TREE SPECIES FOR PROMOTION IN THE FARARANO PROGRAMME

CRS-MADAGASCAR'S "FOOD FOR PEACE DEVELOPMENT FOOD ASSISTANCE PROGRAM (DFAP)

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PORTFOLIO OF TREE SPECIES FOR PROMOTION IN THE FARARANO PROGRAMME

Introduction

The development of the tree portfolio for the promotion of agroforestry tree species is one product of the scoping study that ICRAF undertook in Madagascar during the period from 18th November to 1st December, 2015. This is part of a 5-year USAID/Food for Peace Development Food Assistance Program (DFAP) called Fararano ("harvest season") being implemented by the Catholic Relief Services (CRS) and partners in three of the most vulnerable regions of Madagascar namely Atsinanana, Vatovavy Fitovinany and Atsimo Andrefana. Fararano's goal is to reduce food insecurity and chronic undernutrition and increase resilience in these target areas. This 5 year program will reach over 70% of the population in 44 rural communes (461 fokontany) with an integrated package of nutrition, agriculture, disaster risk reduction, environment and gender focused activities to reduce food insecurity in these target areas.

To develop this tree portfolio for promotion through agroforestry, a scoping study was conducted during which general observations were made on the current status of natural resources as well as some interface with institutions and communities that are participating in the project. A desk review was also carried out to complement the observations. This desk review covered mostly the climatic conditions; forest and agricultural biodiversity as components of the natural resources supporting the rural livelihoods.

General description of the Fararano impact areas

Atsinanana is a region whose economy is dominated by import-export activities owing to its port in Toamasina. The existence of this port has promoted growing of cash crops such as coffee, cloves and litchis. The other agricultural crops grown include paddy rice, manioc, corn, bananas, pineapple and sugar cane. The climate in this region is hot and humid. As it is directly exposed to trade winds, it receives more than 1,200 mm of rain per year, with a maximum of 3,700 mm in Sainte-Marie and a minimum of 1,100 mm in the northern and southern tips. The average annual temperature is around 24°C. Its terrain is mostly mountainous in the highlands and flat along the coastal areas (Razafindrakoto 2013).

The hinterland of Vatovavy Fitovinany's coastal area is formed by medium and low hills from East to West, followed by a swampy coastal plain with many lagoons. The climate is tropical, hot, humid and rainy, with over 2,500mm of rainfall per year. The average annual temperature is around 26°C. Dry periods alternate with floods, which is detrimental to subsistence farming. Cyclones and strong winds are also common in the region. Rice cultivation is very important for farmers of the area. If soil moisture and water availability permit, they produce rice a second time in the year during the off-season. Other subsistence crops are grown on the hills and on riverbank alluvial deposits –mostly cassava, sweet potato, banana and legumes. Vegetable cropping is quite marginal but many fruit trees located near villages complement their diets. The climate of South-East Madagascar is also suited to various cash crops such as cloves, litchis, cinnamon, pepper, citrus fruits, Robusta

coffee and vanilla. However, yields and labour productivity are very low due to low use of external inputs and general constraints including poor soils. Owning cattle is a sign of wealth, but according to studies carried out by Inter Aide in Manakara district in 2006, only 29% of families own some and 50% of the zebu population is owned by 7% of farmers (Ramanantsialonina et al. 2012).

And in Atsimo Andrefana, industries occupy 86.5% of the active population and provide its main export products. The region has some patches favourable for agriculture (irrigated areas), fishing (the entire coast), and livestock (grazing areas). The southwest thus presents considerable potential in terms of livestock and fishery and agricultural resources. The main products in Atsimo Andrefana are in the order of beef, rice, goat meat, sugar cane, milk, cotton, manioc, mutton, lima beans, sweet potatoes, poultry meat, and peanuts. It should be noted that livestock is a large part of this region's economy. The climate in this region is semi-arid. The average annual rainfall ranges from 400 mm to 700 mm, and the average annual temperature is about 24° C with absolute maximum temperatures of over 40° C (Razafindrakoto Benjamin. 2013).

In general Madagascar's socio-economic aspects have been mostly affected by the harmful effects of climate change. This impact has been felt in agriculture, livestock, forestry, water resources, fishing and health sectors. In agriculture, the growing number of floods and droughts, combined with poor water management, erosion and fewer fertile soils, have contributed to the destruction of crops and declining crop (both cash and staple) productivity levels. Livestock farming has been affected by the reduction and degradation of grazing fields due to climate change threatening livestock feed. Grazing areas have shrunk by around 2% due to climate variability and higher temperatures have led to reduced productivity. Climate change also poses water resource shortage risks; in some areas, livestock watering has become difficult due to declining groundwater reserves and the early depletion of ponds. Herds also fall victim to extreme weather events such as droughts and floods. The degradation and disappearance of forestry resources has led to both water and soil erosion of large watersheds leading to low water infiltration in the water catchment areas for ground water recharge. In addition reduced forest cover limits carbon absorption capacity, thereby contributing to global warming. Water resources have also been affected by rainfall disruptions, extreme weather events, and increased evapotranspiration threaten the hydrological regime of various watersheds. Deforestation and the erosion of watersheds also contribute to the silting and sloughing of bottomlands and the general loss of good quality water.

Forest biodiversity of Madagascar

The island of Madagascar is renowned for its exceptional biodiversity, with extraordinarily large and diverse levels of species that are highly endemic as a consequence of over 100 million years of evolution in relative isolation (Table 1). This has made Madagascar to be recognized as one of world's 'hottest' biodiversity hotspots (Buerki et al., 2015; Myers et al., 2000; Myers, 2003; Goodman and Benstead, 2005) sustaining the richest diversity of flora and fauna in the world with more than 80% of the plant species being endemic (Perrier de la

Bathie, 1936; Humbert, 1959; Dejardin et al., 1973; Schatz et al., 1996). Understanding the origin and diversification of these lineages in Madagascar requires consideration of the driving factors including the complex eco-geography and geological history of the island, the varying dispersal abilities of the members of the lineages present there; and Madagascar's proximity to potential source areas, in particular the African continent but also Asia and areas beyond. Madagascar's vegetation as subsequently updated by Moat and Smith (2007) in the "Atlas of Madagascar's Vegetation" does describe Madagascar's forest ecosystems. This Atlas identifies 15 types of terrestrial ecosystems: a primary forest composed of rainforest, dry forests in the West, dry spiny thicket in the South-West, sub-humid forest in the West, rainforest in the West, wooded herb land, bushy, coastal bushy in the South-West, Tapia forest, and coastal forests as highlighted in the subsequent summary paragraphs (MEF, 2009; 2014).

Table 1: Species richness and endemism in Madagascar

Taxon	**No. of Species**	**% Endemism**
Plants	12,000	85%
Birds	2009 (breeding)	51%
Mammals	117	90%
Reptiles	346	>90%
Amphibians	199	99%

Source: Harper et al., 2007

The rainforest ecosystem of the Eastern Ecoregion and Sambirano is described in relation to the dense humid evergreen rainforest of low and medium altitude (0 -1300m,) represented respectively by plants association of the Myristicaceae to Anthostema, and Weinmannia to Tambourissa series. The degraded forest, locally known as 'savoka', has an extremely variable appearance depending on the level of degradation. It evolves from a secondary forest into a bushland or even in a mosaic of savannah. The forest vegetation is mainly composed of ruderal species such as the *Harungana madagascariensis, Ravenala madagascariensis, Tremaorientalis, Dombeya* spp. among other species including the introduced species. Apparently the degraded rainforest covers a relatively large area (58,058 km ^{2}) and out of this 2.45% is in protected areas. The Tapia forest in the Central Ecoregion is considered as a forest remnant that spreads onto the western and central highlands and corresponds to the medium altitude, Sclerophyllous forest (800 to 1,300m.). It is characterized by trees physiology with thick bark to adapt to frequent fires and sandstones soil types. Species include the endemic *Uapaca bojeri series* (locally called 'Tapia') refers to the series of *Uapaca bojeri* and *Chlaenaceae*, the *Sarcolaena oblongifolia, Schizolaena microphylla, Asteropeia labati, Weinmannia* spp., and the *Agauria* spp.

The Western Ecoregion ecosystem is made up of the rainforest, Subhumid and the dry forest. The rainforest lies on an altitudinal gradient between 700 and 1300m stretching from the highlands to the Eastern slopes of Analavelona dominated by a mixture of three types of vegetation including the evergreen, Sclerophyllous, and dry lands (on rocky outcrops.). The

Western Subhumid is located in the Western slopes and along the Mangoky River from Bevoay (vegetation dominated by *Adansonia grandidieri* and *Adansonia rubrostipa*); and on the Westward to Beroroha in the Northeast and Sakarahato in the Southeast (vegetation dominated by *Adansoniaza* in the Zombitse–Vohibasia forest.) It is characterized by species such as *Givotia madagascariensis, Colvillea racemosa Terminalia* spp., *Neobeguea mahafaliensis, Gyrocarpussa americanus, Diospyros* spp., and *Cordyla madagascariensis.* The dry forest stretches from the Mangoky River in the South to Antsiranana in the North. This type of ecosystem is the equivalent of the dense deciduous dry forest or deciduous of low and medium altitude (0 - 1600m) with the plant association of the *Dalbergia, Commiphora,* and *Hildegardia series*. The Western dry forest is diverse depending on the rainfall and the substrate that supports it. Physiognomically, it is in the form of dense forest, thicket or deciduous bushland depending on the rainfall and the substrate. The most common species are *Commiphora* spp., *Cedrelopsis grevei, Colvillearacemosa, and Dalbergia* spp. various species of baobabs such as *Adansonia grandidieri, Adansonia za,* and *Andasonia rubrostipa* are also present.

The Southern Ecoregion is dominated by the spiny dry forest and varies from an ordinary forest to an impenetrable thicket depending on the soil type and rainfall. The degraded spiny dry forest formation has a fragmented low and bushy appearance with the remnants of the *Didieraceae* species family. Some of the common species are: *Didierea madagascariensis, Givotia madagascariensis, Adansonia rubrostipa, Adansonia za, Adansonia grandidieri, Alluaudia procera, Alluaudia montagnacii, Alluaudia comosa,* and *Cedrelopsis grevei*. Other forest types include Mountain Dense Rainforest found above 1600m in altitude dominated by the *Weinmannia* and *Tambourissa* species, and it is also a home to the sole endemic conifer species of *Podocarpus madagascariensis* of the *Podocarpaceae* family. The permanent fog provides cool and humid microclimate promoting the development of epiphytic plant species (*Asplenium nidus,*) tree fern (*Cyathea genus,*) luxuriant lichens (*Usneasp*,) and mosses. The highest altitudes of the central highlands are made up of Silva Lichens type of forests of Sclerophyllous thickets and Paucispecific Mountains with the specific genres *Erica, Senecio, Vernonia, Psiadia, Ocotea, Cussonia, Vitex, Vaccinium*, inter alia succulents like *Euphorbia, Kalanchoe, and Aloe.* The coastal and swampy forests are dominated by the Rubiaceae and Cyperaceae families respectively. Riparian forests are found along the alluvial banks of most big rivers forming narrow strip of evergreen species (*Protorhus, Eugenia*) and others deciduous (*Canarium, Khaya, Terminalia*). The Dry land Ecosystems of Madagascar cover the western and central highlands and the associated escarpments, as well as the Southern and the Eastern fallows, forming the Savannahs at different altitudes. The Savannahs are widely represented in Madagascar covering 70% of the potential areas and are composed of a mosaic of wooded or shrubby grasslands depending on the dominant vegetation type such as *Stereospermum euphorioides, Sclerocarya birrea* spp. *caffra, Gymnosporia longifolia, Dicoma incana,* and *Acridocarpus excelsus.* Reforestation has been encouraged in some of these areas with species like *Pinus, Eucalyptus,* and *Cupressus*. In the West, the woody component of the savannah is dominated

by *Tamarindus indica*, *Stereospermum euphorioides*, *Poupartia caffra*, *Ziziphus spp.,* as well as palm trees species such as the *Bismarkia nobilis* and *Hyphaene shatan*. Some of the dominant grasses include *Aristida rufescens, Hyparrhenia ssp., Heteropogon contortus, Loudetia simplex and Ctenium concinnum.* These summaries (MEF, 2009; 2014) and other biodiversity studies published on the evolutionary and ecological processes provide some indications of spatial distribution of the plant species richness on the island (Table 2).

Indications are that abiotic factors such as bio-climate, substrate type, elevation or paleo-precipitation have played an important role in the formation of the forests (Yoder and Nowak 2006; Pearson and Raxworthy, 2009; Agnarsson and Kuntner, 2012; Buerki et al., 2013; Mercier and Wilmé, 2013; Rakotoarinivo et al., 2013). Others have explored the role of potential key innovations in species diversification and niche expansion (Vary et al., 2011; Evans et al., 2014; Moore and Robertson, 2014). However, it is also on record that Madagascar biota is severely threatened by unsustainable practices such as shifting cultivation, uncontrolled burning and extensive charcoal production, all of which place intense pressure on the island's remaining natural areas. Over the last three decades a major effort has been made to expand and strengthen the system of protected areas, which includes about 5.7–5.9 million hectares of terrestrial parks and reserves, many of which were established during the last 15 years. Despite these efforts, however, deforestation and habitat degradation have continued at an alarming rate as the human population has doubled in the last 25 years, reaching an estimated 22.4 million by mid-2014 (Population Reference Bureau 2015 in Soulebeau et. al. 2016). More than three-quarters of the population lives below the poverty level (World Bank 2015 in Soulebeau et. al. 2016) and almost all Malagasy are directly or indirectly dependent on the island's natural resources as a major source of food, shelter, fuel, and traditional medicine.

Table 2: A summary of Ecosystems and associated common forest tree species

Ecosystem regions	**Common forest tree species**
The rainforest ecosystem of the Eastern Ecoregion and Sambirano, Sambavato, Farafangana	*Harungana madagascariensis* *Ravenala madagascariensis* *Tremaorientalis spp.* *Dombeya* spp. *Uapaca bojeri* *Uapaca Chlaenaceae* *Sarcolaena oblongifolia* *Schizolaena microphylla* *Asteropeia labati* *Weinmannia* spp. *Agauria* spp. *Anthostema madagascariensis* *Canarium* spp. *Cassipourea lanceolate* *Khaya madagascariensis*

	Dalbergia baroni *Ocotea cymosa* *Evodia belahe*
The Western Ecoregion ecosystem dominated by the rainforest, Sub humid and some dry forest **(mainly in Bevoay, Beroroha, Sakarahota, Antsiranana, Toliara).**	*Adansonia grandidieri* *Adansonia rubrostipa* *Adansonia za* *Givotia madagascariensis* *Colvillea racemose* *Terminalia* spp. *Neobeguea mahafaliensis* *Gyrocarpussa americanus* *Cordyla madagascariensis* *Hildegardia spp.* *Commiphora spp.* *Diospyros perrieri* *Dalbergia greveana*
The Western dry forest	*Commiphora* spp. *Cedrelopsis grevei* *Colvillearacemosa* *Adansonia grandidieri* *Adansonia za* *Adasonia rubrostipa* *Adansonia madagascariensis* *Adansonia perrieri* *Adansonia suarezensis* *Adansonia digitate* *Bismarkia nobilis* *Hyphaene shatan* *Dalbergia monticola*
The Southern Ecoregion, dominated by the spiny dry forest	*Didierea madagascariensis* *Givotia madagascariensis* *Adansonia rubrostipa* *Adansonia za* *Adansonia grandidieri* *Alluaudia procera* *Alluaudia montagnacii* *Alluaudia comosa* *Cedrelopsis grevei* *Weinmannia spp.* *Tambourissa* spp. *Podocarpus madagascariensis* *Evodia belahe*
Riparian forests	*Protorhus spp.* *Eugenia spp.* *Canarium spp.* *Khaya madagascariensis* *Terminalia spp.*

Dry land Ecosystems of Madagascar covering the western and central highlands	*Stereospermum euphorioides* *Sclerocarya birrea* spp. *caffra* *Gymnosporia longifolia* *Dicoma incana* *Acridocarpus excelsus* *Phyllarthron madagascariense* *Prunus africana*
Reforestation in most areas	*Pinus, Eucalyptus,* and *Cupressus*.

(MEF, 2009; 2014)

Reports on forest ecosystems deforestation changes show an overall deforestation rate in Madagascar was about 0.82% per year during the 1990's and decreased to 0.55% per year over the 2000-2005 period. The highest deforestation rate has been recorded in the spiny forest, with a rate of 1.1% in the 1990's and after 2000. The rainforest deforestation rate decreased to 0.35% per year after 2000. Studies on forest cover change confirm a couple of evidences: the decrease of forest cover from 1990 to 2005 (except for mangrove ecosystem), and the decrease of deforestation rate. Although there is a decrease of national deforestation rate, critical habitats are shrinking in some areas and continuous fragmentation threatens biodiversity of Madagascar (MEF, 2009). Armstrong et al., (2011) documented the community composition and forest structure of lowland rainforest in eastern Madagascar, with a first quantitative description of the primary lowland rainforest of Reserve Naturelle Intégrale de (RNI) Betampona. The survey findings suggest a forest undergoing thinning, perhaps following recovery from gap formation. Importance Value Indices (IVI) calculated for tree species indicated that an unidentified *Uapaca* species, *Ravenala madagascariensis*, *Anthostema madagascariensis*, *Canarium* spp. and *Cassipourea lanceolata* were the most important species according to their overall frequency, dominance and abundance values, and accounted for 10% of the overall IVI.

While deforestation is devastation, it is also important to note the level of lineage diversification in Madagascar's flora in the 30 most species-rich families include almost 70 % of the total vascular plant flora as well as 30 % of the genera present on the island (Gautier et al., 2012). More than 320 genera (19 %) and a total of 5 families are endemic to the island (Callmander et al., 2011; Buerki et al., 2013) with Sarcolaenaceae being the largest of these endemic families. Sarcolaenaceae comprise 71 species of shrubs and trees belonging to 10 genera (Madagascar Catalogue 2015), each of which has been the subject of a recent taxonomic revision (Lowry II et al. 1999, 2000, 2002; Randrianasolo and Miller, 1994, 1999; Schatz et al., 2000, 2001), followed by the description of several newly discovered species (Lowry II and Rabehevitra 2006; Rabehevitra and Lowry II 2009; Lowry II et al., 2014). Members of the family, Sarcolaenaceae, are found almost throughout the island, with the notable exception of the sub-arid southwest, and the distribution of each species has been carefully mapped using the locality information associated with herbarium collections (Ramananjanahary et al., 2010; Madagascar Catalogue, 2015). Based on the collections in

the herbaria of Paris Museum and the Missouri Botanical Garden, it is estimated that more than 2000 specimens are available for the family, with an average of 30 geographic occurrences per species and a total number of collections ranging from more than 300 for common and widespread species such as *Leptolaena pauciflora* Baker. On the other hand, *Leptolaena masoalensis* G.E. Schatz & Lowry II and *Schizolaena capuronii* Lowry II et al. and *Schizolaena raymondii* Lowry II and Rabehevitra are among the few species known from a single locality conferring a restricted geographic distribution. Furthermore, several other genera are largely or entirely restricted to a particular climatic region, such as Eremolaena, Leptolaena, Rhodolaena and Schizolaena which are found primarily or exclusively in humid areas, and Mediusella and Xerochlamys, which occur only in drier habitats. The genera of Sarcolaenaceae is also reported to vary considerably in size, from Schizolaena with 22 species, Sarcolaena with 8 described species (as well as 6 that remain to be described), to Mediusella and Eremolaena, which include just 2 and 3 species respectively (Madagascar Catalogue, 2015)

MEF (2009; 2014) highlighted some plant groups requiring special attention and these include palm trees, orchids, Baobab and leguminous plants. Madagascar is known as one of the rich spots of palm trees (Arecaceae) in the world. Among the 2,375 species recently inventoried in tropical and sub-tropical areas (Govaerts & Dransfield, 2005), 194 are found in Madagascar. This richness is essentially characterized by a very high level of endemism (about 100%), not only at the genus level or but also at species level (Rakotoarinivo, 2008). Among the 184 indigenous species, only five are not endemic. The abundance of palm species in Madagascar is three times higher than that of the entire African continent (Dransfield and Beentje, 1995; Govaerts and Dransfield, 2005). Among 154 Dypsis species currently known, only three species are found outside of Madagascar. In addition, the genera of Beccariophoenix, Bismarckia, Lemurophoenix, Marojejya, Masoala, Tahina, and Voanioala are all specific to Madagascar. Before 1995, 70 palm species were described and in 1995, 171 were described (Rakotoarinivo, 2008). At least 16 genera are known and 191 species have been described, among which 166 are endemic species (source: www.eFlora.org, 2009). Govaerts et al., (2014.) has recently reported that out of the 202 native palm species presently inventoried, only 3 are not endemic of the island, making an endemism rate close to 99%. The palm trees of the island are mainly dominated by a genus, the *Dypsis,* which species are all endemic. It is the same for the genera of *Beccariophoenix*, *Bismarckia*, *Lemurophoenixe, Marojejya*, *Masoala*, *Tahina,* and *Voanioala* which are all endemic. Since 2008, about thirty new species have been described by Rakotoarinivo & Dransfield (2013). At this rate of discovery it is expected that more species will be inventoried and that Madagascar remains one of the richest countries in palm trees in the world (Rakotoarinivo et al., (2013); MEF, 2014). Orchids are one other group steadily being inventoried with 960 species recorded in 1999, including 105 new species, 11 new varieties, and 62 new combinations. These numbers have increased to about 1100 species of which 86% are endemic (Bosser and Lecoufle, 2013; Rakotoarivelo et al., 2013). It is also on record that out of the 8 Baobab species existing in the world, 7 species are present in Madagascar,

6 of which are endemic and these are *Adansonia grandidieri, A. rubrostipa*, *A. za*, *A. madagascariensis*, *A. perrieri* and *A. suarezensis*. The *A. digitata* species is well represented in the West of Madagascar and common with Africa. Currently, 667 species of leguminous plants (Fabacaee) are known, including 573 indigenous species and 94 species introduced and naturalized in Madagascar (Dupuy et al., 2002). Thus, plants have been introduced in different ways in Madagascar. For trees species it has been both timber or non-timber for reforestation and the most dominant genera are *Eucalyptus* and *Pinus*. Many shrubs for agroforestry use and some ornamental species have also been brought into the country. As for agricultural and fodder species, the introduction of new foreign varieties is common.

For conservation and management of forest plant genetic resources some selected species have been prioritized in the strategic plan as presented in Table 3. Numerous entities are involved in ex-situ forestry resources multiplication in Madagascar. In terms of forest seeds conservation actions, the leader is the National Silo of Forest Seeds (SNGF), created in 1986. It provides excellent quality (physiologically and genetically) in sufficient quantities while ensuring strict measures of conservation. Since 2000, SNGF has been collaborating with the Royal Botanic Garden (UK) as part of the Millennium Seed Bank (MSB) project on the long-term seeds conservation. As part of the project, seeds of forest species from arid and semi-arid region are collected. About 2,000 collections of plant species are at the seeds bank under the Millennium Seed Bank project. They mainly include species that are endangered, overused, and for social and economic use.

The Tsimbazaza Botanical and Zoological Park, created during the colonial period, was established to keep collections of living flora and fauna species. Some species from the Eastern, Western, Southern, arid regions, such as *Pachypodium spp*, *Alluaudia spp*, *Didierea spp*, *Adansonia spp*, and *Euphorbia spp* can be found there, as well as a palm grove, an orchid's greenhouse. Some species prioritized by the National Strategic Plan are also present there: *Ocotea cymosa*, *Phyllarthron madagascariense*, and *Dalbergia spp*. Early in the last decade, arboretums were also created in some Forest Stations throughout the island. Fast-growing exotic species were planted at these arboretums to better understand their reforestation potential. As for conservation trials, their setting up is part of improvement programs and used to preserve the genetic inheritance of a given species as a whole. Exotic species for reforestation such as *Pinus*, *Eucalyptus*, cashew trees, and *Khaya madagascariensis* have been planted in different regions of the island by the DFPR-FOFIFA, in collaboration with both national and international partners. The eucalyptus was introduced to support fuelwood energy supply. More than 90% of the population still use wood resources as a source of energy with an annual wood consumption of 22 million m^3 per year, 80% goes to energy about 17.6 million m^3/year (CEPF, 2013 in MEF 2014) of wood which is well above the replenishment rate of the forest cover. The production and the distribution of charcoal employ thousands of people along the value chain. The energy supply in Madagascar is dominated by wood energy (92%.) Therefore, actions were focused on planting fast-growing species: 140,000 ha of Eucalyptus in small farms in the Central

Highlands; 65,000 ha of industrial pine plantation, and private natural or state forests exploitation, primarily in Mahajanga, Tolagnaro, Antsiranana, Toliara, and Morondava.

Table 3: Priority forest species, potential areas of suitability and their uses

Species	**Elevation (m)**	**Rainfall (mm)**	**Potential areas**	**Uses**
Evodia belahe Baill.	>1000	>1500	Northeastern and Southeastern Coasts	Ferment for traditional alcoholic beverage
Dalbergia baroni Baker	<1300	>1500	Eastern region, from Sambavato Farafangana, low to mid altitudes	The wood is used for sawlog, marquetry, and making of floors
Dalbergia greveana Baill	700-1300	<400	Western region, from Antsiranana to Toliara	The wood is used for sawlog, timber, and carving; the bark is used for medicinal purposes
Dalbergia monticola Bosser & Rabevohitra	700	>1000	Western region of average altitude	The wood is used for sawlog and joinery
Diospyros perrieri Jumelle	700	>1000	Boina and Androy Regions	Ebony is used for carving and joinery
Khaya madagascariensis Jumelle & Perrier	>1300	>1000	Sambirano Region	Redwood is used for joinery and crafts, gum resin
Ocotea cymosa Palacky	800	>2000	Eastern coast	Hardwood is used for timber and joinery
Phyllarthron madagascariense K. Schum	700-1800	>1500	Central Highlands	The wood is used for crafts-making and the leaves for medicinal purposes
Prunus africana Hook f. Kalkmann	800- 2000	>1500	Highlands, Middle-East	Medicinal purposes

(MEF, 2009).

Other than timber and firewood, the flora of Madagascar has also provided local people with medicinal plants, fiber, oil, resins, fodder, vegetable, nuts and fruits for centuries. Wild fruits and nuts have always been of special interest as food sources for local people (Ferraro, 1994; Isaia, 1995). Wild fruits represent an important supplement to the daily diet, which is mainly carbohydrate-rich and lacking important vitamins and micronutrients (Hardenbergh, 1997). Essential knowledge about the use of wild forest resources in Madagascar as well as in other countries lies with the rural population and can harness the food and cash crop potential of wild species (Leakey and Newton, 1994; Turk, 1995) with proper management. Styger et al., (1999) carried out an inventory of indigenous tree species with edible fruits in the three sites

(Andasibe, Masoala or Ranomafana) of the Eastern Region of Madagascar and further to prioritized the species by local peoples' preferences (Table 4).

Table 4: Priority indigenous fruit tree species, exotic and naturalized fruit tree species of Andasibe, Masoala, Ranomafana in the Eastern region of Madagascar.

(a) Indigenous species **(i) First choice, no ranking**	
Species	**Vernacular name**
01. *Labramia costata*	Todinga
02. *Landolphia myrtifolia*	Voaheny
03. *Sorindea madagascariensis*	Voasirindrina
04. *Carissa sessiliflora*	Voatsikopika
05. *Salacia madagascariensis*	Voamasoandro
06. *Symphonia urophylla*	Azinina
07. *Rheedia aphanophlebia*	Vaomalambotaho
08. *Raphia ruffia*	Raffia
09. *Eugenia sp.*	Rotra
10. *Syzygium sp.*	Rotra
(ii) Second choice, no ranking	
Species	**Vernacular name**
11. *Uapaca sp.*	Voapaka
12. *Faucherea sp.*	Vasihy
13. *Treculia madagascarica*	Ampalibeala
14. *Vangueria edulis*	Vavandrika
15. *Calopyxis sp.*	Voamatavy
16. *Dilobeia thouarsii*	Vivaona
17. *Ficus tiliifolia*	Voara
(b) Exotic and naturalized species (no ranking)	
Species	**Vernacular name**
01. *Psidium guajava*	Goavy be
02. *Psidium cattleianum*	Goavitsinahy
03. *Passiflora incarnata*	Garana
04. *Passiflora quadrangularis*	Barbajina
05. *Citrus aurantium*	Voangidy
06. *Citrus aurantifolia*	Tsioha
07. *Citrus medica*	Voatolongo
08. *Eugenia jambolana*	Rotra vazaha
09. *Eugenia jambos*	Zamborozana

Styger et al., (1999)

A total of 150 species from 82 genera and 42 families were identified in the eastern region of Madagascar. Only 20 species occurred in all three sites and 28 species were represented in two of the three sites. This gives some indication of both high biodiversity and site specificity of species distribution. Styger et al., (1999) reported that many genera of the identified endemic species can be found in other parts of the world, for example; *Landolphia* sp., *Vangueria* spp., *Gambeya* spp., *Uapaca* spp., (Africa), *Carissa* spp., (India, Africa), *Garcinia* spp., (Borneo, Malaysia, South America and East and West Africa), *Syzygium* spp., *Pandanus* spp., (South East Asia), *Canarium* spp., (Borneo), *Eugenia* spp., *Rheedia* spp., *Omphalea* spp., *Salacia* spp., *and Mimusops* spp., (South America) (FAO, 1983; Verheij and Coronel, 1992; Maghembe, 1994; Villachica, 1996). The most important families in these areas include Apocynaceae, Clusiaceae, Moraceae, Myrtaceae, Rubiaceae and Sapotaceae. It was also reported that 80% of the inventoried species were endemic, 5% indigenous and 15% of exotic origin but occur spontaneously in the natural vegetation. Seventy-one percent (71%) of the species were trees or shrubs, 9% vines, 5% palms, 4% belong to the family of Pandanaceae, 3% were epiphytes and 8% had a herbaceous habit. Planted species were either naturalized or rare exotic species and these include (*Citrus aurantifolium, C. aurantium, C. medica, Syzygium jambos*), or rare forest species particularly appreciated for their multiple uses (*Sorindea madagascariensis, Carissa sessiliflora, Ficus* spp., *Eugenia* spp.). Managed species were essentially found in the banana fields or along field boundaries and paths. In Andasibe and Ranomafana the main practice of land conversion has been based on slash and burn, and the managed species are therefore considered as part of secondary vegetation regeneration Styger et al., (1999).

Agricultural biodiversity of Madagascar

In broad terms, agricultural biodiversity encompasses the varieties and the variability of animals, plants, and microorganisms that are necessary to the functioning of agro-ecosystems, their structures and processes, all of these contributing to food production and security. The Second National Report on the Madagascar's (2009) of (2) Situation of the Conservation and Use of Agricultural Biological Diversity in Madagascar under Component (2) Agrobiodiversity (2006) describes Plant Genetic Resources for Food and Agriculture (PGRFA) as a composition by species and infra-species diversity of the plant material contained in traditional and improved varieties, as well as wild plants related to cultivated plants that can be used, for human and animal food, and to obtain fibers, textile, shelter, timber, and fuel wood. It is believed that almost all agricultural plants species in Madagascar were probably imported by migrating human population in 8th century. However, Malagasy cultivated plants are still characterized by exceptional diversity, which is reflected both (i) at the species level, with plants ranging from temperate-zone plants to tropical plants and Mediterranean-zone species; (ii) at the infra-species level, with the abundance of ecotypes modeled and conserved in traditional ways by farmers.

Agriculture accounts for 25% of GDP and employs about 75% of the work force. Large-scale plantations dominate the production of sisal, sugarcane, tobacco, bananas, and cotton, but,

overall, Malagasy agriculture is dependent mainly on small-scale subsistence farmers cultivating less than one hectare (2.47 acres) of land. The 4th CBD report (2009) emphasizes that while a wide variety of food crops is grown, rice is the staple of the Malagasy diet; production was an estimated 3,030,000 tons in 2004. Nevertheless, the yield is insufficient to meet the country's needs and in 1982, 1984, and 1990 cyclones severely damaged the rice crop. Cassava, bananas, and sweet potatoes are also important. Madagascar has sought to diversify staple crop production by promoting maize and potatoes. Other important food crops (with 2004 production figures) include cassava (2,191,000 tons); sugarcane (2,180,000 tons); sweet potatoes (542,000 tons); potatoes (280,500 tons); bananas (290,000 tons); corn (350,000 tons); and oranges (83,000 tons).

It has also been report that in the 1980s, coffee earned about 24% of total export revenues, however, coffee exports accounted for only 8.6% of Malagasy foreign trade earnings in 1992 (down from 35% in 1985) following the collapse of the International Coffee Organization in 1989. On the other hand, Vanilla emerged as the leading agricultural export, with production of 3,000 tons in 2004 and exports of 658 tons of extract (for a value of $64.2 million, 16% of total exports). Madagascar is the world's major natural vanilla producer, accounting for about 75% of production. Cloves are another main export crop, grown mostly by smallholders.

Apart from agricultural crops, trading in ornamental plants is also one of the Malagasy people's sources of income. The most marketed ornamental plants are classified in four groups: orchids, palm trees, succulent plants (*Adenia spp., Aloe spp., Alluaudia spp., Commiphora spp., Cyphostemma spp., Delonix spp., Didierea spp., Euphorbia spp., Kalanchoe spp., Operculicarya spp., Pachypodium spp., Senna spp., Uncarina spp.,* and *Zygosicyos spp., etc.*), and water plants, particularly Aponogetons. Exportation of ornamental plants is under the CITES regulation. There currently 20 licensed horticultural operators (Database Flora Permanent Secretary, 2009) and the exported plants come essentially from their horticultural centers.

Although Madagascar's economy is essentially of an agricultural based, much of the land is unsuitable for cultivation because of its mountainous terrain, extensive laterization, and in adequate or irregular rainfall. Only about 5% of the land area is cultivated at any one time. While agricultural crop production covers a relatively small land area, more than half of Madagascar's land is used for raising livestock. "Domestic animals" are mainly composed of cattle (*Bos Taurus*), dominated by Malagasy zebus (*Bos indicus*),pigs (*Scrofa suis*), small ruminants (goats: *Capra aegagrus*; ovines: *Ovis areis*), poultries mainly hens (*Gallus gallus*) and geese (*Anser sp*), ducks (*Anas sp*), guinea fowls (*Numida meleagris*), ostriches (*Struthio sp*) and quails (*Coturnix sp*) as well as the fish species categorized according to their raising environments namely the fresh water fish farming (Tilapias: *Oreochromis niloticus*; Carps: *Ciprinus carpio sp*) and the sea and brackish water fish farming represented mainly by the striped shrimps (*Penaeus monodon*) (Minelv, 2013). Cattle contribute substantially in the

Malagasy economy. The sale of live animals and livestock products often constitutes a substantial portion of the cash income for the poor, significantly contribute to their livelihoods. Livestock also serves as a source of fertilizer (manure for paddy fields), fuel, ploughing, draft power and hauling services, and thereby raise agricultural productivity and alleviate agricultural labor constraints. In the "household economy", livestock constitute a buffer to risk, a form of savings, and confer a certain social status, while, in the broader economic context, livestock generate additional employment and income opportunities for the smallholder farmers.

There are two systems of livestock production that include the extensive system which is important in the rural areas, dominated by the Zebu and small ruminants. On the other hand the more intensive system dominates the peri-urban regions for milk and manure production systems (Ranaivoarivelo, 2002). The areas of savannah grasslands and natural grazing in Madagascar are relatively large and adequate to support its ruminant livestock in the extensive management system. Unfortunately, the system has remained traditional which is not oriented towards commercialization of its products and the grazing areas are still under communal use such that no much effort has been put into improving the system. Fodder production, on the other hand, is developing well in dairy farms in peri-urban zones but on small scale in proportion to the farm sizes. The technology that has been promoted and which seems the most suitable in some cases is the establishment of fodder shrubs "(protein banks)" for some classes of stock during the dry season. FAO 2006 documentation of the Madagascar's pasture and forage profile captures available resources and describes the six large distinct pastoral regions that correspond to the climatic conditions in the different ecological zones and the existing livestock production systems (http://www.fao.org/ag/agp/agpc/doc/counprof/madagascar/ accessed 20 June, 2017). Several authors (Morat, 1969; Granier and Razafindratsita, 1970; Cabanis and Razafindratsita, 1971; Morat, 1973; Suttie and Hablützel, 1974;) have carried out studies and made local descriptions of the vegetation in the different ecological zones.

Promotion of pasture and fodder for livestock feeding

Several research institutions of which the most important are FOFIFA, FIFAMANOR, l'IEMVT, l'IRAM, l'ORSTOM, le CNRE, l'Université d'Antananarivo and L'université de Madagascar have been involved in the assessment of pastures and fodder crops and introduction of the same to the ecological zones of Madagascar (Borget, 1962; Borget, 1971; Delhaye and Granier, 1966). FOFIFA (National Centre for Applied Research in Rural Development) has a mandate for all agricultural research at national level. The Department of Veterinary and Zootechnical Research (DRZV) of FOFIFA is, among other activities, in charge of matters concerning natural and artificial pasture as well as animal nutrition in general. Fodder collections are maintained at the Regional Research Centre of Lake Alaotra and seeds can be produced. FIFAMANOR primarily has a mandate of developing milk production in the Vakininkaratra and the Highlands. The Université d'Antananarivo and the National Centre for Research on the Environment (CNRE), among other activities, are mainly concerned with

university teaching and research studies on natural pastures. Bosser (1969) in-depth study described 291 grass species out of the 450 listed in the flora of Madagascar. Tables 5 present a list of grasses which have been tested and show their adaptation to most of the zones.

Table 5: Forages/grasses introduced to Madagascar and their adaptation

	Regions where tested					
Grasses	North	Northwest	South	Mid-West	Highlands	East
Brachiaria brizantha	+++	+++	+++	+++	+++	+++
Brachiaria mutica	+++	+++		+++	+++	+++
Brachiaria ruziziensis	+++			+++	+++	+++
Cenchrus ciliaris	+++	+++	+++	+	++	
Chloris gayana	+++	+++	+++	+++	+++	
Eragrostis curvula	+++	+		+	++	
Melinis minutiflora	+++	++	+++	+++	+++	+++
Panicum maximum		++	-	++	+++	
Pennisetum purpureum	+++	+++	+++	+++	+++	+++
Setaria anceps =sphacelata)	+++	+	+	+++	+++	+++
Tripsacum laxum		+++		+++	+++	+++
Zea mays			+++	+++	+++	+++

Legend: + poorly adapted; ++ moderately adapted, +++ very well adapted

Most of the cultivated fodders are grown and utilised mostly during the rainy season; this is the case for perennial tropical grasses like *Pennisetum purpureum, Tripsacum laxum, Chloris gayana, Setaria anceps* and *Brachiaria brizantha*. These are grown on non-flooded land. In the Highlands where arable land is scarce the big grasses *(Pennisetum purpureum* and *Tripsacum laxum)* are promoted. *Pennisetum purpureum* is also used for other purposes other than fodder; it is known for its capacity as protection against erosion as such it is grown on field margins and terrace banks on crop land to reduce soil loss (Granier 1971). Establishment, management and utilization of various grasses has been described (Birie - Habas, 1961; BDPA, 1963; Granier and Lahore, 1966; Razakaboana 1967, 1969, 1970; Huynh-Van-Nhan, 1971; Albengue, 1971). Establishment is usually by cuttings for big grasses while other grasses are best established by seed. Small doses of manure are also recommended annually. Yields vary according to climate, and soil characteristics. Maize (Z*ea mays*) and

sorghum (*Sorghum* spp.) crops are also grown as annual grasses during the rainy season (Granier and Bigot, 1970; Rasambainarivo *et al*. 1980), they are mostly used for making silage for dairy farms. In addition, oats and ryegrass have become fodder crops of prime importance for dairy producers (Granier and Razafindratsita, 1970; FIFAMANOR, 2000).

Fodder legumes

Fodder legumes are of relatively recent in utilization compared to the grasses but proved to be very useful plants for feeding livestock during the first part of the dry season (Rasambainarivo 1979 and 1980). The most detailed studies and extension activities have been in the Mid-West with *Stylosanthes guianensis*, between the 1960s and 1980s. The work of Granier and Lahore (1966), Granier (1970, 1971, 1973) and Granier *et al*. (1972) tried to determine the most favourable factors for establishing *Stylosanthes guianensis* to improve natural pasture. The authors recommended reduction of competition from the natural vegetation by burning and light cultivation of the soil before sowing the legume. *S. guianensis*, particularly the cultivars 'Endeavour' and 'Schofield', were very successful in the Mid-West during the years 1970 - 1980. State farms and private individuals grew *Stylosanthes,* either in pure stand, (Rasambainarivo and Rakotozandrindrainy, 1980), or for improving natural pasture. In the drier areas of the south *Stylosanthes humilis* and *S. hamata* were also tested and used in extension work (Suttie and Hablutzel, 1974; Suttie, 1976, 1977). Tables 6 present a list of fodder legumes which have been tested and show their adaptation to most of the zones.

Table 6: Fodder legumes tested in the different regions

	Regions where tested					
Legumes	North	Northwest	South	Mid-West	Highlands	East
Centrosema plumieri	+++			+++		+++
Centrosema pubescens	+++	+++				+++
Desmodium intortum			+	+++		+++
Dolichos lablab	++	++		+++		
Macroptilium atropurpureum		+++		+++		+++
Mucuna utilis	+++	+++	+	+++		+++
Neonotonia wightii (2)			+	+++		+++
Pueraria phaseoloïdes	+++	+++		+++		+++
Stylosanthes guyanensis	+++	+++	+	+++		+++
Stylosanthes hamata		+++		+++		
Stylosanthes humilis		+++	+++	+++		
Vigna unguiculata	+++	+++	+++	+++		+++

Legend: + poorly adapted; ++ moderately adapted, +++ very well adapted

Multipurpose shrubs

The use of shrubs as fodder began in the dry regions of the south (the Androy zone) with several cultivars of *Atriplex nummularia* and *A. canescens* which showed to be well adapted (Suttie and Berte, 1974). Later on utilization of shrubs was also reported in the Mid-West and the Highlands (Rasambainarivo and Razafindratsita, 1991). Shrubs that have survived under various conditions include *Leucaena leucocephala, L. diversifolia, Calliandra calothyrsus, Acacia mangium* and *Albizia falcataria.* The recommended establishment method is transplanting young nursery raised plants aged 3-4 months. After 18-24 months the bushes can be harvested and yield 600 - 650 grams of dry matter per bush and per year in two or three cuts (Rasambainarivo *et al*. 1993).

General observation during the field visits in November 2015

It was observed that agricultural expansion is being done in two ways: conversion of forests into farmlands and transformation of water bodies and marshes into rice fields. The conversion of forests into farmland through clearing is often followed by burns. This process also known by the local names such as “tavy” or “hatsake” is practiced by households living on the border of forests for their livelihoods. Coincidentally, the highest population growth rates in Madagascar are observed in rural areas (80% of the households). These rural households sustain their livelihoods on natural assets, including the land. In such instances there is a direct link that when the population grows, needs for farmland increases in order to meet the basic needs. These acts of land reclamations have resulted into the deforestation on highlands and catchment basins thereby increasing soil erosion. Runoff water wears off the parent rock and carries sediments downstream to estuaries. In addition the slash-and-burn in the cleared highlands; and forest fires remain a predominant cause of natural resources destruction in Madagascar. With increasing deforestation, exploitation and changes in land use, the diversity in the indigenous vegetation is declining. It is apparent therefore that while promoting the use of these plants; conservation of the same and its environment is paramount. This conservation can be done in situ (forests) or in the agricultural landscapes. During our field visit in Madagascar, it was observed that a variety of tree species are already grown on farms and around homesteads (Table 7).

Table 7: Common tree species observed on farm and homesteads in the Fararano programme target sites.

Region visited	Fruits	Other woody tree types
Atsinanana (Eastern region)	Litchi (*Litchi chinensis*) Mangoes (*Mangifera indica*)	Gliricidia (*Gliricidia sepium*) Pigeon pea (*Cajanus cajan*)
Vatovavy Fitovinany (South East of Madagascar)	Avocado (*Persea Americana*) Orange (Citrus sinensis) Guava (*Psidium guajava)* Lemon (*Citrus limon*)	*Albizzia lebbeck* *Acacia angustissima* *Harungana madagascariensis*
Atsimo Andrefana (South West of Madagascar)	Zizyphus (*Zizyphus mauritiana*) Tamarind (*Tamarindus indica*) Baobab (*Adansonia spp*) Mangoes (*Mangifera indica*) Pawpaw (*Carica papaya*)	Moringa (*Moringa oleifeira*) Neem (*Azadirachta indica)* Spectacular senna (*Senna spectabilis)* Yellow cassia *(Senna siamea*) Tephrosia (*Tephrosia vogelli*) Leucaena spp (*L. triacandra*) Apple-ring acacia *(Faidherbia albida)*

Additionally, a list of some multipurpose tree species was obtained from a compilation by Centre ValBio (Table 8). Centre ValBio is an International Centre of Research and Forest Conservation. This organization aims to provide protection of the forest reserve in Ranomafana in an effort to conserve biodiversity while ensuring sustainable provisions of ecosystem services to the surrounding communities. Farmers living around the reserve are encouraged to plant trees or conserve naturally regenerating trees in the deforested areas. The Centre's mission is oriented towards research but at the same time ensuring capacity development and sensitization of the surrounding communities on issues of forestry conservation. In addition, the Centre provides environmental education in order to conserve the forest for multiple benefits and products.

Table 8: Compilation selected list of some multipurpose tree species by Centre ValBio.

Local Name	Species	Honey production	habitat for Lemur	Household use*
Albizzia	*Albizzia gummifera*	■		
Ambaravati	*Cajanas cajan*			■
Apody	*Vepris ampody*			■
Dikana	*Allophylus cobe*			■
Dite	*Aphloia theiformis*	■		■
Fagnamo	*Mundulea sericea*	■		
Goavy vave	*Psidium guajava*			■
Grevelia	*Grevillea robusta*	■		
Hafitra	*Dombeya species*	■		
Hafitaikalala	*Grewia species*	■		
Harina	*Bridelia tulasneana*			■
Harongana	*Haroungana madagascariencis*	■	■	■
Lalomaka	*Weinmannia bojeriana*	■		■
Lalona	*Weinmannia rutenbergii*	■		■
Maka	*Weinmannia bojeriana*	■		■
Malambovora	*Erythroxylum spp.*	■		■
Mandravasa	*Leptaulus citrodes*			■
Nato jabo	*Mammea bongo*		■	■
Natovoraka	*Mammea species*	■	■	■
Rahiaka	*Chrysophylla boivinianum*		■	■
Ramandrion	*Dilobeia thouarsii*			■
Ramiavona	*Xylopia buxifolia*			■
Ramiavonto	*Ambavia capuronii*			■
Ramy	*Canarium madagascariencis*		■	■
Rotra	*Syziygium species*	■	■	■
Sandramy	*Protorhus ditimena*	■	■	■
Sovoka	*Dalbergia species*			■
Tavolo	*Cryptocarya species*		■	■
Vanana	*Sloanea rhodantha*	■	■	■
Varongy	*Ocotea species*	■	■	
Voabe	*Eugenia louvelii*	■	■	
Voamboana	*Dalbergia baroni*	■		■
Vonitra	*Dypsis fibrosa*		■	■

**Provision of fruits, fuelwood and construction material*

The Fararano programme aims to promote the integration of trees in farming systems in an effort to regenerate the land on small scale farms, and to increase family food production and cash income. Intensive farming that integrates trees into crop and livestock production systems at the field, farm, and landscape scales will ensure diversified farming systems, intensify production, protect and regenerate soil fertility at the farm level. This can be

achieved through the integration of adapted leguminous trees for soil fertility improvement, fruit, fuelwood, timber and fodder trees on crop land and around homesteads.

While agroforestry is not a panacea, it generates significant public goods and environmental services in this era of climate change. Agroforestry practices involve a wide range of trees that are protected or planted and managed on farms and agricultural landscapes. These include trees that provide fruit, nuts, oils and leaves for food and nutrition, fodder trees that improve smallholder livestock production, fertilizer trees for land regeneration that improve soil health and thus contribute to food security; trees that are hosts to edible insects or used in honey production, trees that provide timber and wood energy, others that provide shelter; medicinal trees to combat disease; and trees that produce gums, resins or latex products. Many of these trees have multiple uses, providing a range of these benefits. Thus, trees in agricultural landscapes provide many livelihood and environmental benefits, among them include:

- increased genetic and crop diversity on farms
- improved soil fertility and livestock productivity on farms
- resilience to climate change
- increased access to dietary diversity, as a means for reducing undernutrition
- safety net and resilience in an increasingly erratic climate, providing foods all year round and also when annual crops fail
- enriched asset base of poor households
- links to markets for high-value fruits, oils, cash crops and medicines
- a balance between improved productivity and the sustainable management of natural resources
- stable or enhanced supply of environmental services in agricultural landscapes for water, soil health, carbon sequestration and biodiversity.

In order to attain the described services, both biophysical and socioeconomic factors have a bearing on the level of adoption of the promoted technologies and practices. However socioeconomic factors are more crucial for adoption. Some of the factors limiting wide-scale adoption of agroforestry practices include low extension capacity, high initial costs of agroforestry practices and low access to tree seeds. The increased understanding among farmers on the connection between land productivity and land quality can be an opportunity that could lead to wide scale adoption of agroforestry practices. Farmer-centered approach in agroforestry remains the key to wide-scale adoption of agroforestry. This implies that practices recommended for communities in the respective regions should be tailor-made conforming to the prevailing farming practices and socio-economic conditions of the farmers. Without prescribing the tree species for the Fararano programme in the implementation areas, it is important for policy makers, researchers and extension providers to work closely with farmers in identifying suitable agroforestry technologies and practices on a case by case basis to ensure effective adoption and scaling out. This review provides a variety of potential tree species that can be promoted in the respective Fararano impact areas. Finally, to overcome the limiting factors for the establishment and promotion of

agroforestry systems in general, there will be need to ensure familiarity with the agroforestry practices and relevant information through training of both field staff and farmers. This will enable them develop skills to manage competition between trees and crops in the various association. In addition they will also be able to develop appropriate technology designs based on producer goals, land and labour availability.

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