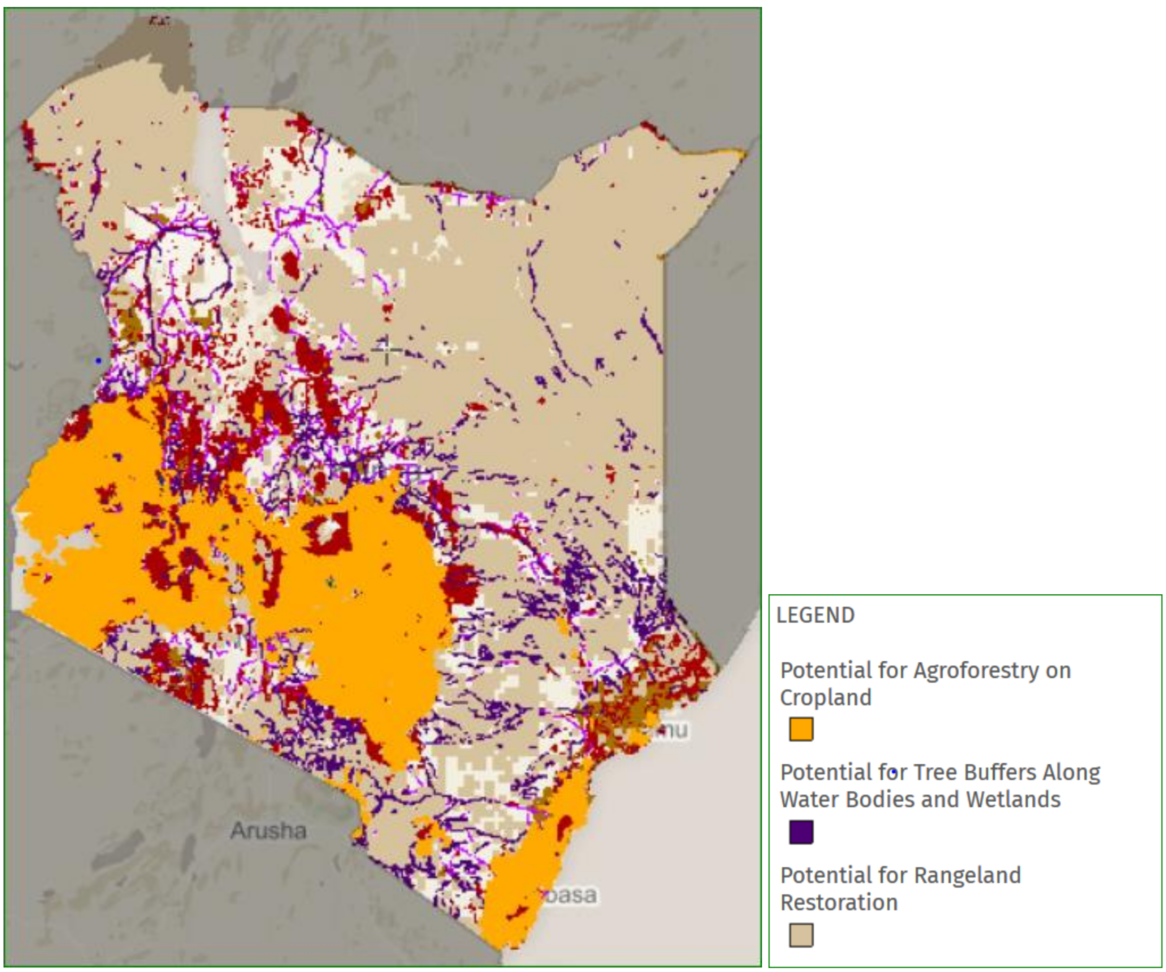

Figure 1: Tree-based Landscape Restoration Potential Options in Kenya
***Source: Kenya Forest Service (KFS)*[25]**

[25] http://ken.restoration-atlas.org/map/

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Annex 1. A brief description of the agro-climatic zones (ACZ) of Kenya[26]

ACZ	Zone description related to agricultural production	Geographical Area
I	- Altitude over 2700m above sea level - Minimum annual rainfall of 1500mm. - **Covers** 25,400 Km^2 of total land mass i.e. 4.36% - Immediate surroundings are very attractive for agriculture especially tea, coffee and dairy farming among others. - Forested areas also serve as water towers but are also suitable for timber and pulp production.	- Mountains such as Mt Kenya and Mt Elgon and immediate surrounding. - Also covers the immediate surrounding of Mau and Aberdares ranges as well as other major water towers in the country including Kakamega Forest and other areas such as Kisii highlands.
II	- Highlands between 1980 -2700 m - Minimum annual rainfall of 1000mm. - **Covers** 23,800 Km^2 i.e. 4.08% of total land mass - Mainly occurs as forests or open grasslands up the mountains. - Significant for rain-fed agriculture with some of the most suitable crops being wheat, maize, beans, Irish potatoes, tea and coffee. - This zone is also significant for dairy farm ing.	- Mt Kenya (parts of Meru, Embu, Kirinyaga and Nyeri) - Parts of the Rift Valley around Mau and Aberdares ranges (e.g. around Kericho and Nyahururu respectively), - The surrounding of Mt Elgon (e.g. around Kitale and Webuye), Kisii highlands and Kakamega forest.
III	- Mainly at elevations between 900-1800 m - Annual rainfall between 950 and 1500 mm. - **Covers** 25,700 Km^2 i.e. 4.41% of total land mass - Numerous tree species but somewhat of shorter stature than in Zone II and abundance of shrubs - Most significant zone for agricultural cultivation in crop-livestock systems. - Some of the most suitable crops include pulses, maize, wheat, cotton and cassava.	- Vast parts of Nyanza, Western and Central regions, - Most of Central Rift-Valley (Nandi, Nakuru, Bomet, Uasin Gishu, Trans Nzoia) - A small strip of the Coastal belt
IV	- Same elevation as AEZ III (900-1800 m) or at times lower. - Annual rainfall of about 500-1000 mm. - **Covers** 28,700 Km^2 i.e. 4.93% of total land mass - A significant zone for nomadic pastoralism and can support some commercial ranching - High potential to support irrigated agriculture especially with added technological input[27]. - Most suitable crops for this zone include barley, cotton, maize, groundnut and sorghum.	- Surroundings of Naivasha - Some parts of Laikipia and Machakos counties, - Vast parts of the Coastal belt (Kilifi, Kwale and Lamu) - A small strip along the shore of Lake Victoria - Parts of Narok county to Tanzania's border
V	- Usually lower elevations than Zone IV - Annual rainfall is 300-600mm. - **Moisture index of 0.25-**0.39 - **Covers** 87,300 Km^2 i.e. 14.98% of total land mass - High trees and shrub diversity - Mainly significant for nomadic pastoralism and ranching - High potential for irrigated farming with beans pigeon peas, sweet-potatoes, sorghum and millet as some of the most suitable crops.	- Parts of Rift Valley (West Pokot, Turkana, Baringo, Laikipia, Samburu, Kajiado and Narok Counties) - Parts of eastern region (parts of Machakos, Kitui and Makueni counties) - Parts of North Eastern region and Marsabit County - Some parts of coastal Kenya (Tana River)

[26] Main sources of information are: i) Tengnas (1994), and ii) http://www.infonet-biovision.org/EnvironmentalHealth/AEZs-Kenya-System

[27] Global Yield Gap Atlas. Link: http://www.yieldgap.org/kenya

VI	- Zone is semi desert and is the driest part of Kenya - Annual rainfall is 200-400 mm and unreliable. - **Moisture index of 0.10-**0.24 - **Covers** 126,400 Km^2 i.e. 21.69% of total land mass - The zone is significant for ranching and wildlife conservation. - Crop farming best under irrigation otherwise dryland varieties of maize, sorghum, millet and cowpeas can perform well	- **Parts of Marsabit, Turkana, Mandera, Garissa and Wajir counties** - Parts of Kajiado, Kitui, Makueni, Laikipia, Samburu, Baringo and West Pokot counties. - Small strip of the coastal region particularly Taita Taveta, Tana River and Kilifi counties.
VII	- **This zone covers very arid land mass of the country which are mainly rangelands.** - Annual rainfall is 150-300mm and unreliable. - **Moisture index of < 0.10** - **Covers** 265,300 Km^2 i.e. 45.53% of total land mass - **Some diversity of perennial tree and shrubs for livestock fodder.** - **Crop farming is possible under Irrigation especially along major permanent water sources such as rivers and aquifers.**	- **It covers vast part of Marsabit,** Garissa, Mandera, Tana River and Wajir Counties - It also covers eastern part of Isiolo and Turkana counties.