Forestry/Agroforestry

Study on Indigenous Tree and Shrub Species of Churches, and Monasteries of Wag-Lasta District

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Introduction

It is a common scenario in Ethiopia that forest areas composed of indigenous trees and shrubs are dwindling at an escalating rate as a result of high dominating whereby the family Fabaceae is a significant contributor to the biomass of the area. Several species of Acacia (A. abyssinica, A. albida, A. seyal, A. tortilis, etc.), Albizia gummifera, Celtis africana, Cordia africana, Croton macrostachyus, Dodonaea angustifolia, Ekebergia capensis, Erythrina abyssinica, Euphorbia candelabrum, Hagenia abyssinica, Juniperus procera, Olea europaea subsp. cuspidata, etc. are dominating (Aalbaek, 1993). The vegetation in the area could be categorized under dry Acacia-dominated Afromontane forest (Friis, 1992; Kebrom, 1998). The objectives of the study, therefore, were to collect information on the availability and status of indigenous trees and shrubs; and to assess opportunities of obtaining seed sources of indigenous trees and shrubs for the future research and development works

Materials & Methods

Site selection

Site selection was handled through series of steps. First the whole church data in the mandate area was recorded. Secondly, ancient churches that are greater than 30 years of age were recorded. Third, information on churches' and monasteries' natural forest, which may have greater than 1.5ha were collected from the district agricultural offices. Then at office level sample churches were distributed evenly across the altitudinal ranges of the research mandate area. Finally 7 churches were selected for survey.

Sampling design

The general samplingdesign employed was systematic-stratified design. Actually the sampling designs employed in some forest fragments were deviated from the general design due to forest composition and land terrain feature. Transects were laid down in 100 m internal and a 100 m^2 circular plots and 16 m^2 subplots were employed at each 50 m interval in each transect. Occasionally, the gap 50 m and the shape 100 m^2 circular plot were corrected for ease of survey.
Churches have been selected by sratifaying them in to Kolla, Weyna dega and Dega agroecologies. In such a way, two churches were selected in each agroecological zones of Weyna dega and Dega and only one monastry was selected for Kolla agroecolgy depending on the availability on church and monastry forest in the mandate area.

Data collection

In each plot species were identified and height and DBH were recorded in each plot. Taking a 4×4 m sub-plot in each plot, sapling and seedling counts were recorded. Moreover, other important data of every tree and shrub species were collected through questionnaire.

Data analysis

Species identification

Species were identified using the manuals entitled Useful Trees and Shrubs for Ethiopia (Azene, 1993), Flora of Ethiopia, Vol. 3 (Hedberg and Edwards, 1989), Flora of Ethiopia and Eritrea, Vol. 2 Part 2 (Edwards, et al, 1995) and Flora of Ethiopia and Eritrea, Vol. 4 Part 2. Thus, nomenclature followed were that of Azene (1993), Hedberg & Edwards

(1989, 1995), Edwards et al. (1997), Edwards et al. (1995), Friis (1992) and Woldemichael Kelecha (1980).

Species richness and Diversity indices

Shannon Diversity Index and Simpson Diversity Index were used. Species richness is estimated with the total number of observed species. The Shannon Diversity Index is calculated by multiplying a species proportional abundance by the natural log of that number:

$$H = -\sum p_i \ln p_i$$

Where p_i is the proportion of individuals found in the species "i". This index assumes that individuals are sampled randomly from an infinite or very large population. Similarly, it supposes that all species are represented in the sample. The value of the Shannon Diversity Index usually falls between 1.5 and 3.5 and only rarely exceeds 4.5.

The Simpson Diversity Index is defined as the sum of squares of proportion abundance of each species:

$$D = \sum p_i^2$$

As D increases, diversity decreases. Therefore, the Simpson Diversity Index is usually expressed as 1 -D or 1/D. Where 1 - D is used as the index, it ranges from 0 to 1, with values close to 1 showing a community of many species with equally low abundances while numbers close to 0 express fewer species with one of them clearly dominant.

Basal area, species density and regeneration status

Basal area for each species was analyzed using the formula: $BA= \pi D^2/4$. And the basal area per hectare was analyzed using the formula: $G=\pi/40000*\Sigma D^2/a$. Species density was summarized from total number of individual abundance in each species. .

Regeneration status was analyzed by looking at the tree diameter size distribution known to be population structure. Normally it shows the proportion of seedlings, saplings and mature tree for each species in all churches. Population structure or tree stem diameter distribution has been used to infer past disturbances, regeneration patterns and successional trends in tree populations (Tamrat, 1994; Demel, 1997a; Mekuria et al., 1999; Tadesse et al., 2000; Feyera et al., 2002). Besides, the diameter distribution can be used to construct stand tables and estimate stand volumes of a wide range of products. A diameter size class distribution that drops exponentially with increasing diameter at breast height (DBH) is characteristic of species with good rejuvenation (Kebrom, 1998). Such a distribution is often referred to as an inverse J-shaped distribution. In contrast, flatter distribution curves indicate a lack of recruitment and perhaps changes in species composition (Tamrat, 1994; Demel, 1997a).

Results and Discussion

According to Shannon diversity indices, only Barkidane Mihret monastery has a good number of tree and shrub species but the other church forests are covered by a kind of forest which is dominated by a very few number of species. For example, only 5 tree and shrub species were discovered from each churches of Yimrhane Kiristos(50 plots) and Ayna Eyesus(62 plots). The difference in their species richness and diversity between

Barkidane Mihret monastry and the other surveyed churches is due to their difference in agro-ecological location, and difference in management. Regardless of their difference in altitudinal location, Ayna Eyesus (at 5 species) from Weyna Dega and Yimrhane Kiristos(at 5 species) from Dega reflects similarity in their species richness and diversity. The main reason for their similarity could be other factors like, soil, slope and management of the areas. Meanwhile, the presence of only saplings and seedlings with out their respective mature ones in almost all churches might reflect that succession is or will taking place between very important indigenous trees and less quality shrubs.

Species richness, and diversity

The highest shannon diversity indices exhibited in the Kolla agroecology of Barkidane Mihret at a value of 2.5 and of course it has the highest number of species among the churches though it has the lowest number of plots (Table 1). The remaining churches, except the Asketema church of Weyna Dega agroecology, have below 1.5. Generally, there is a general difference in species richness and diversity across agroecological locations though Dega and Weyna Dega show similarity (at Dega=23 species from two churches, Weyna Dega=18 species from two hchurches, and Kolla=20 number of species from one monastery which is the smallest number of plots).

Table 1: Species richness and diversities in the communities.

	DEGA		**Weyna dega**		**kolla**
	Nakuto Leab	**Yimrhane Kirstos**	**Ayna Eyesus**	**Asketema**	**Barkidane Mihret**
Plot number	62	50	62	19	14
Individuals	207	262	316	131	67
Species	18+4*	5+4*	5+16*	13+5*	20+8*
Sapling	42+19*	52+15*	142+43*	58+23*	57+7*
Seedling	164+124*	29+162*	131+490*	1263+103*	73+13*
SW diversity	1.48945	0.536	0.629	1.83712	2.495
Simpson’s diversity	0.38928	0.715	0.60365	0.18515	0.12939

- Where * is the number of saplings and seedlings that does not have representative matured individuals.

Basal area and density

Basal area (BA) varies from 0.028 m^2 at Ayna Eyesus to 1.192 m^2 at Yimrhane Kirstos. Basal area per hectare varies from 78.45 m^2 at Asketema to 693.41m^2 at Yimrhane Kirstos(Table 2).

There were totally 63 species in the surveyed area. The species density varies greatly, ranging from 1 (for 15 species) to 525 stems for *Juniperus procera* (Table 2).

Table 2: Total species, individuals and basal area at each site and per hectare

	Dega		**Weyna dega**		**Kolla**
	Nakuto Leab	**Yimrhane Kirstos**	**Ayna Eyesus**	**Asketema**	**BarkidaneMihret**
Species	18	5	5	13	20
No. of individuals	207	262	316	131	67
BA	0.041	1.192	0.028	0.039	0.066
BA/ha=G	265.754	693.41	481.27	78.45	132.72

Tree Population Structure

As already mentioned Population structure or tree stem diameter distribution has been used to infer past disturbances, regeneration patterns and successional trends in tree populations (Tamrat, 1994; Demel, 1997a; Mekuria et al., 1999; Tadesse et al., 2000; Feyera et al., 2002). A diameter size class distribution that drops exponentially with increasing DBH is characteristic of species with good rejuvenation (Kebrom, 1998). Such a distribution is often referred to as an inverse J-shaped distribution. In contrast, flatter distribution curves indicate a lack of recruitment and perhaps changes in species composition (Tamrat, 1994; Demel, 1997a).

In the case of Wag-Lasta churches, the stem diameter size distribution does not show an inverse J-shaped distribution for the dominant species such as *Olea europea ssp. Cuspidata* and *Juniperus procera*. The diameter class distributions exhibited different trends from species to species within a church forest and among church forests, even for the same species (Fig.). The major observed diameter distributions observed are: species having individuals only at the lowest class or the two lowest classes, or species having a high proportion of individuals at the lowest class and a sharp decline at the next class/classes followed by a gradual decline in the number of individuals towards the next classes. In many instances there are populations where species having a high proportion of individuals at the lowest class and a sharp decline at the next class/classes followed by a gradual decline in the number of individuals towards the next classes , but with missing individuals at one or several of the classes.

In undisturbed natural forests, it is common to see the number of seedlings, number of saplings, number of matured ones for a species. However, in the case of this study the reverse was true. As seedling-sapling-mature tree and shrub pattern graphs shows very irregular patterns in almost all the species in all churches and monastery except Olea Africana of Ayna Eyesus seems proportional(100-100-89). This reveals that the perpetuation of the species is questionable unless urgent silvicultural measures take place like improving gene pool, viability of soil seed bank, thinning and the likes. Further the data shows forest stewardship problem of the churches and monastries. And hence, there is the need to revise the stewardship system of church and monastery forests.

Tree population structure also called diameter distributions of trees, number of trees over diameter at breast height, are strongly related to forest structure and disturbance history. They have been successfully used in distinguishing young, mature, and old-growth stands, in measuring similarity to old-growth structure, and in describing successional pathways and structural development (Demel, 1992). The reverse J-shaped form has been traditionally considered an essential feature of balanced, uneven-aged diameter distributions; on the other hand there are deviations from this curve in a steady state condition.

The two parameter Weibull distribution function was used to model the diameter distribution of the dominant tree species in the church forests of Wag-Lasta

$$F(x) = 1 – e^{-(x/\beta)\alpha}$$

This distribution is characterized by the distribution function F(x), the number of trees at DBH class x, the scale parameter β, the slope parameter α, and the DBH(x) in cm. This function is very successful in fitting stem-size distribution data and is popular with

modelers dealing with uneven-age stands. Most forms of the distribution show either a simple decline or a unimodal form. Depending on the shape parameters, the distribution is skewed to the left, symmetrical, or skewed to the right. The scale parameter (β) is approximately equal to the median DBH while the shape parameter controls the skewness of the distribution. When the shape parameter becomes less than 1 the curve approaches an inverse J-shape distribution. Model parameters were determined by means of linear regression and maximum likelihood methods (Sheil and Salim, 2004). The disparity between the observed and the predicted distribution and between sites was explained by the responsible ecological factors (Lykke, 1998; Swaine, 1998).
The mean value of the scale parameter β approaches the median value, and the value of the scale parameter shows skewness. When the value of the scale parameter is less than 1 it will be skewed to the right and approaches inverse J-shaped distribution. Most of the shape parameters showed skewness to the right, their peak towards the higher diameter classes. Tree diameter distribution fitted with the two parameter Weibull distribution function.

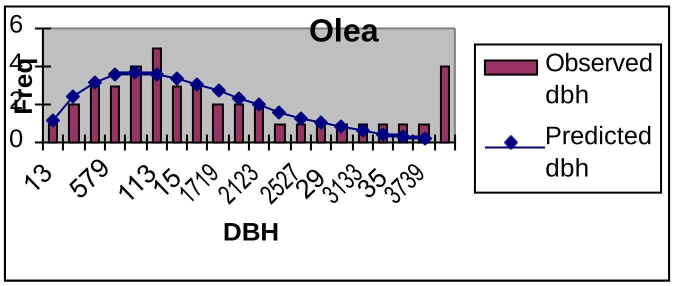

Figure 1: Tree diameter distribution for *Olea europea ssp. cuspidata* f or the Asketema church

Despite the presence of good number of individuals in the middle and upper diameter classes, there is lack of individuals in the lower diameter class may be due to trampling by human or lack of favorable environment for the establishment of seedlings, may be due to lack of viable seeds or soils moisture.

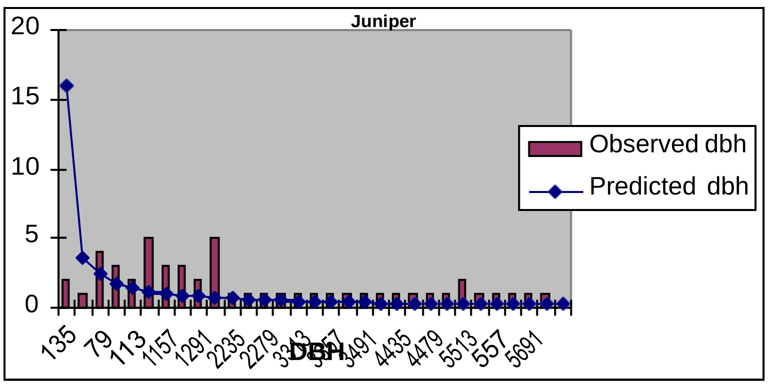

Figure 2: Tree diameter distribution for Juniperus procera for the Asketema church

The same trend is observed on Juniper. The only difference may be it has an inverse j-shaped distribution, but with great disparity between the observed and predicted values. The same biotic and abiotic factors might have been responsible for the observed population structure.

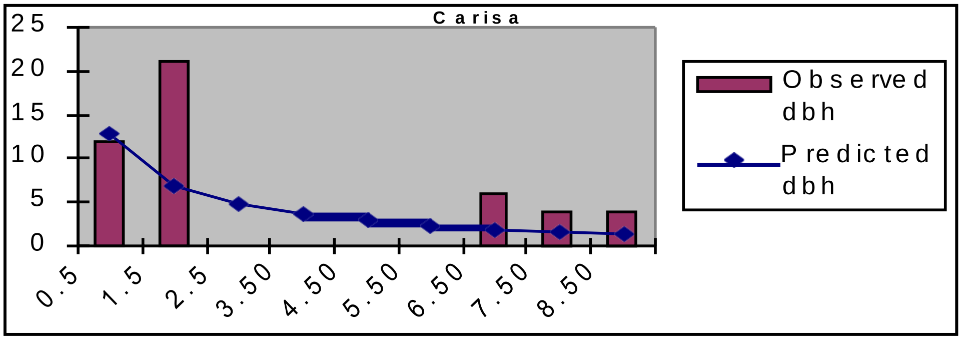

Figure 3: Tree diameter distribution for Carisa edulis for the Asketema church

When it comes to the diameter distribution of the shrub species *Carisa edulis*, it is found in good condition. The observed number of individuals is higher than the predicted one, and yet with great variation between the observed and the predicted one. This observed population structure might be due to due to species specific virtues such as being thorny and having low quality wood, or the ability to germinate its seeds in harsh environments.

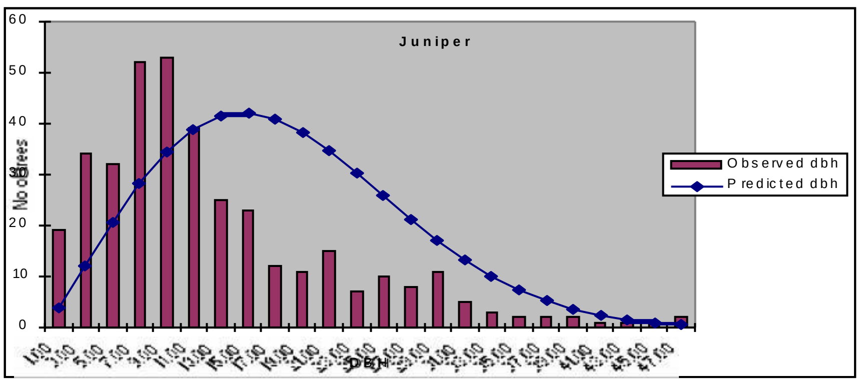

Figure 4: *Juniperus procera* for the AynaYesus Church

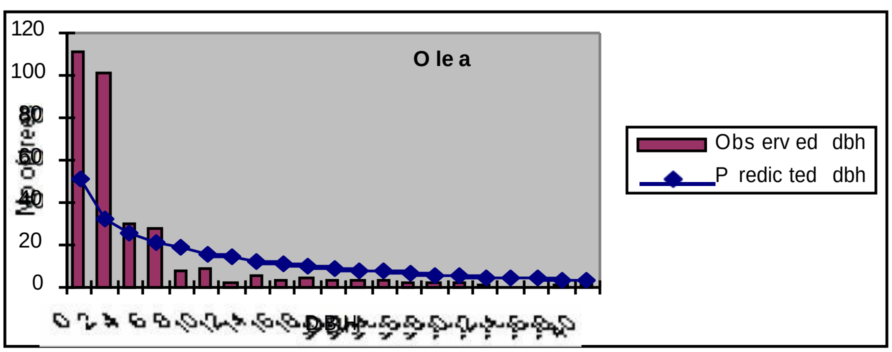

Figure 5: *Olea europea ssp. cuspidata* for the Aynayesus Church

There is no as such remarkacble difference between the observed and predicted diameter distribution at AynaYesus. Juniper is under estimated at the lower diater class and over estimated in the higher diameter classes. This might be due the secession of deleterious factors responsible for the death of seedlings such as trampling by human and livestock, or closure of the area.

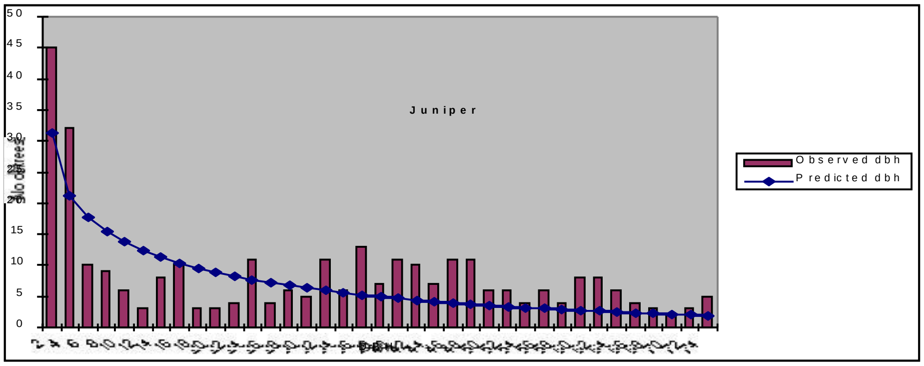

Figure 6: *Juniperus excelsa* diameter distribution for the Yemerahene-Kerstos church

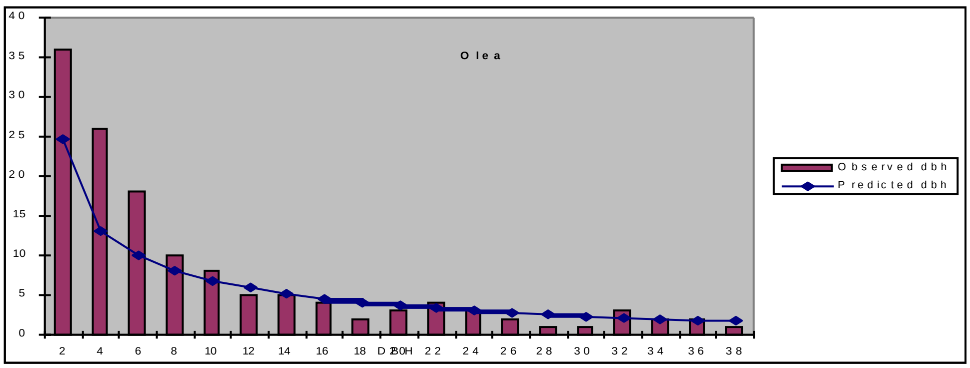

Figure 7: Olea europea ssp. cuspidata diameter distribution for the Yemerahene-Kerstos church

The tree diameter distribution of the dominanat species at Yemerahene-Kerstos showed typical J-shaped distribution which is supposed traditionally as an essential feature of balanced, uneven-aged diameter distributions. The fact that the church is located far away from urban areas, and its importance as a religious figure, contributed for the observed tree population structure. As far as silvicultural management in the *Juniperus procera* population is concerned, there might be a need to thin some individuals in the 20-40 cm diameter class so that it will have typical inverse J-shaped distribution.

Basal area, and Species density

All the churches and monastry exhibited basal area per hectare ranging from 78.45 in Asketema to 693.41 at Yimrhane Kiristos. This reveals that there is a good stands of forest except for Yimrhane Kirstos and Ayna Eyesus which are over stocked. Further more, the data on the two churches show the need to take urgent appropriate silvicultural measures like thinning and others.

Only two species, (*Juniperus procera(52.34%) and Olea Africana(30.20%)*), totally controlled about 82.55% of the total stand density. And only six species covers about 10.56%. The rest 55 species (87.30% out of the total number of the species), covers below 10% of the total density in total. This can further disclose that the church forests are dominated by a large number of rare species. Existence of these much rare and unique species indicates the severity of species threat all over the sampling units.

Conclusion and Recommendation

To safeguard the dying species and keep up the potentials the following conclusion and recommendations are forwarded.

- Silvicultural measures like enrichment plantation: in almost all surveyed churches, it is observed that the forest were dominated with old aged trees that shows the dying nature of the whole church forest in the near future unless urgent silvicultural measures like enrichment plantation, thinning and the likes are taking place.
- Improvement of the gene pool and viability of soil seed bank is paramount to perpetuate the species. Poor in the genetic pool and soil seed bank viability of the species might be one reason that made the domination of old aged trees and shrubs. Otherwise the perpetuation of the species in such a way is questionable
- Attitudinal change in stewardship system of church forest: there is frustration from the priest and community that planting seedlings inside the forest brings the wrath of God rather only guarding is safe and blessing. The forest is there untouched since our forefathers planted. They use only that naturally died and fell for different religious purposes like for smoking during Mass, church construction and the likes.
- Establishing and strengthening collaborative partnership with Ethiopian Orthodox Church, BOA, NGOs, GOs, local communities, administrative bodies and other respective partners for technical, financial, stewardship, managerial and administrative synergies and complementarities is necessary.
- Establish activities like implementing income-generating projects to make the local communities become direct beneficiaries from the church forest. Such a deed might trigger a motive and owner ship feeling.
- Needs due attention and back up of policy makers in guarding and widening of EOC forest hold by their land administration policy
- Housing for religious ceremonies: there were open areas for communal meetings like Senbete, and the likes in Churchyards of Ayna Eyesus, Barkidane Mihret, and Nakuto Leab. Performing these things in houses could reduce forest depletion.

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Annex Table 1: Density and occurrence of species

Local name	**Species**	*Family*	Density	No. of SGs of occurrence	No. of SPs of occurrence
Kitkita	*Dodonaea angustifolia L. f.*	*Sapindaceae*	6	154	17
Yebesha tiid	*Juniperus procera* L.	*Cupressaceae*	525	42	95
Kechme				175	18
Weyra	*Olea africana* L.	*Oleaceae*	303	129	116
Atat	*Maytenus arbutifolia* (A. Rich.) Wilczek	*Celastraceae*		371	31
Embs	*Rhus vulgaris* Meikle	*Anacardiaceae*	19	14	
Beles	*Opuntia ficus-indica Mill.*	*Cactaceae*		12	5
Tallo	*Rhus retinorrhoea* Olive.	*Anacardiaceae*	11	14	4
Girar	*Acacia abssynica* Hochst.ex Benth.	*Mimosoideae*	1		
Atana			8	2	
Tsalwa			20	11	44
Shefelda			3	11	1
Egula			3	2	
Arna			1	23	1
Abika			5	7	2
Ekma			3	1	1
Bete musie			1	2	2
Mita				1	3
Ebrna					1
Angula			4		1
Amla			2		1
Lessa				2	
Maloza				2	
Tsiwa			2	12	
Lomii				2	
Dedeho	*Euclea schimperi* (A. DC.) F. White	*Ebenaceae*		10	19
Luciniya			10	5	1
Morla					1
Milta				1	1
Gba	*Zizyphus spinachristi (L.) Willd.*	*Rhamnaceae*			1
Shesha					
Firtata	*Adansonia digitata L.*	*Bombacaceae*	2		
Tigualmata					
Gita			1		

Annex Table 1 (contd.):

Degima			2		
Tulsa			1		
Warka			1		
Shola	*Ficus sur Forsk.*	*Moraceae*	1		
Kulqual			24	14	1
Agam	*Carisa edulis* (Forrk.) Vahl	*Apocynaceae*		27	24
Temblel			1	44	5
Msrosh	*Clerodendrom myricoides* (Hochst)R.Br.ex.Vatke	*Verbenaceae*		6	6
Yesit kibat				1	
Koret	*Osyris quadripartite* Decn.	*Santalaceae*		5	5
Merez			8	1272	3
Segeg			1		
			22	66	19
Dgta					
Yabsha grar					2
Smiza				2	
Nechlo			1	3	
Sola				10	
Simayteru			2	1	
Azamira			1		
Yetotakolet			1		
Akakma				8	
Feyelefeg				3	
Bazragrar				1	
Doret			1	3	
Kokoba			1		
Yewrawat					
Nechigrar					1
Hmasta			1	2	1
Dodota			4	8	
		Total	1003		