Forestry

Farmers' Tree Preferences: an Assessment of Constraints and Opportunities in Selected Watersheds in East Amhara

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Abstract

Agroforestry is very ancient and dominant land use practice in eastern ANRS. These practices are numerous as the area covers a larger area and wider agroecology. However, little scientific information is available about the major agroforestry practices in order to improve and optimize the productivity of the land and the land user. With respect to this, the challenge in these areas is to diversify and avail to farmers a whole range of tree species for various purposes, with alternative spatial and temporal arrangement. In most cases, assessment of farmers tree needs, uses, interests and priorities is essential to determine germplasm acquisition and plan species to be raised in nurseries and to define extension methods. Therefore a research was conducted in north and south Wello and Oromiya zones with the major objectives first to assess farmers' tree needs, identify constraints and opportunities for agroforestry research and development activities, identify tree products that farmers are most interested in, determine tree planting niches and tree management practices of farmers, assess factors influencing farmers' decision in the selection of species and niche. Stratified systematic and random samplings were used in order to select the target household. Hence; Bati, Kemisse, Jamma, Wuchale, Haik, and Sirinka were selected. The identity, diversity and growing niche of each tree species was recorded together with household characteristic. The Shannon diversity index H, Simpson diversity index D-1 and inverse Berger-Parker index d-1, and Rényi diversity profile was used during analysis. In addition Linear Redundancy Analysis (LRDA) and pair wise ranking were used in order to analyze the relation between species and other variables. The results showed, tree preferences and species diversity vary across agroecology and household characteristics. Hence, list of the most desired species for different locations was suggested. Based on the diversity of tree species and availability of tree growing, different agroforestry interventions such as tree diversification, introduction of new species, alternative uses and new growing niches have been recommended.

Key words: agroecology, agroforestry, diversification, domestication, germplasm

Introduction

North and South Wello and Oromiya zones occupy the major part of eastern part of ANRS. There is extreme land degradation in this area due to historical, demographic and environmental reasons. The forest and woodlands have already disappeared long ago. As a result land productivity is very low. The cropping system is rain fed agriculture, where irrigation is practiced in very limited areas. The rain fed Agricultural has always a poor performance as the rainfall distribution is getting erratic and scanty in amount. Farmers in the area grow trees in combination with crops and livestock in order to avert and mitigate the vagaries of bad environmental conditions. Although it is an age old practice, technically speaking this land use system is called agroforestry.

Agroforestry is a collective name for a range of land use practices in which trees or shrubs are grown in association with herbaceous plants (crops or pastures), in a spatial arrangement or a time sequence, and in which there are both ecological and economic interaction between the tree and non tree components of the system (ICRAF, 1997). The economic interaction is the production of fuel wood or fruit for cash or income; and the ecological interaction, which is the distinctive feature of agroforestry, the biogeochemical cycle in the system. For example combining tree fodder with grasses in the nutrition of livestock and returning farmyard manure to arable land, with benefits of improved livestock productivity, higher income and soil fertility maintenance.

There are numerous agroforestry practices and systems in Ethiopia. An agroforestry practice is an arrangement of components (trees, crops, pastures, and livestock) in space and time, and system is a distinctive local example of a practice, characterized by environment, plant species, management, and social and economic functioning.

The agroforestry practice and system in the area has not been well studied in order to improve and optimize the productivity of the land and the land user. It has been believed that tree domestication diversifies agro-ecosystems and make them more productive and stable, as there is positive relationship between ecosystem diversity, and ecosystem stability and productivity (Elton, 958; Hutchinson, 1959; Frank & McNaughton, 1991; Tilman & Downing, 1994; Tilman, 1996; Rodríguez & Gómez-Sal, 1994; Naeem et al., 1994; Hooper & Vitousek, 1998; Hector et al.,1999; Loreau & Hector, 2001; Smith & Rushton, 1994).

Domestication covers a wide area and defined to encompass accelerated and human induced evolution to bring species into wider cultivation through a farmer-driven or market-led process. In tandem with individual tree, domestication of landscapes by investigating and modifying the uses, values, intraspecific diversity, ecological functions, numbers, and niches of both planted and naturally regenerated trees is an approach that is getting promoted recently (Kindt; 2001).

With respect to this, the challenge in these areas is to diversify and avail to farmers a whole range of tree species for various purposes. Lack of seeds, seedlings and other planting materials is frequently identified as the most important constraint to a greater adoption of agroforestry technology/practices. Therefore there is a need is to develop and apply better methods to forecast germplasm needs, and to facilitate establishment of sustainable seedling production and distribution systems that draw on the strengths and capabilities of the farmers and private sectors.

Assessment of farmers tree needs, uses, interests and priorities is essential to determine germplasm acquisition and plan species to be raised in nurseries and also to define extension methods. In other words, this is essential to determine agroforestry tree choice for farmers. Moreover, identifying farmer's top priority products and species that brings highest benefits and understanding the way how farmers currently manage trees on-farm is important in defining the principal tree species.

Therefore this research has been initiated and executed with the objectives first to assess farmers' tree needs, preferences for MPT species and identify constraints and opportunities for agroforestry research and development activities. Then, identify tree products that farmers are most interested in and that may best meet their needs and determine those species producing them. Side by side determine tree planting niches and tree management practices of farmers and assess factors influencing farmers' decision in the selection of species and niche. Finally, help target project activities at solving farmers' priority problems with appropriate interventions

Materials and methods

The study was conducted in Eastern Amhara, mainly in North and South Wello and Oromiya zones. A combination of random and systematic sampling approach has been used. The survey area was stratified in to three, based on traditional agroecology classification: Dega, Woina-Dega and Kolla. For the Kolla agroecology, Bati and Kemisse taken in to consideration; for the Dega Jamma was chosen; and for the Woina-Dega Wuchale and Haik taken. For reference purpose, the Sirinka catchment was taken. In the selected watersheds every third household during farm walk was selected. The principle of functional ecological groups was the guiding rule in the data collection process. Functional groups can be defined as clusters of species that play the same role in maintaining and regulating ecosystem processes (Gitay et al. 1996). Norberg et al. (2001) define functional groups as clusters of species that share similar resources and predators.

For every tree species encountered on a farm, information was collected on the presence in particular on-farm niches by interviewing household members involving farm walks, and data recording using pre-tested questionnaires. On-farm niches for trees refer to the location on the farm and the establishment pattern of trees at the location. The niches that were distinguished were trees in the homestead area, trees mixed in cropland, trees on contours in cropland, trees on boundaries of the farm, live fence, trees in woodlots, and trees in degraded lands.

Use-groups were defined as groups of species providing similar products or services to the farm household. Studying use-groups is similar to studying functional groups. Free responses on tree uses were obtained on a species-by-species basis. These answers were post-coded during data entry in the databases that were created for data analysis and storage (Table 1).

Respondents were also requested to name the main use of the species on the farm. Information was provided by the farming household on the source of seedling or germplasm of each tree species. Origins of germplasm were post-coded in categories including the own farm, from neighbor or from government nurseries. Farmers were also interviewed to prioritize desired species and modifications in tree composition and niche.

Several farms × species matrices were formed by inserting abundance > 0 in a specific matrix cell. Use-groups (i.e. matrices) defined by species occurrence and use as recorded at individual farms. Abundance > 0 was recorded for a cell in case the specific farmer (listed in rows) had communicated to use the particular species (listed in columns) for the particular use (product or service). Niche matrices were formed in an analogous way.

In order to prioritize each species for a particular purpose to grow on a particular niche, pair wise ranking was employed.

Table 1. Summary of sampled watersheds and household characteristics

Location of watershed	No. of HH visited	Average land holding (Ha)	No. of Female HH
Bati	32	0.69	4
Jama	25	0.62	6
Chefa	25	0.84	3
Kalu	25	0.46	5
Ambassel	25	0.39	7
Tehuledere	25	0.5	5
Sirinka	25	0.54	8

Measuring diversity for comparison

Usually ecosystem diversity is measured with species richness. Species richness (S) refers to the number of species that were encountered on a specific farm, in a specific watershed. Alpha diversity was analyzed by taking the average number of species per farm. Gamma diversity was analyzed by the total number of species in each category of use or niche in respective agroecology.

The Shannon diversity index H, Simpson diversity index D^{-1} and inverse Berger-Parker index d^{-1}, which are all values at specific scales of the Rényi series H_a were calculated directly from information on species' presence and absence. The Rényi series provides diversity profile values (Ha) based on a scale parameter value a, which varies from 0-10 (Tóthmérész 1995; Legendre & Legendre 1998; Rennols & Laumonier 2000):

$$Ha= \log (\sum p^{a}_{i})/1-\alpha,$$

Where pi = proportion of item i, α variable to be determined by maximum likelihood method, a=0-10.

The Renyi profile gives information about the diversity and evenness of an ecosystem and therefore more efficient for diversity analysis. This is because some ecosystems may be diverse but less even. For instance, if there are ecosystem a and ecosystem b, in the Renyi profile, system a is more diverse than system b if all values of the diversity profile corresponding to system a are larger. Systems that have intersecting profiles consist of one system that is richer but not more evenly distributed. H_8 is only determined by the proportion of the dominant species, therefore the value of evenness that correspond to H_8 (i.e.E8) provides an insight in the contribution of the dominant species to evenness. Therefore, systems with larger E8 have a more evenly distributed dominant species. Systems with intersecting evenness profiles consist of one system where the dominant species is more evenly distributed but the other species less evenly.

Shannon H (Magurran 1988; Condit et al. 1996, Legendre & Legendre 1998)

$$H1= -\sum p_i \log p_i$$

Simpson D^{-1} (Magurran 1988 ; Legendre & Legendre 1998)

$$H2 = \ln (D^{-1}) = \ln (\sum p_i^{\ 2})^{-1}), \text{ and}$$

Berger-Parker d^{-1} (Magurran 1988)

$$H = \ln (d^{-1}) = \ln (p^{-1}_{max}),$$

Diversity indices are also used for comparison purpose.

Results and Discussion

Detailed information has been gathered on the diversity of each agroecology in terms of trees and tree growing niches, the distribution of uses over species, diversity characteristics of niches, diversity characteristics of use-groups, constraints of tree growing, and priority use and niche of existing tree species. The tree species grown by farmers is annexed to the text.

Gamma diversity analysis based on Shannon diversity index showed, Sirinka is the most diverse (3.33) followed by Kalu and cheffa with values 3.24 and 3.2 respectively. Jama is the least diverse agroecosystem with value of 1.93. In general there is a pattern that as elevation increased, diversity of the agroecosystems observed decreased (Table 2).

Comparing evenness and the contribution of the dominant tree, that is the most widely planted tree species, for diversity; Kalu is the most diverse, followed by Cheffa and Sirinka. The high elevated area Jamma is both less diverse and even (Figure 1). Important to mention may be, Sirinka is the most diverse agroecosystem, but the contribution of the dominant species for the observed diversity is very low.

Table 2. Gamma diversity values of the watersheds

Woreda	Shannon	Simp-son	J	E	Berger-Parker	Menhinick	Margalef	McIntosh
Bati	2.97	15.96	0.95	0.84	0.16	3.22	5.60	0.87
Jama	1.93	5.49	0.84	0.69	0.27	1.49	2.36	0.67
Chefa	3.20	17.95	0.89	0.66	0.11	3.34	7.48	0.84
Kalu	3.24	19.53	0.88	0.66	0.08	3.20	7.59	0.84
Wuchale	2.87	11.93	0.83	0.57	0.15	3.15	6.56	0.79
Tehuledere	2.96	13.36	0.85	0.59	0.17	2.71	6.40	0.79
Sirinka	3.33	19.43	0.89	0.65	0.13	3.24	8.12	0.84

Analysis of species by sample matrix by taking the occurrence of use group over species, occurrence in terms of the number of times the use was mentioned showed, growing trees for construction has the highest frequency. It has been mentioned 876 times. This may be due to many tree growers who have diverse tree species grow the trees mainly for this purpose. The other uses were mentioned on average from 214-298, except forage use group which was mentioned 57 times. On the other hand, farm occurrences, the number of households where the use was mentioned, showed fuel wood is the most important use group followed by construction. Interestingly, fuel wood has the highest result in species average, number of species per farm and per use for those farms where the use was mentioned. That means farmers have different alternative for fuel wood or diverse plant species are used as fuel wood (Figure 1). On the contrary extremely low species average value for forage shows, farmers have little or no alternative woody plant that can be used as fodder (Table 3). That means the average number of tree species that can be used as fodder on each household is less than one and there is a possibility that fodder trees are not planted on the farm.

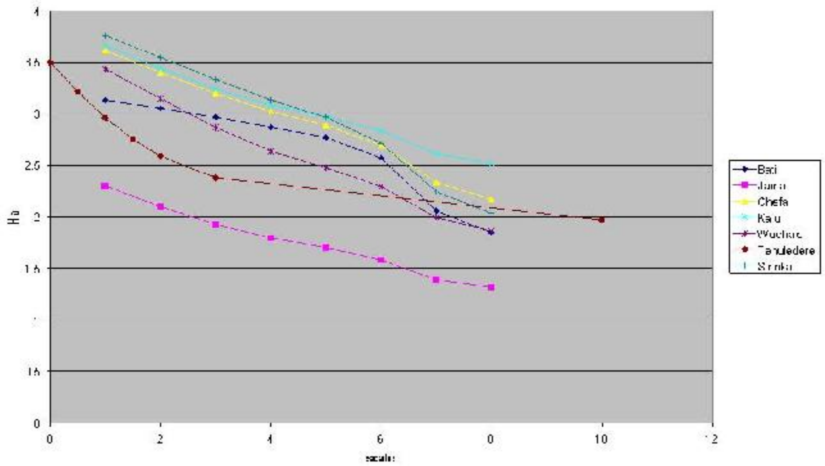

Figure 1. Diversity profile values of the selected watersheds

Table 3. Characteristics of the seven use-groups

Use group	Occurrence[1]	Farm occurrence[2]	Species average[3]
Construction	876	139	2.69
Fuel wood	221	181	10.69
Farm implement	214	117	2.61
Fence	298	161	3.28
Market	221	124	3.63
Lumber	269	128	2.69
Forage	57	55	0.70

[1]*Occurrence: number of times the use was mentioned;*
[2]*Farm occurrences: number of households where the use was mentioned;*
[3] *Species average: number of species per farm and per use for those farms where the use was mentioned*

Analysis of species by sample matrix by taking tree growing niche and the associated plant species showed, homestead areas being the most important tree growing niches followed by trees scattered inside own farm. Live fences and farm boundary is also moderately important tree growing niches. In terms of farm occurrence, number of households where the tree growing niche was mentioned also showed homesteads being the best and preferred niches followed by live fencing and scattering trees in side own farm (Figure 2).

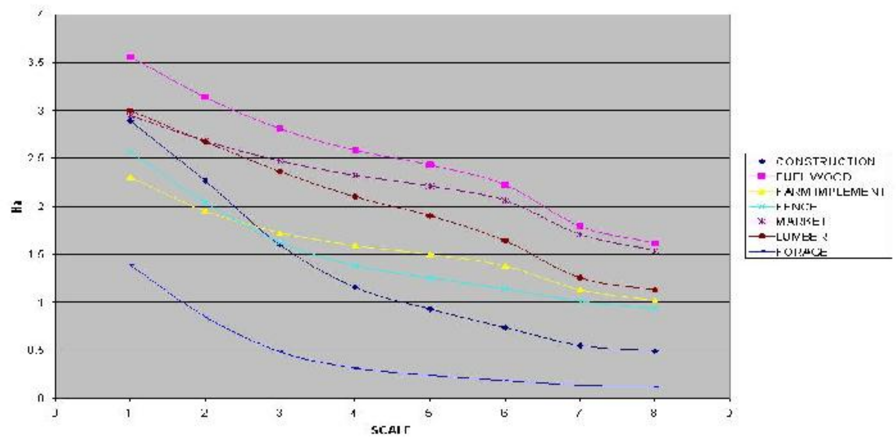

Figure 2. Diversity profile values for the seven use-groups

Note only are homesteads important tree growing niches, they are also diverse as they have higher species-average result, that is the number of species per farm and per niche for those farms where the niche was mentioned (Table 4).

Table 4. Characteristics of the 8 tree growing niches

Tree growing niche	Occurrence[1]	Farm occurrence[2]	Species average[3]
Homestead	746	166	8.88
Live fence	279	163	3.34
Farm boundary	125	77	1.51
Scattered inside farm land	371	121	4.39
Degraded hills	63	24	0.75
Gully	29	15	0.35
River banks	51	15	0.62
Soils conservation structures	31	24	0.38

[1]*Occurrence: number of times the use was mentioned;*
[2]*Farm occurrences: number of households where the use was mentioned;*
[3] *Species average: number of species per farm and per use for those farms where the use was mentioned*

Diversity and productivity of niches and watersheds

Extremely low species- average value for degraded hills, gully, river banks, and soils conservation structures; shows, these tree growing niches are not utilized for growing trees. This may be due to free grazing as these areas are common properties utilized without any regulation, or due to security problems as trees need relatively longer time before being ready for harvest, and the uncertainty during this time who will take the benefit (Figure 3).

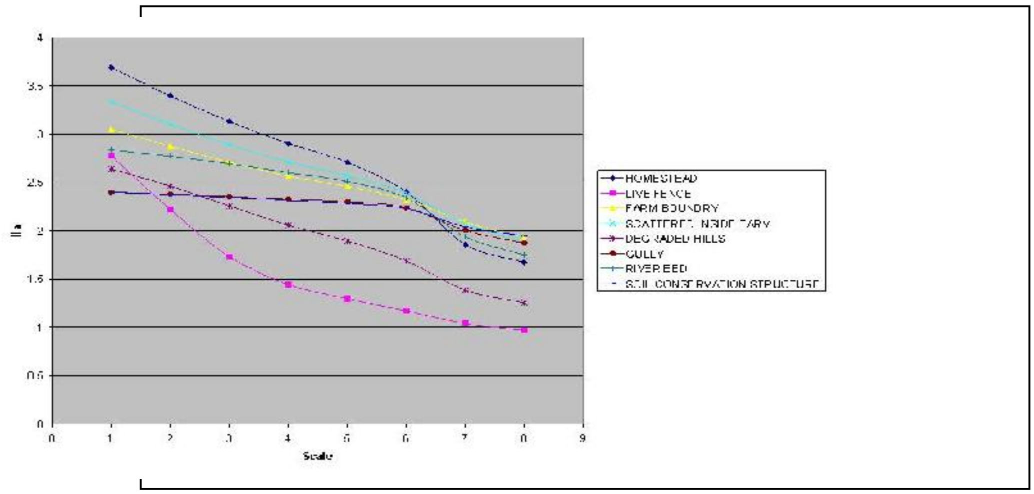

Figure 3. Diversity profile values for the different tree growing niches

The same diversity and evenness pattern is evident from the analysis of diversity and evenness by taking niche across agroecologies. The most important niches for Kolla agroecology are homesteads and scattered trees in own farm. Scattered trees in side farm as tree growing niche got lesser importance in high elevated agroeocologies such as Jamma. Therefore, project that aim to increase diversity should focus on first introducing new species in the area so that to increase diversity. Second, using tree growing niches some how away from the farm where food crops are grown (Table 5).

Table 5. Alpha diversity values across agroecologies

Niche	Watershed	H	J	E	S	Berger Parker	Menhi nick	Margalef	McIntosh
Homestead	Kalu	2.93	0.85	0.60	12.73	0.18	3.16	6.57	9.08
	Tehuledre	2.99	0.86	0.62	13.45	0.19	2.81	6.37	0.80
	Ambassel	2.78	0.89	0.70	11.95	0.19	2.21	4.70	-9.68
Live Fence	Kalu	2.00	0.80	0.62	5.08	0.37	1.95	3.02	5.61
	Tehuledre	1.32	0.64	0.47	2.53	0.59	1.21	1.85	0.44
	Ambassel	1.31	0.67	0.53	2.83	0.49	1.07	1.59	0.48
Farm Boundary	Kalu	1.95		1	7	0.14	2.65	3.08	1.32
	Tehuledre	2.51	0.93	0.82	10.45	0.17	2.5	3.91	0.83
	Ambassel	1.78	0.91	0.85	0.80	0.31	1.94	2.34	0.77
Inside farm	Kalu	2.62	0.89	0.72	10.13	0.2	2.19	4.17	3.63
	Tehuledre	2.55	0.92	0.80	10.96	0.17	2.18	3.76	0.81
	Ambassel	2.39	0.88	0.73	8.40	0.22	2.47	3.88	-5.43
Degraded hills	Kalu	0.69	1	1	2	1	1.41	1.44	0.40
	Tehuledre	1.92	0.93	0.86	5.83	0.31	2.22	2.73	0.81
	Ambassel	-	-	-	-	-	-	-	-
S.conservati on	Kalu	1.33	0.96	0.95	3.57	0.4	1.79	1.86	1.14
	Tehuledre	-	-	-	-	-	-	-	-
	Ambassel	-	-	-	-	-	-	-	-
River bank	Kalu	-	-	-	-	-	-	-	-
	Tehuledre	2.44	0.98	0.96	10.89	0.14	3.21	4.15	0.95
	Ambassel	2.04	0.98	0.96	7.36	-	-	-	-
Gully	Kalu	-	-	-	-	-	-	-	-
	Tehuledre	-	-	-	-	-	-	-	-
	Ambassel	1.39	1	1	4	0.25	2	2.16	-1.5

Farmers get planting materials from different sources. For instance source of seedling by ownership shoed 66.70 % of the respondents got their seedling from government nurseries and 50.94% from their neighbor and the rest from their own.

The most valued tree or shrubs (in order of decreasing importance) *Eucalyptus globules, Eucalyptus camaldeulesis, Chata edulis, Acacia seyal, Psydium guava, Mangifera indica, Persea Americana, Citrus sp., Cordia Africana, Albizia gummufera, Grewia ferruginea, Ehretia cymosa, Erythrina abyssinica.* The list of species encountered during the survey is annexed to this text.

The most important tree management activities (in order of decreasing importance) are side pruning, lopping, hoeing, weeding, manuring, and fencing. Thinning, that is reducing the stocking number as the tree grows in size, was not mentioned as a management activity.

Major tree diseases or pests include termite on Eucalyptus and Khat; unidentified worm on Coffee, Khat, Citrus, and Eucalyptus; wood pecker birds on Cordia; insects on Ziziphus; and beetle on mango. The extent of the damage in all instances was reported to be high.

Gender segregation in to male and female headed households for diversity of niche and tree species showed, male-headed households had highest species richness values than the female headed house holds. In terms of niche, *homestead* and *scattered inside farm* are important tree growing areas and *live fence* and *boundary planting* for the female headed ones. This may be related to security to farm and home.

Wealth as determined by the number of cattle, seem to have no impact on the species diversity characteristics of the studied house holds. The results do not show consistent results (Table 6).

Table 6. Percentage (%) of respondents as their source of wood for various purposes

	Farm	**Homestead**	**Near Forest**	**Market**	**Neighbor**	**Other**
construction	9.67	83.33	0	7	0	0
farm implement	3.33	91.67	3	2	0	0
fodder	72	25	3	0	0	0

inside farm or from the adjoining forest or woodland. Very small fraction of the wood supply comes from other tree growing niches.

The average numbers of uses per species and use-group frequencies highlight the potential value of extension messages on alternative uses of species. Widespread extension of information on potential uses of species that do not occur on all farms at present could result in increased on-farm diversity if this information would encourage farmers to incorporate new species in their farm.

Niches or use groups with low diversity should be targeted for diversification. The gamma diversity provides suggestions on how alpha diversity can be improved. For niches or use groups with higher gamma diversity, a wider distribution of existing species within the area would offer one method of enhancing alpha diversity.

For low gamma diversity niches or use groups, for instance forage, the solution would be to introduce new species or to promote alternative uses for species that are already present. Increasing gamma diversity could also result in increased stability and productivity at the landscape level.

Diversification could be targeted towards more important use-groups, rather than targeted towards those groups which have low diversity. The major emphasis should be on economic importance and importance for the household food security

The major points that need attention when a new niche and/or use is introduced should, first the quality of production of these species for a particular niche or use; second the complementarity in production in the existing land use system for instance compatibility with crops and grazing situation; and third, the characteristics of the species. The decision could be made not to promote all uses. Decreasing the number of uses per farm could result in higher profitability per farm.

An analogy is the criterion introduced by Van Noordwijk et al. (1997) on the relationship between biodiversity and profitability. If initial diversity loss would result in large gains in profitability, then these authors suggest that a segregation (specialisation) approach may be more appropriate – if increment of profitability is the major goal for the landscape.

Similarly, Van Noordwijk & Ong (1999) indicated that the value of diversity in agroecosystems strongly depended on the ability of farmers to derive value from a large number of components, and not from one dominating component.

Reduction in the number of species for a particular niche or use-groups per farm could result in substantially greater risks to individual farmers, therefore needs great care.

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Annex 1. Species list in each agroecology

No.	**Woina- Dega**	**Kolla**	**Dega**
1	*Acacia decurrens*	*Carisa edulis*	*Acacia decurrens*
2	*Acacia saligna*	*Eucalyptus camaldulensis*	*Buddleja polystachya*
3	*Carisa edulis*	*Coffee*	*Cupressus lusitanica*
4	*Catha edulis*	*Catha edulis*	*Chamaecytisus palmensis*
5	*Calpurnia auria*	*Euclea recemosa*	*Dombeya torrida*
6	*Chamaecytisus palmensis*	*Calpurnia auria*	*Erica arborea*
7	*Cupressus lusitanica*	*Delonix regia*	*Eucalyptus globulus*
8	*Coffee*	*Acacia etbaica*	*Hagenia abyssinica*
9	*Eucalyptus globulus*	*Jejeba*	*Hypericum quartinianum*
10	*Euclea recemosa*	*Karor*	*Juniperus procera*
11	*Juniperus procera*	*Kombocha*	*Maesa lanceolata*
12	*Lomi Citrus*	*Ziziphus spinachristi*	*Olea africana*
13	*Maesa lanceolata*	*Lomi Citrus*	*Salix subserata*
14	*Mangifera indica*	*Mangifera indica*	*Senecio gigas*
15	*Moringa stenoptela*	*Papaya*	*Vernonia amygdalina*
16	*Olea europea ssp. cuspidata*	*Acacia saligna*	
17	*Papaya*	*Sebansa*	
18	*Sesbania sesban*	*Sesbania sesban*	
19	*Syzygium guava*	*Moringa stenoptela*	
20	*Salix subserata*	*Woyiba*	
21	*Senecio gigas*	*Zeitun*	
22	*Vernonia amygdalina*		