Monitoring of the Golis Mountain Forest in Somalia

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1 Background

1.1 General

SWALIM phase III did identify loss of vegetation cover as one of the main land degradation types in Somalia. Other land degradation types identified during SWALIM Phase III included loss of topsoil, gully erosion, and loss of soil nutrient in agriculture productive areas. SWALIM phase III also did conclude that these degradation types occur due to aridity, over-grazing, tree cutting for charcoal production and construction materials, increase of settlements and water points, continuous mono-cropping, lack of nutrient management, increase of enclosures, and encroachment of crop cultivation into marginal rangelands.

"For the first few days in the range, one is taken by the beauty and variety of flora, a natural botanical garden. It was on the fourth day, as we were sitting on a ledge overlooking the great cliffs that surround the Tabah Gorge, that it hit us . thud ... thud . thud. Yes, it was an axe chopping a tree. We turned our ears and eyes to locate the source of this logging. Far away in a distance we saw a plume of smoke rising from the thick canopy. From then on and for the next four days, we saw only destruction, juniper trees felled like matchsticks, huge 100-year old Commiphoras cut for charcoal and building material, areas cleared for Qat plantations, total destruction of a pristine and extremely exotic forest. It was sad to discover that the origin of the sweet smell we enjoyed a few days before in our camp fire was not so innocent: aromatic Commiphoras turned into charcoal. Old trunks of Juniperus procera cut to make firewood, charcoal or building materials are not an uncommon sight". http://www.plant-talk.org/stories/36somali.html

One of the main recommendations of SWALIM phase III was the establishment of land degradation monitoring systems for Somalia. In response to this recommendation and considering that the Golis forest is facing such wanton destruction, and also given that successful resource management should be based on facts about the ecosystem, SWALIM phase IV has planned to establish a strategy for monitoring Golis forest in Somalia. The aim of this monitoring activity is to continuously generate data on the Golis forest ecosystem. This data will

subsequently aid in the sustainable management of the Golis forest ecosystem management.

1.2 Geographic Location

Golis Mountain range (Cal Madow range) extends from the border with Ethiopia in the northwest to Cape Guardafui (Ras Casayr) in northeastern Somalia. The general elevation along the crest of the mountains averages 1800 meters and 2100 meters above sea level. The highest peak is Mount Shimbirberis, lying in the central part of the Golis and rising to 2416 meters. This mountain lies about 19 km northwest of Cerigaabo. A fault zone demarcates the northern front of this section of the mountain. The boundary of the uplifted area is separated from the Gulf of Aden by a coastal plain varying in width from 60 kilometers in the west to less than 1 kilometer in the east.

1.3 Climate

The Golis mountain range receives the highest amount of rainfall in the northern regions. The rainfall is over 700mm yearly due to the influence of the relatively high altitude factor. The mountain range receives additional precipitation in form of plenty of mist from the sea. The average annual temperature ranges 20-22^{0}C. Figure 1 shows the mean annual rainfall distribution in Somalia while figure 2 shows the monthly distribution of rainfall Somalia.

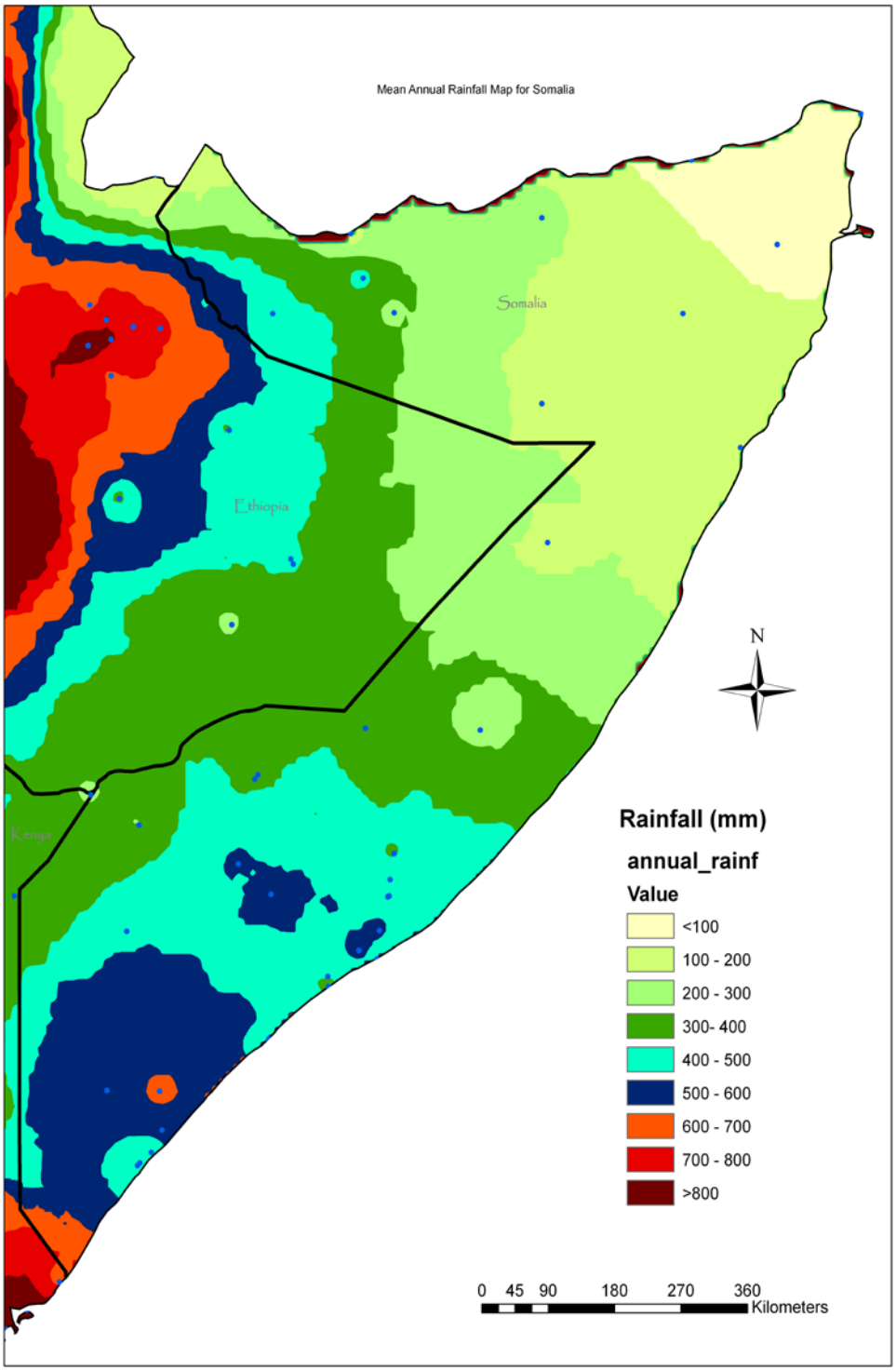


Figure 1: Mean annual rainfall for Somalia

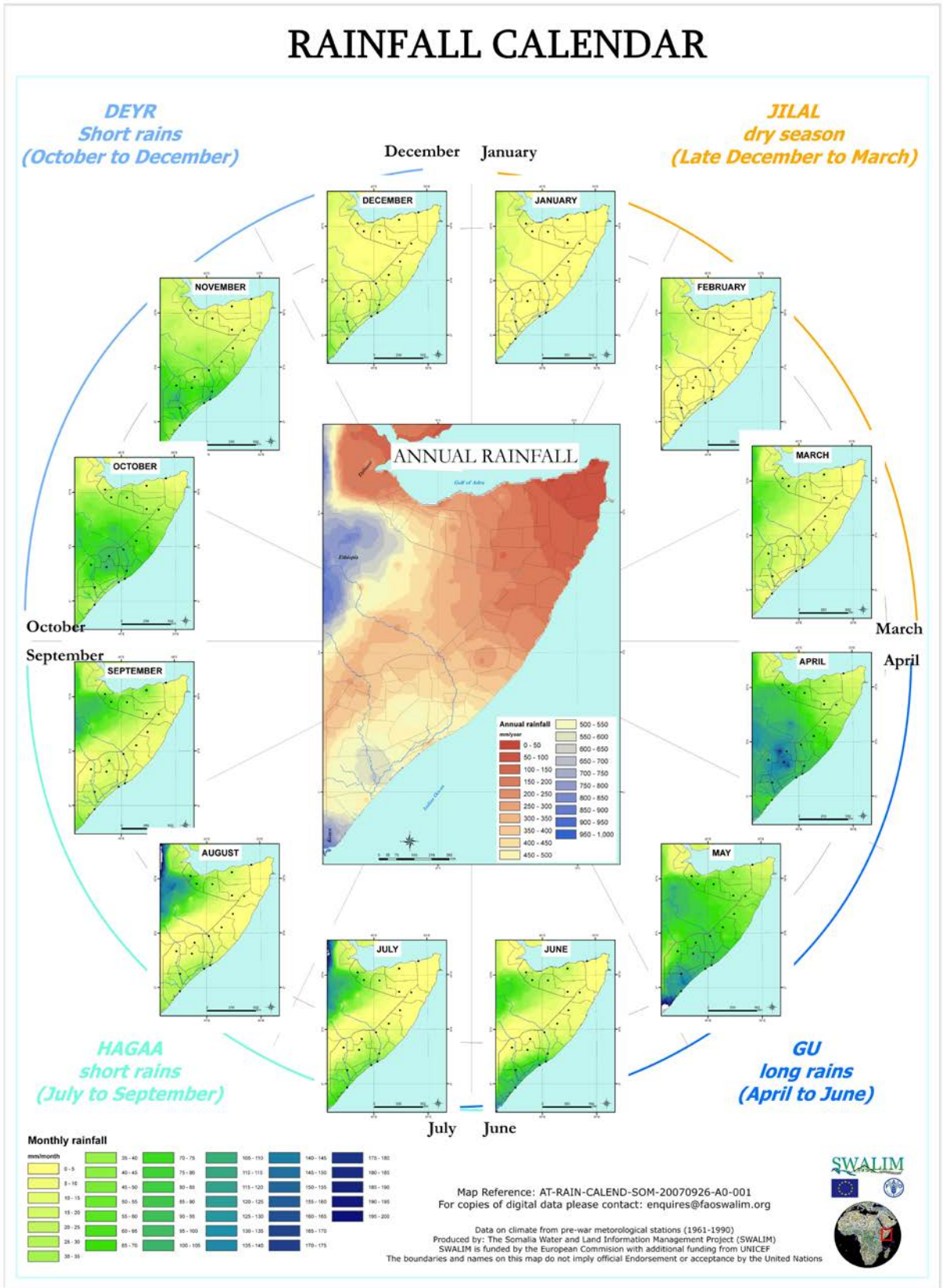


Figure 2: Mean monthly rainfall for Somalia

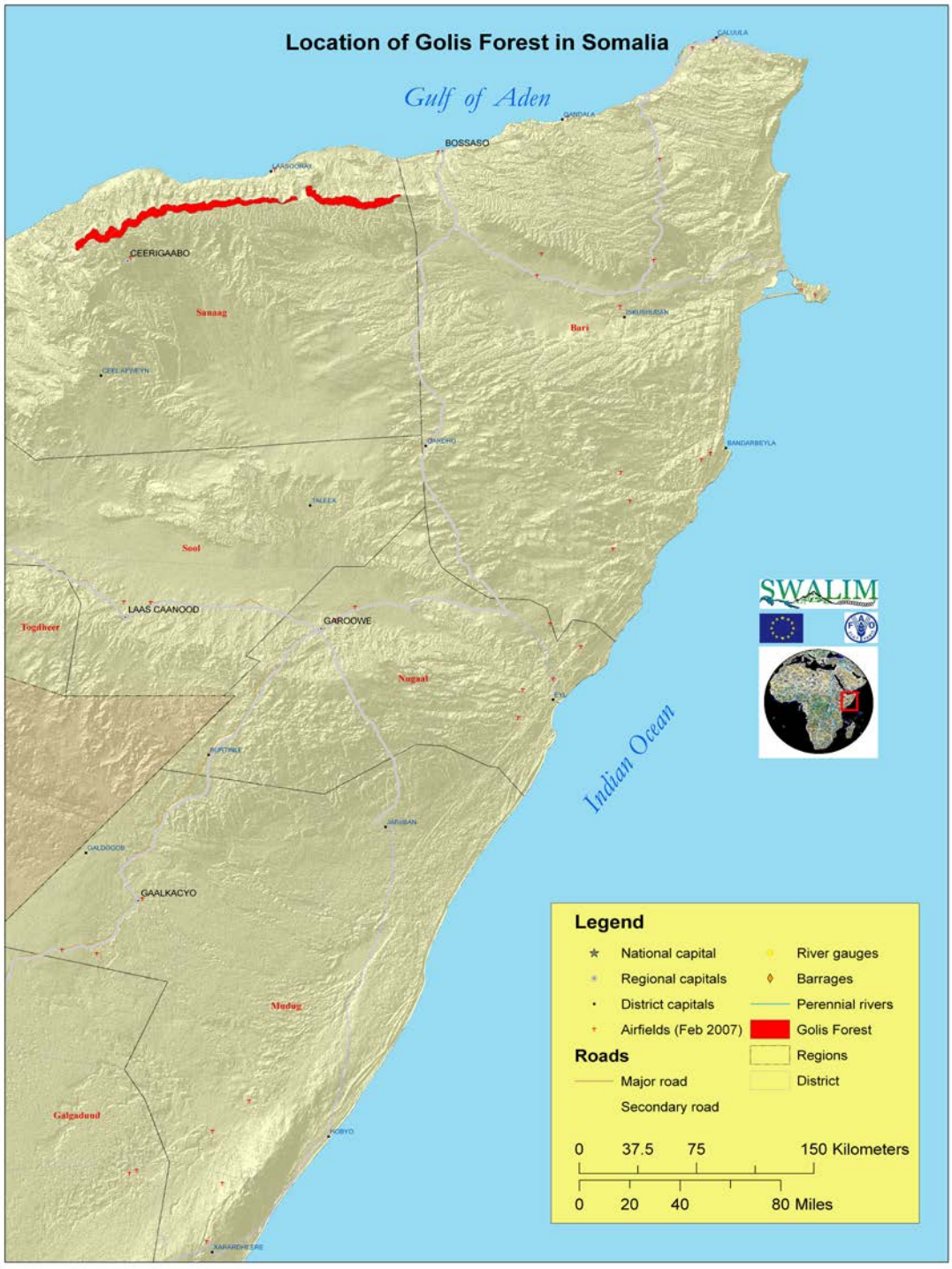


Figure 3: Location of Golis Mountain Forest in Somalia

1.4 Golis Mountain Forest (Figure 3)

Forests cover on the higher elevation of the mountainous terrain of Golis Mountain range from several km west of Boosaaso, in Bari Region, to the northwest of Cerigaabo, in Sanaag region. The Golis Mountain forest area comprises of the Daallo and Suurad Plateau forests south of the escarpment edge, and the Cal Madow escarpment forest and scrub areas. This forest vegetation was covering nearly about 1 million hectares before the collapse of government institutions for environmental protection (in 1991). These forests constitute the major part of the only true forest areas in Somalia and are important centers of biological diversity and species endemism.

The area contains some remnant patches of Juniperus procera (Cedar tree known as Dayib in Somali) species. The Juniperus procera forest is associated with *Olea africana* (Weger), *Sideroxylon buxifolium* (Shooy), *Pistacia spp* and all species in broadleaved dry mountain forests. Other plant species include *Dracaena schizantha* (Mooli) and bushes of *Buxus hildbrandtii* (dhosoq).

According to Hemming (1966) the *Juniperus* forests are found on the best developed soils in Sanaag Region which has a valuable capacity to absorb water from rain and mist for storage and gradual release. The regular mist is crucial factor favoring the survival of Dayib during prolonged dry seasons.

1.5 Use of the forest products

The natural forest is normally cut and the deforestation is caused by the following factors.

1. Production of firewood and charcoal for domestic cooking and export
2. Clearing of forests for agriculture
3. Production timber for construction materials (doors, windows and furniture) and wood for livestock enclosures and fencing farms
4. Overgrazing of the forests by livestock during droughts

1.6 Threats

The poorly regulated land-use change and deforestation leads to many environmental problems such as vegetation denudation, loss of biodiversity and soil erosion. Over the last three decades, there has been growing danger of forest cover reduction and serious deterioration of the fragile environment ecosystems. This will have major implications on Somalia's ability to conserve its natural resources (UNEP, 2005). These threats require quick-fix solutions that are based on timely information base.

2 Objectives

The overall objective of the project was to generate baseline data for monitoring of the Golis mountain forest.

Specific objectives were to:

1) generate baseline data on vegetation (species composition, frequency, density and cover) of the Golis forest
2) produce a land cover map of the Golis mountain Forest.
3) outline the activities related to resource use and management in the Golis forest ecosystem.
4) Establish monitoring sites within the Golis forest

3 Methods and materials

The methods used in this activity included the following:

1. Interpretation of satellite Images
2. Ground field ecological observations
3. Interviews with the local people on use and management of the Golis forest

3.1 Satellite image interpretation

3.1.1 Preliminary land cover mapping

A preliminary land cover map, of the Golis forest ecosystem, was generated using Google Earth images of between 2003 and 2006. The resultant map just showed the main land cover types within the forest ecosystem. The satellite image interpretation was based on visual interpretation. According to Lillesand and Kiefer (Lillesand and Kiefer, 1994) interpretation refers to "the identification of the objects seen in the image and the ability to communicate the information so generated to others". In this exercise, homogeneous land cover types were identified and delineated into polygons. These polygons were then classified using the FAO-Africover developed land cover classification system (LCCS) by assigning labels from a legend code.

However, the process for producing the preliminary map was done without prior knowledge about the area under investigation other than application of expert knowledge of the interpreters. The preliminary map was then verified using ground information collected as described in the section below.

3.1.2 Final land cover mapping

Materials used for mapping the Golis Forests land cover was Landsat Enhanced Thematic Mapper (ETM). Three scenes of Landsat covered the whole area of interest. The scenes of Landsat ETM used were of the following descriptions of path and row.

PATH	ROW	DATE
162	052	20051022
163	052	20051029
163	053	20060101

3.1.3 Image preprocessing

False color composite images were used in the final mapping of the Golis forest land cover. Prior to the interpretation exercise, a panchromatic band, with a resolution of

15 meters pixels was fused to the multispectral false color composite image to improve spatial resolution of a multispectral image. The fusion of the two images was referred to as pan sharpening. A false colour composite image of bands 432 at a resolution 28.50 meters resolution was created using custom ArcGIS ArcInfo workstation image processing routine. Each of the 432 false color composites were then pan sharpened by adding panchromatic band of spatial resolution of 14.25 meters resolution. This improved the spatial resolution of the composite to 14.25 meters pixels resolution. This routine was repeated three times for all the three image scenes that were used to map land cover of the Golis mountain forest.

With all the three images pan sharpened, a mosaic of the three scenes was made by staking all the images together using ArcGIS ArcInfo. The mosaic was then clipped to produce a smaller portion covering only the Golis Mountain and its surroundings for easy analysis (see figure 4).

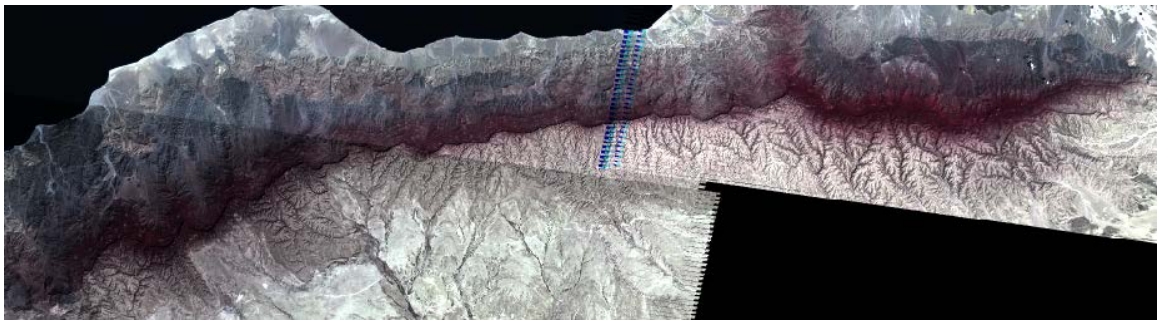


Figure 4: Pan sharpened Landsat Image of Golis maintain ecosystem.

3.1.4 Image classification

Image classification was done using spectral analysis tools within ENVI 4.3 image processing software. Using k-means unsupervised segmentation routine in ENVI software, the images was classified into six different classes with just number identifiers. The resultant classified image was then converted into shape files using a Raster vector conversion. The final vector files was cleaned in ArcInfo into a final vector map with 34644 polygons and their numerical identifiers.

3.1.5 Further cleaning and assigning class names

At this stage, the resultant polygon map was superimposed on the satellite image mosaic. The training data that emanated from the field survey data was also used at this stage. Google Earth high resolution images were also used at this stage. The 34644 polygon map had several errors of misclassification. The clouds and there shadows had been classified as land cover in the map. The lines along the boundaries in the image mosaic were also identified as land cover boundaries. In addition, the image mosaic had been classified into very small polygons, some as big as one pixel size, hence the thousands of polygons. To clean and edit this automatic classification product, a manual visual approach was used in Arc Gis/Arc Marc program. This manual visual activity involved merging of polygons, deleting polygons, adding polygons and among others, correcting the boundaries in the polygons. Polygons around clouds were deleted, for example. Land cover class names were assigned to every polygon in the map. The resultant map contained 1265 polygons. In total, 33379 polygons had been lost at the end of this stage.

Figure 5 shows a schematic presentation of the procedures that were carried out to generate the visually interpreted and classified land cover map.

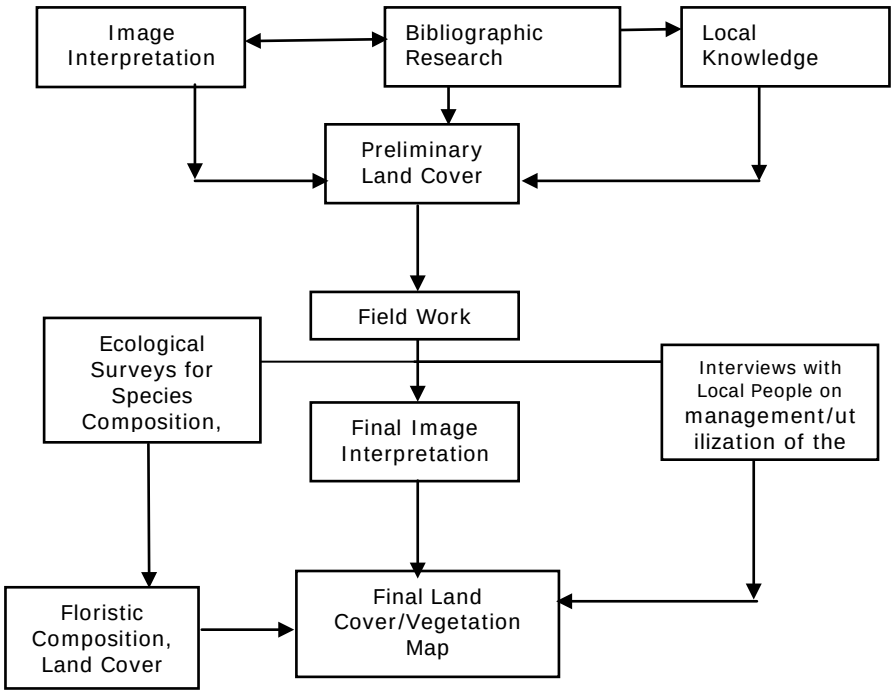


Figure 5: Land cover and vegetation mapping procedures

3.2 Ground field ecological observations

Vegetation sampling and data collection was carried out using the line transects method as described by McIntyre (1953), Johnston (1957), Crocket (1963), Heady (1983), Westman (1984) and. A line transect measuring 100m in length was laid within the sample points. Appendix 1 and 2 show the data forms used here.

Sampling of vegetation was done by dropping vertical points at every 1 m interval along the line transect. The species hit by the vertical point were recorded and in the absence of a species at the vertical point, the nearest plant to the hit was recorded. The records also indicated if the hit was mineral soil, litter or base of a plant. Plant base was used to denote the presence of woody vegetation species within the sample point.

The trees were sampled along the transect lines and the woody crown interceptions were recorded. The following woody vegetation attributes were determined: species name, frequency, crown cover and height class. Figure 6 shows the procedure followed during the vegetation sampling exercise.

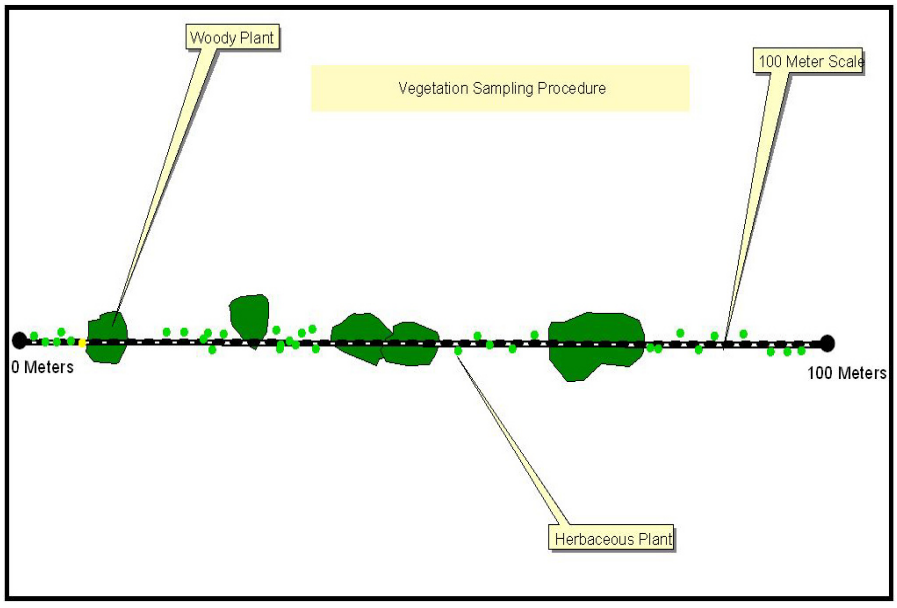


Figure 6: Vegetation sampling technique along a transect line

During the ground field observations, data was also collected on land cover using the data form in appendix 3.

3.3 Interviews with the local people

The interviews were conducted using a semi-structured questionnaire (see appendix 4). The questionnaire was administered to individuals in every village that was visited. These groups of the local people were mobilized with the help of village elders.

4 Results

4.1 The land cover/vegetation map

The resultant land cover/vegetation map had 9 classes (see figure 7). These classes included Closed Shrubs with Trees, Closed Shrubs, Open Shrubs, Very Open Shrubs, Sparse Vegetation, Herbaceous, Crop Fields, Bare Soil and Settlement. The classification of land cover was done using the land cover data collection form in Appendix 3. The vegetation data was collected using the forms given in Appendix 1 and 2 of this report. Appendix 7 gives the concepts of land cover mapping and and the FAO land Cover Classification System (LCCS).

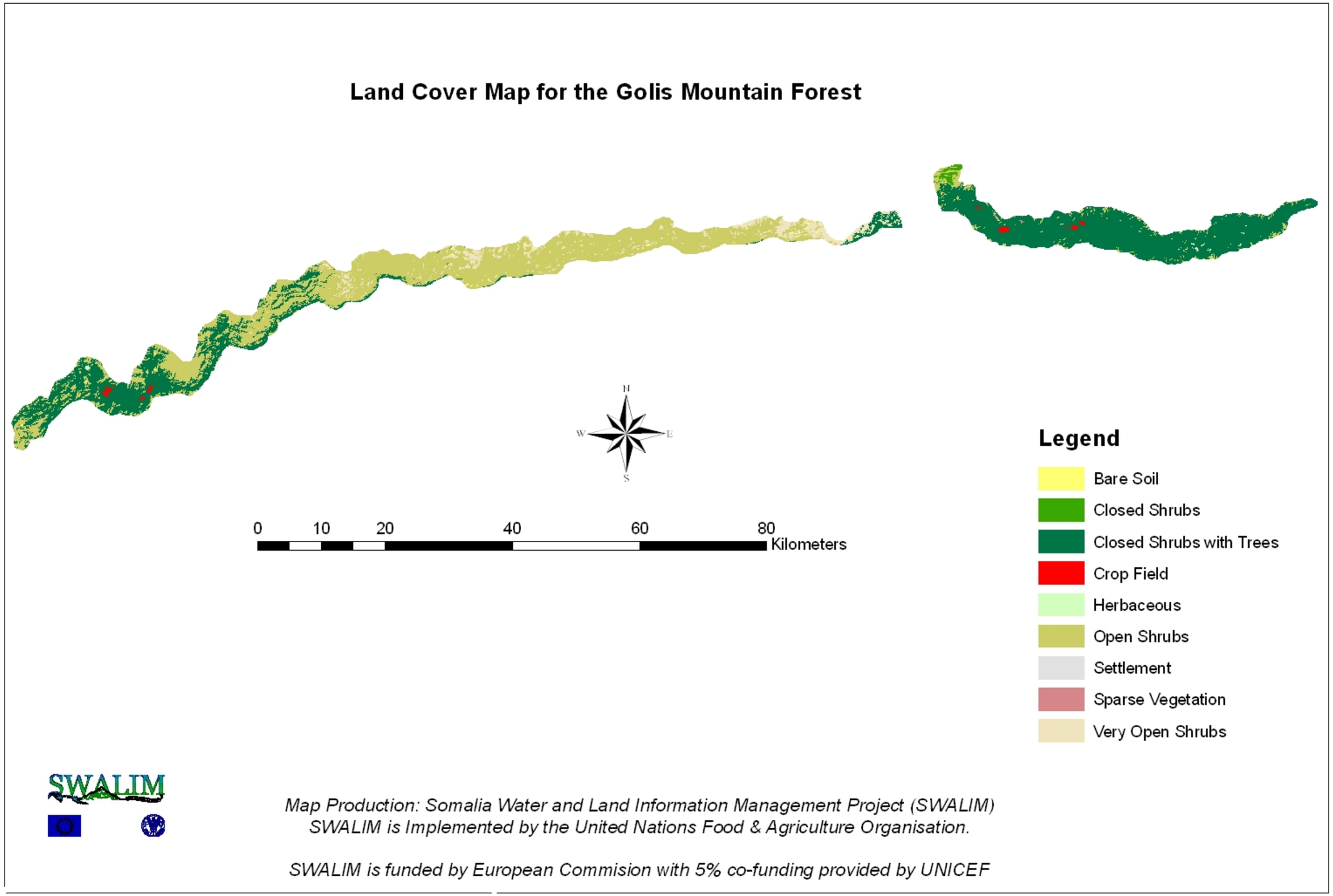


Figure 7: The Land cover map of the Golis forest

4.1.1 Closed Shrubs with Trees

The open shrubs and trees was the most dominant land cover class in the Golis forest with an area of about 4300 hectares (46.41%) in size. The trees here included *Juniperus procera, Conocarpuslansifolia, Acacia senegal, Cryptolis gilletii, Aloe vera, Codia purpurea and Buxus hildebrandtii.*

4.1.2 Open Shrubs

The Open Shrubs was the second largest land cover class in the Golis forest and occupied an area of about 4286 hectares (46.09%). The dominant vegetation species included the following: *Acacia melifera, Acacia reficiens, Ehretia orbicularis, Buxus hildebrandtii and Hypestus hildepren*

4.1.3 Very Open Shrubs

This land cover class occupied an area of about 557 hectares (5.98%). The plants here included *Acacia melifera, Acacia reficiens, Ehretia orbicularis, Buxus hildebrandtii and Hypestus hildepren.*

4.1.4 Closed Shrubs

Closed shrubs occupied an area of about 48 hectares (0.52%). The plant species here included *Acacia reficiens, Acacia melifera* and *Buxus hildebrandtii.*

4.1.5 Crop Fields

The crop fields occupied an area of about 46 hectares (0.50%). The crop production is rainfed farming and the crops included fruits (banana, citrus, mangoes, guava), miraa (*Catha edulis*) and vegetables (tomato, onion, cabbage, etc).

4.1.6 Herbaceous

The herbaceous cover was limited and stood at about 12 hectares (0.13%) in area. The plants found here included Sansevieria sp., Aloe vera etc.

4.1.7 Sparse Vegetation

Sparse vegetation land cover is not common and formed only 2.925 ha (0.03%) of the total land cover of the area. *Acacia reficiens, Salvadora persica* and others formed the land cover.

4.1.8 Bare Soil

Barer soil in the Golis Mountain forest ecosystem was limited to an area of about 30 hectares (0.32%).

4.1.9 Settlement

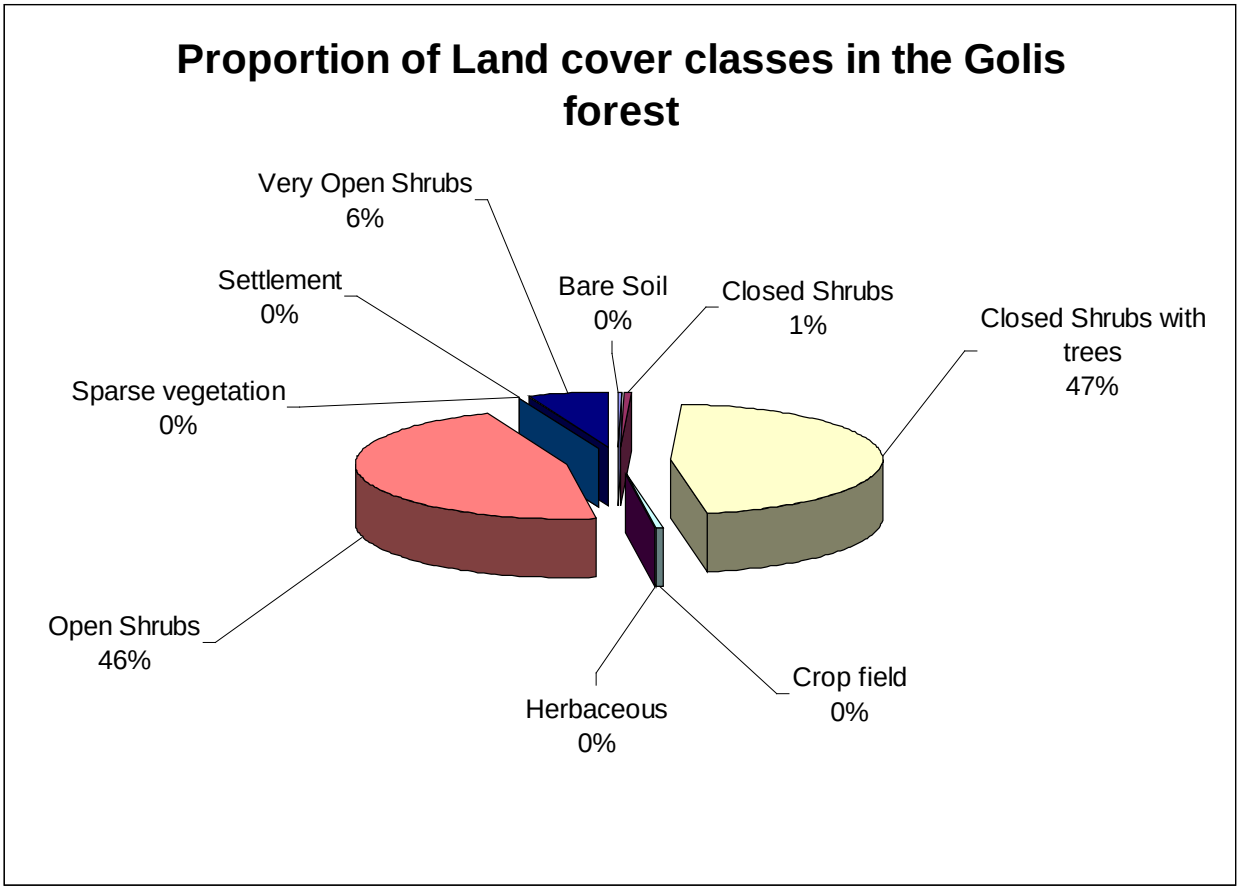
The settlements in the study area covered an area of about 2 hectares (0.02%) and were found to be associated with the areas of increased farming activities.

4.1.10 Proportion of Land cover classes in the Golis forest

Land cover	Hectares	%
Bare Soil	30	0.32
Closed Shrubs	48	0.52
Closed Shrubs with trees	4300	46.41
Crop field	46	0.50
Herbaceous	12	0.13
Open Shrubs	4286	46.09
Settlement	2	0.02
Sparse vegetation	2.925	0.03
Very Open Shrubs	557	5.98

Table 1: Proportion of land cover classes in the Golis forest

Figure 8: Proportion of land cover classes in the Golis forest



From the table 1 and the pictorial figure 8 presented here, Closed shrubs and trees and Open shrubs are the most dominant land cover classes in the Golis forest. Very Open Shrubs are also abundant and are third in size. Other land cover classes found in the Golis forest with their respective sizes are shown in the figure.

4.2 Plant density and Percent cover

Tables 2 and 3 show the plant density per species and the percent cover, respectively.

Table 2: Species density in the Golis forest by sampling site

Species Density in Golis Mountain

ID	Area Name	Coordinates		Species Name	Height Class (m)				Counts (10*10m Quadrat)	Density (ha)
		x	y		< 1	1-7	7-14	>14		
GS 01	Gugur	0734884	1190338	Inaccessible					-	-
GS 02	Gugur	0734074	1189391	Acacia etbaica			√		7	700
				Buxus hildebrah		√			17	1700
				Psiadia arabica		√			12	1200
					√				50	5000
					√				23	2300
				Aloe vera	√				24	2400
				Cardia purpures		√			4	400
GS 03	Gaacidh	0741075	1190421	Inaccessible					-	-
GS 04	Yabe	0738117	1194564	Inaccessible					-	-
GS 05	Laaga Daals	0753329	1197626	Inaccessible					-	-
GS 06	Dayin	0750980	1193999	Acacia etbaica	√				6	600
				Dodonaea viscosa	√				2	200
						√			4	400
GS 07	Dhula Cas	0752820	1198489	Gure		√			1	100
				Acacia mellifera		√			2	200
				Acacia reficiens		√			3	300
				Ehretia Arbicultris		√			3	300
GS 08	Bay Bile	0763321	1198288	Inaccessible					-	-
GS 09	Eersakaal	0785223	1216173	Acacia reficiens	√				6	600
				Salvadora persica	√				2	200
					√				3	300
GS 10	Shumux	0739002	1191676	Cadia purpurea		√			18	1800
				Buxus hildebrandtii		√			52	5200
				Aloe vera		√			2	200
				Acalypha fruticasa		√			3	300
					√				8	800
				Salvia Spp	√				21	2100
				Hypoestes hildebrandtii	√				75	7500
				Sideroxylon			√		3	300
				Psiada arabica	√				8	800
				Loranthus spp	√				6	600
				Dharaan	√				3	
GS 11	Shixshirix	0745618	1189026	- Inaccessible					-	-
GS 12	Xumbo	0745076	1190680	- Inaccessible					-	-
GS 13	Xareed	0747852	1192356	Buxus hildebrandtii		√			125	12500
				Dracaena			√		7	700
				Cadia purpurea		√			15	1500
				Xeela sixin		√			10	1000
GS	-	0748720	1196417	- Inaccessible					-	-

14										
GS 15	**Jilib Saygaala**	**0755292**	**1195185**	**-** Inaccessible					**-**	**-**
GS 16	**Gasdheer**	**0757167**	**1198333**	**-** Inaccessible					**-**	**-**
GS 17	**Dagho**	**0758947**	**1196326**	**-** Inaccessible					**-**	**-**
GS 18	**Fadhigaad**	**0736773**	**1195596**	**-** Inaccessible					**-**	**-**
GS 19	**Buur Dabar**	**0743063**	**1194509**	**-** Inaccessible					**-**	**-**
GS 20	**Gurgur**	**0789054**	**1215398**	**-** Inaccessible					**-**	**-**
GS 21	**Gurgur**	**0781663**	**1215215**	**Acacia senegal**		√			**3**	**300**
				Acacia tortilis	√				**2**	**200**
				Conocarplus lancifolia			√		**2**	**200**
						√			**7**	**700**
				Dugow	√				**1**	**100**
GS 22	**Jilib Suguur**	**0752234**	**1195733**	**-** Inaccessible					**-**	**-**
GS 23	**Dano**	**0749085**	**1190394**	**Dodonaea viscosa**		√			**34**	**3400**
				Cadia purpurea		√			**24**	**2400**
				Cordia ovalis		√			**9**	**900**
				Juniperus excellesa				√	**7**	**700**
				Licium europaeum		√			**55**	**5500**
GS 24	**Guri Qacable**	**0751412**	**1199200**	**Acacia mellifera**		√			**6**	**600**
				Acacia tortillas		√			**3**	**300**
				Turraea pavifolia	√				**4**	**400**
				Indigofera intricata	√				**15**	**1500**
GS 25	**Hegeba**	**0735534**	**1191809**	**Aloe vera**	√				**72**	**7200**
				Acacia					**3**	**300**
				Cadia purpurea		√			**17**	**1700**
				Senecio longiflorus					**17**	**1700**
				Psiadia arabica					**9**	**900**
				Cryptolepis	√				**17**	**1700**
GS 26	**Gumburo Yar**	**0785860**	**1213527**	**-** Inaccessible					**-**	**-**
GS 27	**Tuur Bahalood**	**0754059**	**1193223**	**-** Inaccessible					**-**	**-**
GS 28	**Madarmoqe**	**0752029**	**1194888**	**Azima Tetracantha**		√			**21**	**2100**
				Acacia bussei		√			**3**	**300**
				Codia purpurea		√			**12**	**1200**
				Commiphora lughesis		√			**2**	**200**
				Sansevieria spp	√				**67**	**6700**

Table 3: Percent interceptions by plant species, by sample site

ID	Area Name	Coordinates		Species Name	Height Class (m)				Interceptions (m)	%
		x	y		<1	1-7	7-14	>14		
GS 01	Gugur	0734884	1190338	Inaccessible					-	-
GS 02	Gugur	0734074	1189391	Ephedra alte		√			0.2	0.4
				Buxus hildebrah		√			0.2	0.4
				Bouchea sessilo	√				3	6
									0.5	1
									0.5	1
				Ragu		√			0.1	0.2
				Coleus cicatrices		√			2	4
				Mayeer	√				0.4	0.8
									0.2	0.4
									2	4
									0.3	0.6
				Psiadia arabica	√				0.7	1.4
									0.5	1
									0.4	0.8
				Euphorbia		√			0.4	0.8
				Senecio longi		√			2.6	5.2
				Buxus hildebrah		√			1.6	3.2
				Cardia purpures			√		2.9	5.8
				Acacia etbaica	√				3	6
GS 03	Gaacidh	0741075	1190421	Inaccessible					-	-
GS 04	Yabe	0738117	1194564	Inaccessible					-	-
GS 05	Laaga Daals	0753329	1197626	Inaccessible					-	-
GS 06	Hoyin	0750980	1193999	Buxus hildebrah		√			0.4	0.8
				Cardia purpures		√			0.2	0.4
									7.8	15.6
				Cadanyaale		√			0.6	1.2
				Maraa		√			0.4	0.8
									2.4	4.8
									3	6
				Dodonaea viscosa		√			0.6	1.2
				Waylo subki	√				0.5	1
				Acacia bussei	√				3	6
GS 07	Dhula Cas	0752820	1198489	Bottegoa insignis-chiov	√				0.3	0.6
									0.4	0.8
									0.45	0.9
				Euphorbia cuneata		√			0.5	1
				Bottegoa insignis-chiov	√				0.2	0.4
				Epherdra		√			2	4
				Bottegoa insignis-chiov		√			0.7	1.4
				Sansevieria Spp	√				0.3	0.6
									0.5	1
				Bottegoa insignis-chiov	√				0.4	0.8
				Acacia reficiens	√				7.7	15.4
				Sansevieria Spp		√			0.3	0.6
				Bottegoa insignis-chiov		√			0.4	0.8
									7	14
									0.2	0.4
					√				0.7	1.4
									0.6	1.2
									0.55	1.1
									7.5	15
									4.5	9
				Hypoestes hildebrandtii	√				0.2	0.4
GS 08	Bay Bile	0763321	1198288	-					-	-
GS 09	Eersakaal	0785223	1216173	Acacia reficiens	√				0.9	1.8
				Salvadora persica	√				0.81	1.62
									0.3	0.6
GS 10	Shumux	0739002	1191676	Cadia purpurea		√			-	-
				Buxus hildebrandtii		√			-	-

				Aloe vera		√			-	-
				Acalypha fruticasa		√			-	-
				Salvia Spp	√				-	-
				Hypoestes hildebrandtii	√				-	-
				Sideroxylon	√				-	-
				Psiada arabica		√			-	-
				Loranthus spp	√				-	-
				Dharaan	√				-	-
GS 11	Shixshirix	0745618	1189026	Inaccessible					-	-
GS 12	Xumbo	0745076	1190680	Inaccessible					-	-
GS 13	Xareed	0747852	1192356	Buxus hildebrandtii		√			-	-
				Dracaena			√		-	-
				Cadia purpurea		√			-	-
				Xeela sixin		√			-	-
GS 14	-	0748720	1196417	Inaccessible					-	-
GS 15	Jilib Saygaala	0755292	1195185	Inaccessible					-	-
GS 16	Gasdheer	0757167	1198333	Inaccessible					-	-
GS 17	Dagho	0758947	1196326	Inaccessible					-	-
GS 18	Fadhigaad	0736773	1195596	Inaccessible					-	-
GS 19	Buur Dabar	0743063	1194509	Inaccessible					-	-
GS 20	Gurgur	0789054	1215398	Inaccessible					-	-
GS 21	Karin Turak	0781663	1215215	Acacia senegal		√			-	-
				Acacia tortilis	√				-	-
				Conocarplus lancifolia		√			-	-
							√		-	-
				Dugow	√				-	-
GS 22	Jilib Suguur	0752234	1195733	Inaccessible					-	-
GS 23	Dano	0749085	1190394	Dodonaea viscosa		√			-	-
				Cadia purpurea		√			-	-
				Cordia ovals		√			-	-
				Juniperus excellesa		√		√	-	-
				Licium europaeum					-	-
GS 24	Guri Qacable	0751412	1199200	Acacia mellifera		√			-	-
				Acacia tortillas		√			-	-
				Turraea pavifolia	√				-	-
				Indigofera intricata	√				-	-
GS 25	Hegeba	0735534	1191809	Aloe vera					-	-
				Acacia					-	-
				Cadia purpurea					-	-
				Senecio longiflorus					-	-
				Psiadia arabica					-	-
				Cryptolepis					-	
GS 26	Gumburo Yar	0785860	1213527	Inaccessible					-	-
GS 27	Tuur Bahalood	0754059	1193223	Inaccessible					-	-
GS 28	Madarmuge	0752029	119488	Sensevieria Spp		√			0.2	0.4
									0.35	0.7
				Xeel-Sixin		√			0.2	0.4
									0.5	1
				Ecbolium anisacathus		√			0.5	1
				Sesamothanus		√			1.3	2.6
				Acacia tortillas		√			0.3	0.6
									0.2	0.4
				Sensevieria Spp		√			0.5	1
									0.6	1.2
				Acacia senegal		√			0.05	0.1
									0.2	0.4
				Danyo		√			0.06	0.12
									0.7	10.4
				Raguna		√			0.22	0.44
									0.1	0.2
				Sensevieria Spp		√			0.15	0.3
									0.5	1
				Buxus hildebrandtii		√			0.5	1
									0.4	0.8
				Raguna		√			0.3	0.6
				Sensevieria Spp		√			0.75	1.5

									0.3	0.6
				Raguna		√			0.12	0.24
				Xeel-Sixin		√			0.7	1.4
									0.75	1.5
				Sensevieria Spp		√			0.1	0.2
									0.15	0.3
				Commiphora lughensis		√			0.7	1.4
				Acacia tortillas		√			0.2	0.4
				Buxus hildebrandtii		√			0.3	0.6
									0.5	1.0
				Sensevieria Spp		√			0.45	0.9
				Acacia tortillas		√			0.3	0.6
									0.1	0.2
				Raguna		√			0.15	0.3
				Sensevieria Spp		√			0.7	1.4
				Buxus hildebrandtii		√			7.7	15.4
				Sesamothanus		√			7.7	15.4
				Cissus Spp		√			0.2	0.4
				Buxus hildebrandtii		√			0.7	1.4
									0.22	0.44
				Sesamothanus		√			0.6	1.2

4.3 Activities related to resource use and management in the Golis Mountains forest

The information related to this chapter was collected from the respondents using the questionnaire attached in Appendix 4.

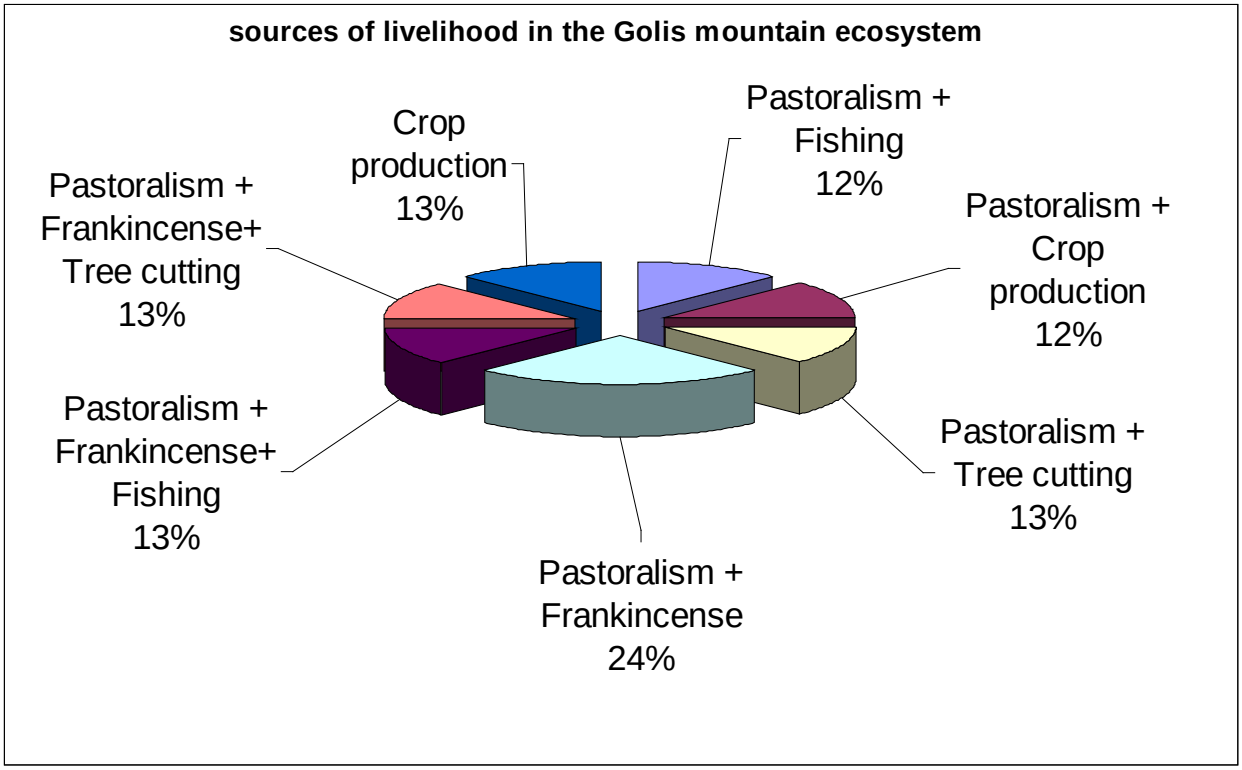
4.3.1 Settlement

Years of settlement, by the inhabitants, in the Golis Mountain Forest range from as early as 1920. There have been people in the forest for as long as 90 years.

4.3.2 Source of livelihood

Table 2 and figure 9 show the sources of livelihood to the inhabitants of the Golis forest ecosystem. The table shows that most of the engagement is a combination of two or more livelihood activities. For example, the table shows that out of all those respondents interviewed, there was none that engaged in pastoralism alone. They all engaged in pastoralism and other sources of livelihood like fishing, tree cutting, extraction of gum for frankincense and crop production. Only 12.5% of those interviewed indicated that they engaged in crop production alone. Other sources of livelihood engagements are shown in the table 2 (see also figures 10 and 11).

Figure 9: Sources of livelihood



	Pastoralism	Fishing	Crop production	Tree cutting	Frankincense	Frankincense+ Fishing	Frankincense+ Tree cutting
Pastoralism	0	12.5	12.5	12.5	25	12.5	12.5
Fishing	0	0	0	0	0	0	0
Crop production	0	0	12.5	0	0	0	0
Tree cutting	0	0	0	0	0	0	0
Frankincense	-	0	0	0	0	-	-

Table 2: sources of livelihood in the Golis mountain ecosystem(% of respondents)

Figure 10: Settlement within Golis Mountain

Figure 10 shows a settlement with permanent buildings up in the Golis mountain. This settlements require goods and services from the Golis mountain forest ecosystem.

Figure 11: Crop fields within Golis Mountain

Figure 12: Shallow well within Golis Mountain

Figure 12 shows a water source alternative, the shallow well up in the Golis mountain. The water from the shallow well is used for human consumption, livestock and crop production.

4.3.3 Environmental degradation problems

Table 3: Environmental degradation problem

	Environmental degradation problem							
	Tree cutting	None	Monkey menace	Soil erosion	Tree disease	Overgrazing	Crop pests	Bush encroachment
% interviewed	8	25	17	8	17	8	8	8

Table 3 and figure 13 show the problems of environmental degradation that are associated with activities in the Golis mountain forest ecosystem. About 25% of those interviewed felt that there were no environmental degradation problems associated with the Golis forest ecosystem. 17% of the respondents indicated that the trees in the forest ecosystem were attacked by diseases while 8 % indicated that overgrazing in the forest was a big environmental problem. Other environmental problems and response during the interviews are also shown in the table.

Figure 13: Environmental degradation problem

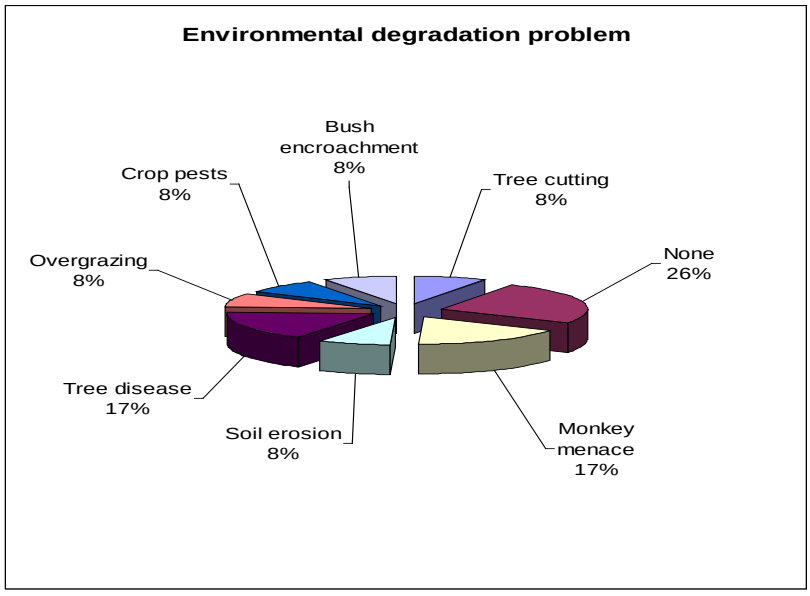


Figure 14: Settlement in Golis mountain

4.3.4 Goods and services provided by the Golis forest

Table 4: Goods and services from the Golis forest (% of respondents)

Goods and services from the Golis forest (% of respondents)									
Fire wood	Construction	Shade	Fodder	Medicine	Windbreak	Rain	Human food	Honey	Frankincense
8	23	15	15	8	8	8	4	8	4

Majority (about 23%) of the respondents indicated that they obtained construction materials from the forest. A great number of them indicated that they obtained fodder (about 15%) from the forest. Other materials obtained in the forest and the % respondents against them are shown in the table 4 and figure 15. The table also translates into the importance of the Golis mountain forest to the inhabitants.

In addition, about 60% of the respondents indicated that the forest ecosystem is important in providing feed and habitat to many bird species (see figure 17).

Figure 15: Goods and Services from the Golis Forest ecosystem

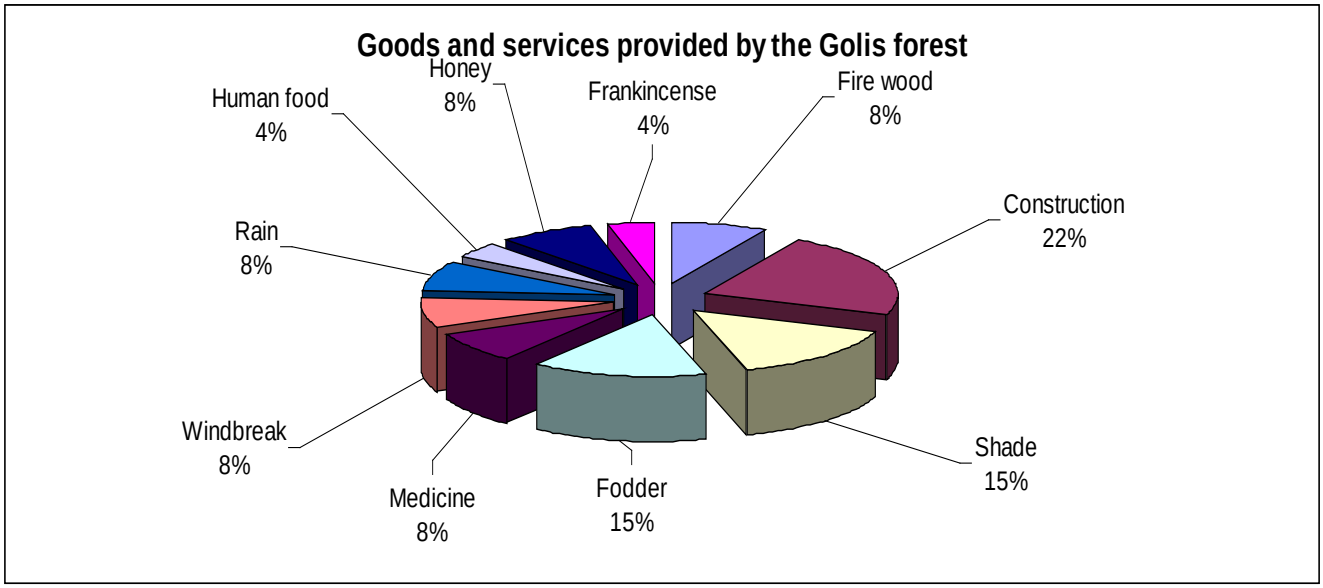
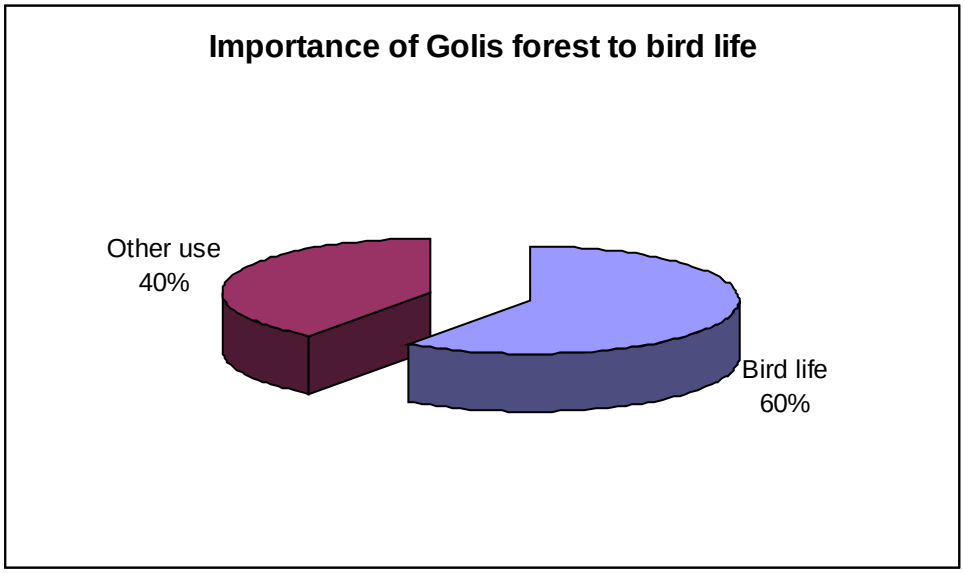


Figure 16: Somali ecological survey experts at work in the Golis Mountain

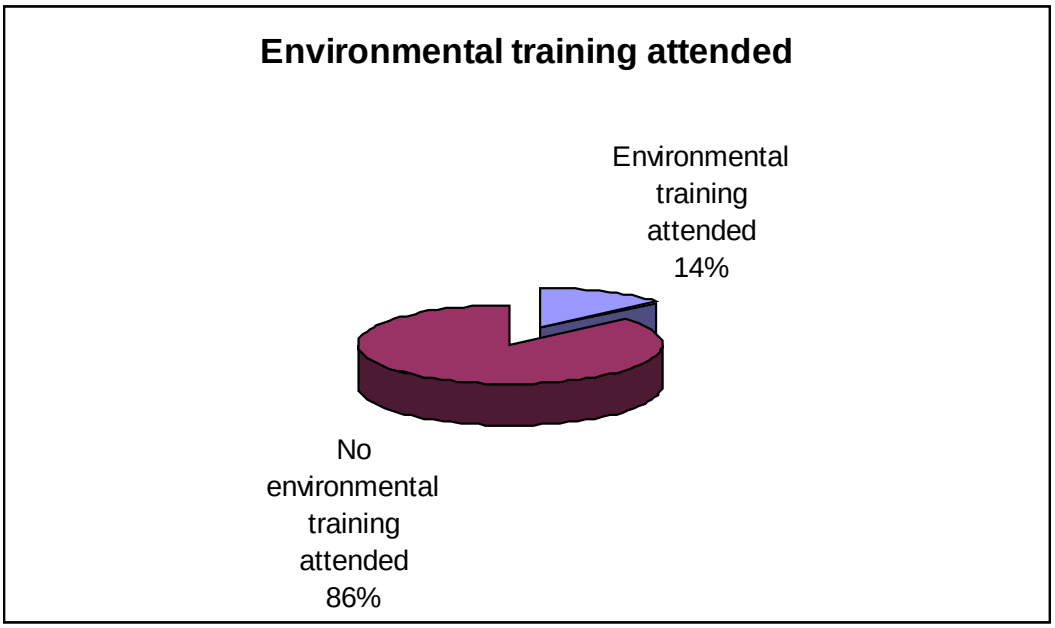
Figure 17: Importance of Golis forest to bird life



4.3.5 Environmental training attended

Only 14% (figure 18) of the respondents indicated that they had attended any form of training related to the environment. An NGO called the German Agro Action (GAA) was cited as one organization that was involved in training the inhabitants here on issues related to the environment.

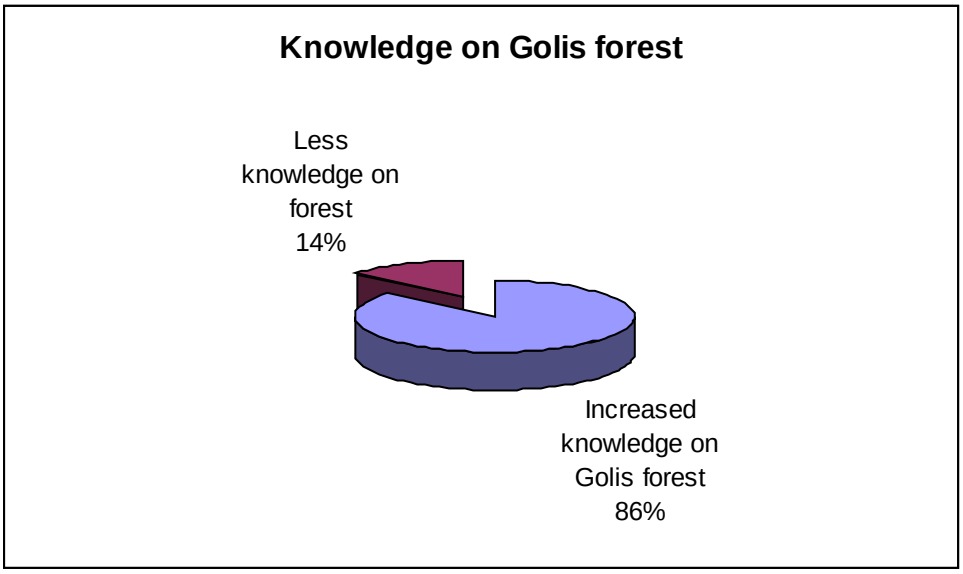
Figure 18: Environmental training attended



4.3.6 Knowledge on the Golis forest.

About 86% (see figure 19) of the respondents indicated that their knowledge on the Golis forest had greatly improved and that they were more knowledgeable about the forest ecosystem today than they were before. They cited several issues that to them were of great concern regarding the conservation of the forest. Among the cited issues were agricultural encroachment into the forest and lack of law enforcement initiatives aimed at protecting the forest. The respondents indicated that the trees were being cut at an alarming rate besides settlements that were also destroying the forest. The respondents also indicated that the human and livestock population had increased in the forest.

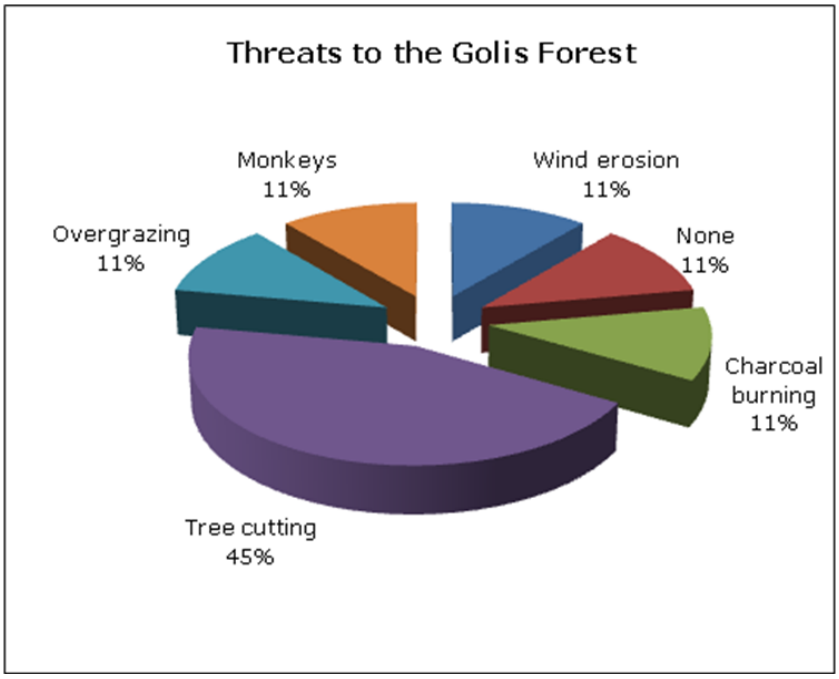
Figure 19: Knowledge on the Golis forest



4.3.7 Threats to the Golis Forest

The threats to the Golis forest are varied as indicated by the respondents during the field interviews with the local people. Figure 20 is a pictorial presentation of the results of the interviews. Tree cutting was identified as the biggest threat to the Golis forest. The trees are cut for charcoal burning besides poles for construction. The other threats to the forest are given with the response percentage from the interviewees.

Figure 20: Threats to the Golis Forest



In addition, all those who were interviewed indicated that the status of the forest was declining. They indicated that the condition of the forest was getting worse every year.

4.3.8 Beneficiaries of the Golis forest

Figure 21: Beneficiaries of the Golis forest

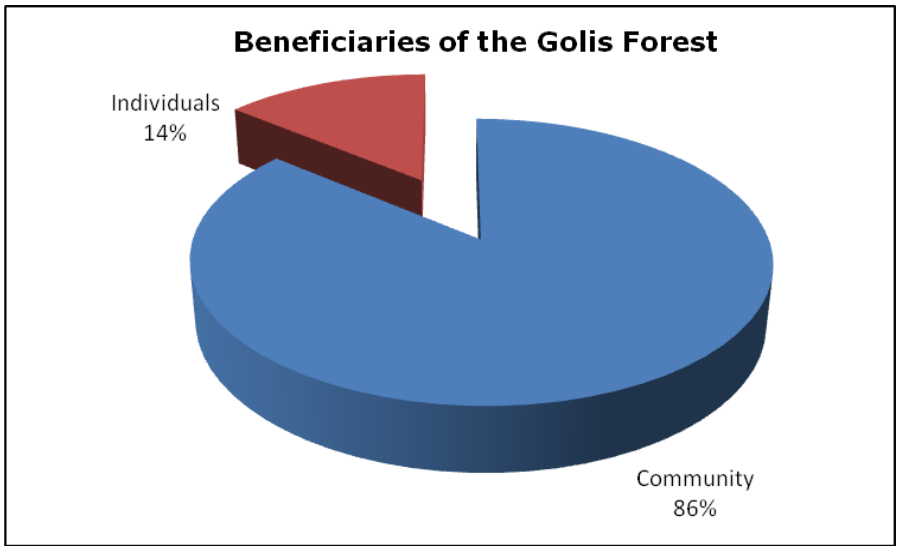


Figure 21 shows the beneficiaries of the Golis forest. Close to 90% of the respondents indicated that the whole community benefits from the Golis forest while only about 10% of those who were interviewed indicated that the forest only benefits a few individuals. These benefits from the forest range from construction poles to charcoal burning and honey provision.

4.3.9 Golis forest extraction trend

Figure 22. Golis forest resource extraction trend

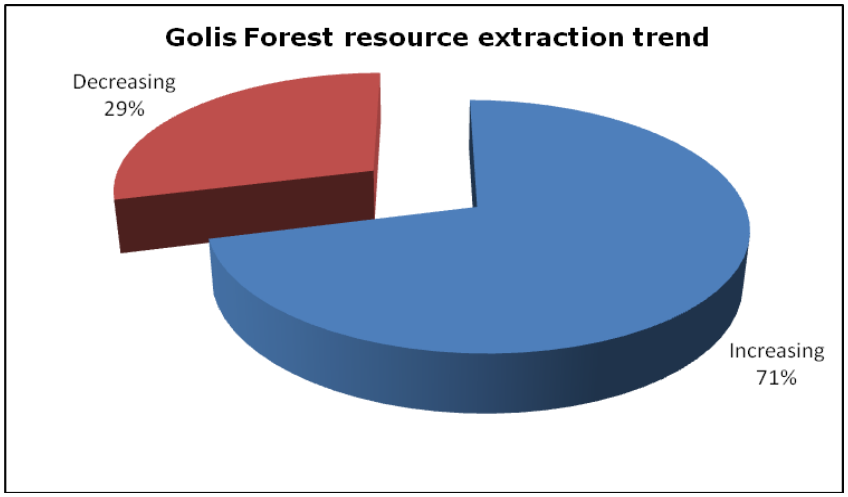


Figure 22 indicates the trend in the Golis forest resource extraction. The interviews with the local people indicated that the trend in extraction of the resources from the Golis forest has been increasing over the years. The resources being extracted include the woody component in the form of poles for construction and charcoal burning. There has also been an upward trend in livestock population, consequently and subsequently exerting pressure on the vegetation for fodder/feed to the animals.

4.3.10 Destination of Forest products

Figure 23: Destination of the Golis forest products

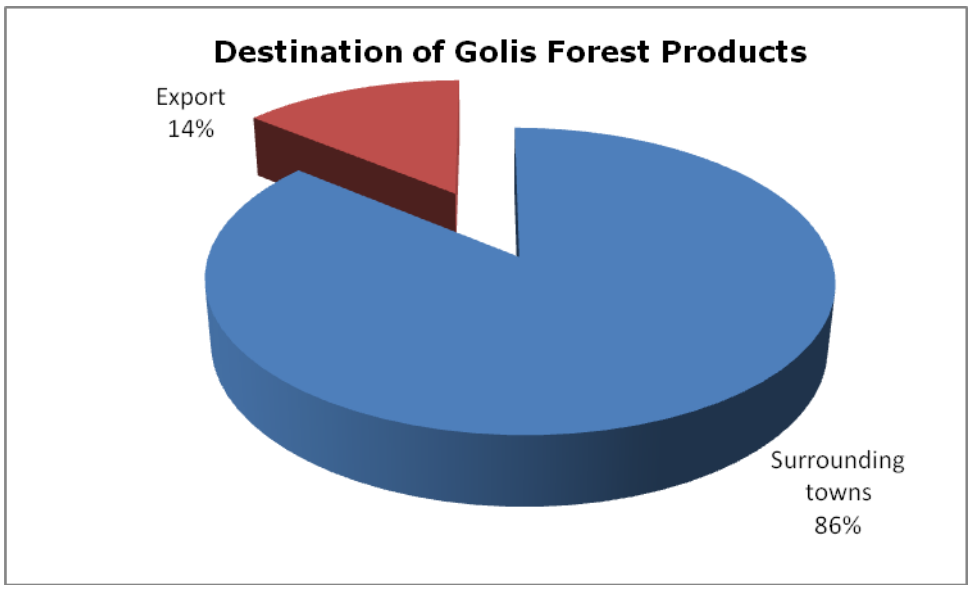


Figure 23 shows the destination of the Golis forest products. During the interviews, about 86% of the respondents indicated that most of the products extracted from the Golis forest are destined for the surrounding towns. However, about 14% of those interviewed, indicated that some of the products find themselves in the export market, with some of them going as far as Europe. As explained before, these products extracted include timber, charcoal, honey, frankincense and others.

5 Discussions and conclusions

Frankincense extraction and tree cutting for charcoal burning were found to be the main sources of livelihood in the Golis forest. These activities may have negative effects to the forest, if not checked, as they involve destruction of the trees. Those interviewed also associated these activities to serious land degradation problems facing the forest. Introduction of crop fields in the forest may also not be a desired activity as it leads to forest encroachment. Consequently, these activities pose as great threat to the forest as a national heritage site.

As the human population within the forest increases, the demand for the goods and services provided by the forest increases. This explains why the respondents

indicated that there has been a steady increase in the demand for the forest products. This increased pressure on the forest also has negative environmental effects. Uncontrolled tree cutting, for example, exposes the soil on the mountain and consequently leaves it susceptible to soil erosion by wind and water.

The goods and services provided by the forest ecosystem are varied and could be classified into those that are environmental friendly and those that are destructive to the environment. Bee keeping, for example, is an activity that could be managed without harming the environment in the mountain forest. Cutting of wood for fuel wood provision could be controlled by the introduction of alternative sources of energy. There is need to review the utilization and management strategies in place, to ultimately come up with secure and environmentally friendly initiatives within the forest ecosystem.

Given the fragility of the forest ecosystem, and that environmental training of the communities living in the forest is wanting, it is important to initiate environmental awareness creation campaigns. These campaigns will ultimately ensure that the environment is protected by these communities. Tree cutting ought to be controlled and if necessary, stopped altogether. The local people need to be educated about the negative effects associated by the wanton destruction of the trees in the forest. Everybody wants to benefit from the forest but this is at the peril of the fragile ecosystem. More so, given that the demand for the Golis forest products is ever increasing and goes beyond its borders, there is urgent need to sought for quick-fix solutions. The danger is ever increasing, and if nothing is done to stop this trend, it may be very difficult to restore the forest to its original form.

Lastly, there is need to spread the monitoring sites within the forest ecosystem so that those areas that were not covered during this initial survey could also be covered. More training, to the Somali surveyors, on the field survey techniques used is required. It is therefore necessary that before this is achieved, annual

monitoring surveys ought to be carried out by the Somali experts. There is also need to initiate, concretize and make operational the proposed Golis mountain forest monitoring system within the Somali authorities. This will subsequently make it possible to monitor the trend in forest management and utilization, consequently leading to forest ecosystem sustainability.

6 Challenges

During the time of the field survey, the security situation could not allow a comprehensive survey of the entire forest. The field survey was confined to the area around Ceerigaabo. The central and eastern sides of the mountain were not touched during the survey. Mapping of these areas was based on the high resolution Google Earth images. The concentration of the survey sites was therefore skewed and only focused on the extreme left side of the forest. Consequently, there is need to extend the monitoring sites to the other parts of the mountain as soon as the security situation improves in the forest.

7 Bibliography

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8 Appendices

Appendix 1: FAO-SWALIM GOLIS FOREST VEGETATION SAMPLING DATA FORM

Quardrat NO:_____ Area Name:_____Location:_____Observer:_____Date:_____

Time:_____ _____

Coordinates (Upper left) N or S:_____ East:_____UTM

(Lower left) N or S:_____ East:_____UTM

Quardrat size (10 meters X 10 meters)

Height Class				Species Name	Count	Total count
<1m	1-7m	7-14m	>14m			

Appendix 2:

FAO-SWALIM GOLIS FOREST VEGETATION SAMPLING DATA FORM

Woody Layer

Transect NO:_____ Area Name:__________Location:____________Observer:__________Date:______

Time:_____________Transect Length_________________________________

Coordinates (Start) N or S:________________ East:__________________UTM

(End) N or S:________________ East:__________________UTM

Height Class	**Species Name**	**Interceptions**	**Count**	**Total (meters)**	**% Cover**
<1m, 1-7m, 7-14m, >14m					
Herbaceous Cover					
(Only % cover for all)					
<0.3m, 0.3-1m, >1m					

Remarks: (indicate whether shrubland, forest or grassland)

Appendix 3:

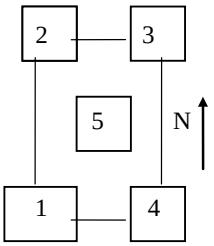
FAO-SWALIM LAND COVER FIELD VERIFICATION FORM (LCCS)

A. GENRAL INFORMATION

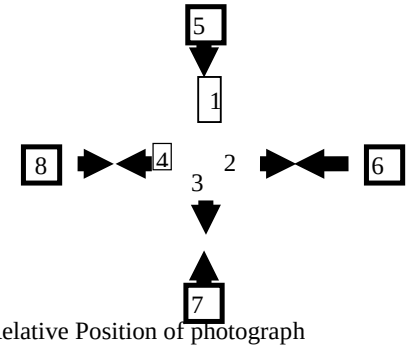
RELEVEE N^0		ACCESSIBILITY	☐	Very Good
AREA NAME			☐	Good
LOCATION			☐	Medium
OBSERVER			☐	Bad
DATE				
TIME				
RELEVEE SIZE		(in m $^{3 \text{ or}}$ ha)		

COORDINATES

N or S	East

On the spot	Observing the spot from a distance
Indicate relative position of Coordinate 	Distance from viewpoint to observed point ☐ (m) The bearing of the observed point ☐ (^{0})

FIELD PHOTOGRAPHS



Relative Position of photograph

GENERAL LANDFORM

Slope

- ☐ Flat to Gently Sloping Terrain (0-7%)
- ☐ Gently Sloping to Moderately Sloping (8-3%)
- ☐ Sloping to Moderately Steep, Undulating to Rolling terrain (14 - 20%)
- ☐ Steep to Very Steep, Rolling to Hilly terrain (21-55%)
- ☐ Extremely Steep Terrain, Steeply Dissected Hilly and Mountainous Terrain (56 - 140%)

B. GENERAL LAND COVER INFORMATION

LAND COVER

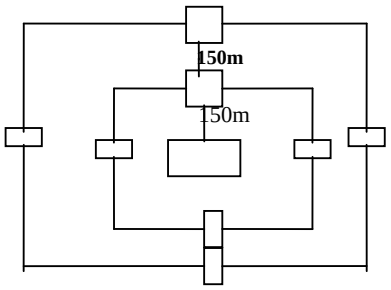
- General land cover Type	A.	☐ Vegetated	☐	Non - Vegetated
Relevee Site	B.	☐ Terrestrial	☐	Aquatic or Regularly Flooded Land (including WADY Areas)

- Specific Land Cover Type	Single major Land Cover Aspect	Two Mixed major land Cover Aspects	
		Most Important	Second
Cultivated	☐	☐	☐
Natural/Semi-Natural	☐	☐	☐
Built Up	☐	☐	☐
Bare	☐	☐	☐
Artificial water Body	☐	☐	☐
Inland Water	☐	☐	☐

AREA LANDCOVER HOMOGENITY (Applicable if on spot)

Land cover Homogeneous for more than 300 m ☐ Yes

Around the sample area: ☐ No



LAND COVER SEASONAL ASPECTS

	Natural/Semi-Natural vegetation				Cultivated Fields			
	dry	green	flowering	fruits	ploughed	initial stage	full mat stage	harvested
TREES	☐	☐	☐	☐	☐	☐	☐	☐
SHRUBS	☐	☐	☐	☐	☐	☐	☐	☐
HERBS	☐	☐	☐	☐	☐	☐	☐	☐

C SPECIFIC LAND COVER INFORMATION

NATURAL & SEMI-NATURAL VEGETATION				Leaf Type			Leaf Phenology	
	Level	Cover	Height	Broad	Needle	Aphyllous	Evergreen	Deciduous
WOODY				☐	☐	☐	☐	☐
Trees	1			☐	☐	☐	☐	☐
	2			☐	☐	☐	☐	☐
	3			☐	☐	☐	☐	☐
Shrubs	1			☐	☐	☐	☐	☐
	2			☐	☐	☐	☐	☐
HERBACEOUS								
Graminoids								
Forbs								

Cover Estimation of vegetation Visual ☐ Instrumental ☐ Other ☐

CULTIVATED TERRESTRIAL AREA AND MANAGED LAND

-Life Form of **MAIN** CROP	Leaf Type		Leaf Phenology			
	Broad	Needle	Evergreen	Deciduous	Fruit Trees	Plantation
☐ Trees	☐	☐	☐	☐	☐	☐
☐ Shrubs	☐	☐	☐	☐		
☐ Herbaceous						
☐ Graminoids						
☐ Other						

. Crop Name ☐

-Life Form of SECOND CROP	Leaf Type		Leaf Phenology			
	Broad	Needle	Evergreen	Deciduous	Fruit trees	Plantation
☐ Trees	☐	☐	☐	☐	☐	☐
☐ Shrubs	☐	☐	☐	☐		
☐ Herbaceous						
☐ Graminoids						
☐ Other						

Crop Name ☐

-Average Field Size ☐ (m^2 or ha)

-Field Distribution

- ☐ Bordering Fields
- Distance between fields
  - ☐ < average field size
  - ☐ = 1 to 3 X average field size
  - ☐ = 3 to 9 x average field size
  - ☐ > 9 x average field size

- Cultivation period

- ☐ main crop, during two or more different periods within same year
- ☐ second crop in same period as main crop
- ☐ second crop in different period as main crop
- ☐ second crop starts during active period main crop

- Cultivation Time Factor

Time lap between two consecutive active periods

- ☐ =< 1 year
- ☐ 1 to 4 years
- ☐ > 4 years

-Water Supply/Irrigation

- ☐ Not Irrigated
- ☐ Supplementary Irrigation
  - ☐ Post flooding
  - ☐ Surface
  - ☐ Sprinkler
  - ☐ Drip
  - ☐ Other ☐

-Life Form MANAGED LAND

Urban Vegetated Area

Area covered by trees is

- ☐ > 40%
- ☐ between 20% and 40%
- ☐ < 20 %

—

BARE AREAS

- ☐ Consolidated
  - ☐ Bare Rock
  - ☐ Gravel, Stones and Boulders
  - ☐ Hardpans
- ☐ Unconsolidated
  - ☐ Bare Soil
    - ☐ Stony (5 - 40%)
    - ☐ Very Stony (40 - 80%)
  - ☐ Loose and shifting sands
- ☐ Dunes
  - ☐ Barchans
  - ☐ Parabolic
  - ☐ Longitudinal
    - ☐ Saturated
    - ☐ Unsaturated

Appendix 4: FAO-SWALIM Golis Forest monitoring Questionnaire form

Part 1: GENERAL INFORMATION

Questionnaire Number: ……..

Administered by …… Date……..

Location: x …….. y ……

Altitude
……

Village/site ……District …… Region ……

What is the population of this village? ……

What is the approximate family size? ……

PART 2: Livelihood and land degradation

1. When did you settle here? ……

2. What is your major source of livelihood? >…….
   - **a.** Pastoralism……..
   - **b.** Fishing……..
   - **c.** Crop production…….
   - **d.** Tree cutting…….
   - **e.** Other tree cutting……..
   - **f.** Other (specify)…….

5. List some of the main environmental degradation problems in this area

Degradation problems	

PART 3: Knowledge and understanding of the golis forest ecosystem

Can you list the main goods and services provided by the Golis forest?

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

How is the Golis forest important to human beings?

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

How is the Golis forest important to other animals (fish, birds, etc)?

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

Is the Golis forest important in other ways?

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

Have you attended any classes, seminars, meetings or workshops on the environment over the last year, and if so what?

a. ……..
b. ……..
c. ……

Do you think that you now know more about the Golis forest than before, and if so why?

a. ……..
b. ……..
c. ……
d. ……

e. ……..
f. ……

PART 4: Attitude and perception about the Golis forest ecosystem

Do you think that the Golis forest here is in good shape, and if so why? (explain yourself with examples)

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

Is the Golis forest here threatened? And if so, what are the major threats in order of importance?

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

Is the status of the Golis forest improving or declining?

……

Are the threats to the Golis forest increasing or decreasing?
……..

Does this community own the Golis forest in any way?
……
……
……
……

PART 4: Golis forest resources extraction (Practice and use)

Does anyone extract resources from the Golis forest? If yes, what do they extract?

a. ……..
b. ……..
c. ……
d. ……

e. ……..
f. ……

Is the extraction of products within the Golis forest increasing or decreasing?
……..

Who benefits from the products extracted from the Golis forest ? List the beneficiaries

a. ……..
b. ……..
c. ……
d. ……
e. ……..
f. ……

Is the number of beneficiaries from the Golis forest increasing or decreasing?
……

What are the products extracted and their destination?

Products extracted	**Destination**

Appendix 5: Monitoring sites for the Golis Mountain Forest ecosystem in Somaliland

ID	x	y
GS13	747854	1192356
GS21	781663	1215215
GS25	735617	1191639
GS17	758941	1196326
GS23	749085	1190394
GS06	750980	1193999
GS28	732029	1194888
GS24	751412	1199200
GS07	752820	1198489
GS10	739802	1191676
GS02	734075	1189394
GS09	785223	1216173
GS11	745618	1189026
GS26	781876	1215850
GS16	758729	1198333
GS05	753329	1191626
GS20	789054	1215398
GS08	763321	1198288
GS22	752234	1195733
GS15	755292	1195185
GS14	748720	1196417
GS03	739915	1188752
GS18	736173	1195596
GS04	738117	1192648
GS19	743063	1194501
GS01	734884	1190338
GS12	744067	1192265
GS27	754059	1193223

Appendix 6 : Golis Mountain Forest Field Sample Points July 2010 - Puntland

Town	ID	X	Y
	G1	277698	1219315
	G2	274392	1218335
	G3	270473	1217233
	G4	268262	1215396
	G5	261901	1216131
	G6	259330	1213682
	G7	257370	1213682
	G8	254799	1212335
	G9	249802	1211806
	G10	247600	1214427
	G11	244244	1217049
	G12	243300	1215162
	G13	241098	1214427
	G14	239944	1214952
	G15	238266	1216840
	G16	236798	1213903
	G17	233756	1213274
	G18	233337	1216001
	G19	229771	1215686
	G20	229141	1213798
	G21	225785	1214218
	G22	224946	1216525
	G23	222954	1218623
	G24	219312	1220318
	G25	218332	1219306
	G26	220767	1217124

Appendix 7: Mapping Land Cover

The concept of Spatial Distribution

The concept of spatial distribution describes the fields in the following terms:
Continuous: a continuum of more than 50% of cultivated fields
Scattered Clustered: percentage of fields is between 20 – 50%
Scattered Isolated: percentage of fields is between 10 – 20%

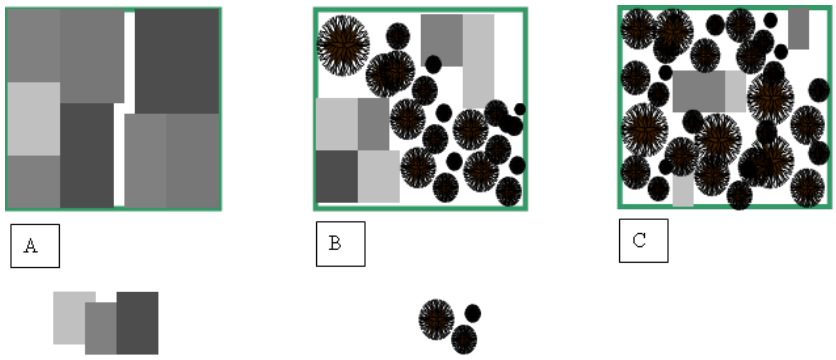


Figure 4.8.10: A=Continous fields; B=Clustered fields; C=Isolated fields (from LCCS presentation)

8.1

0% to 5%	Absent or scattered
5% to 15%	Sparse
15% to 65%	Open
65% to 100%	Closed

8.2

8.3 Estimating cover

The following are example and exercises on estimating cover.

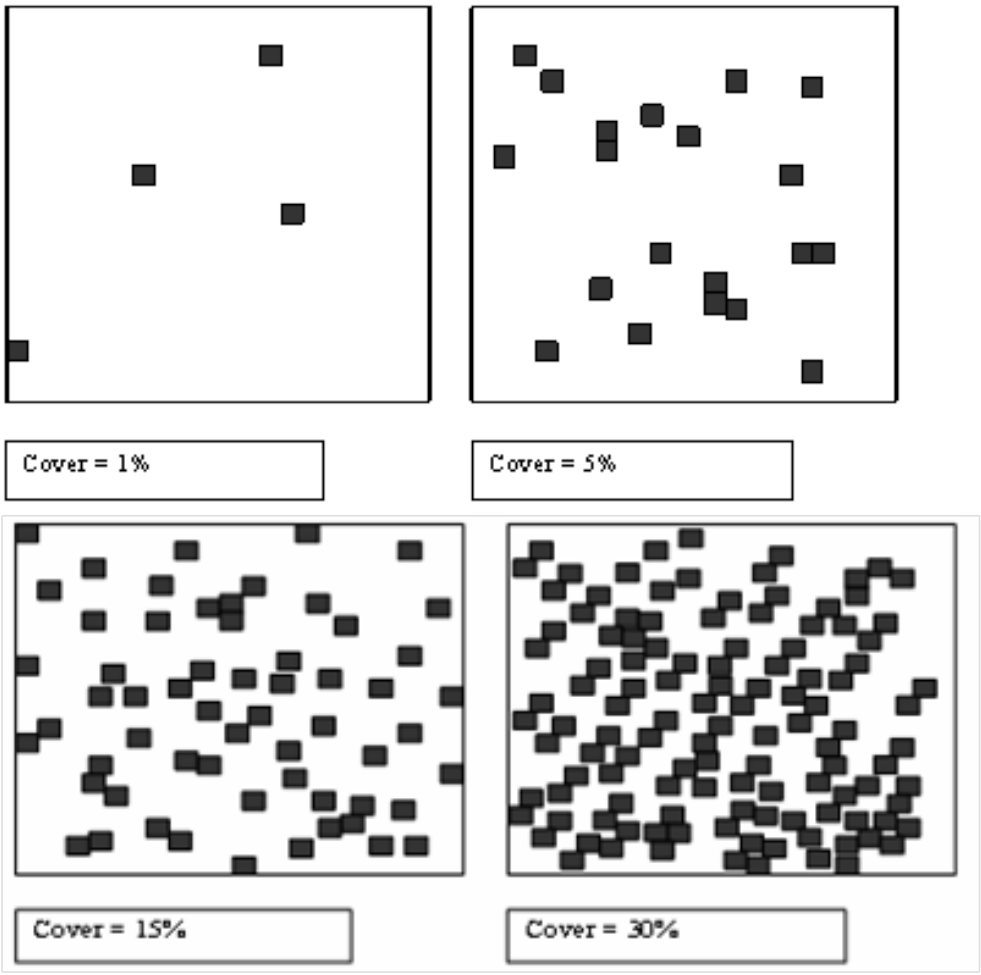
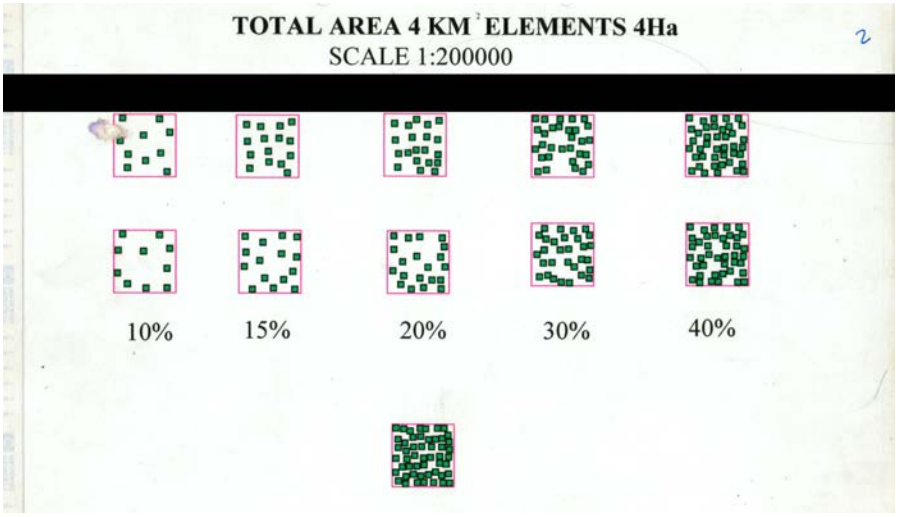
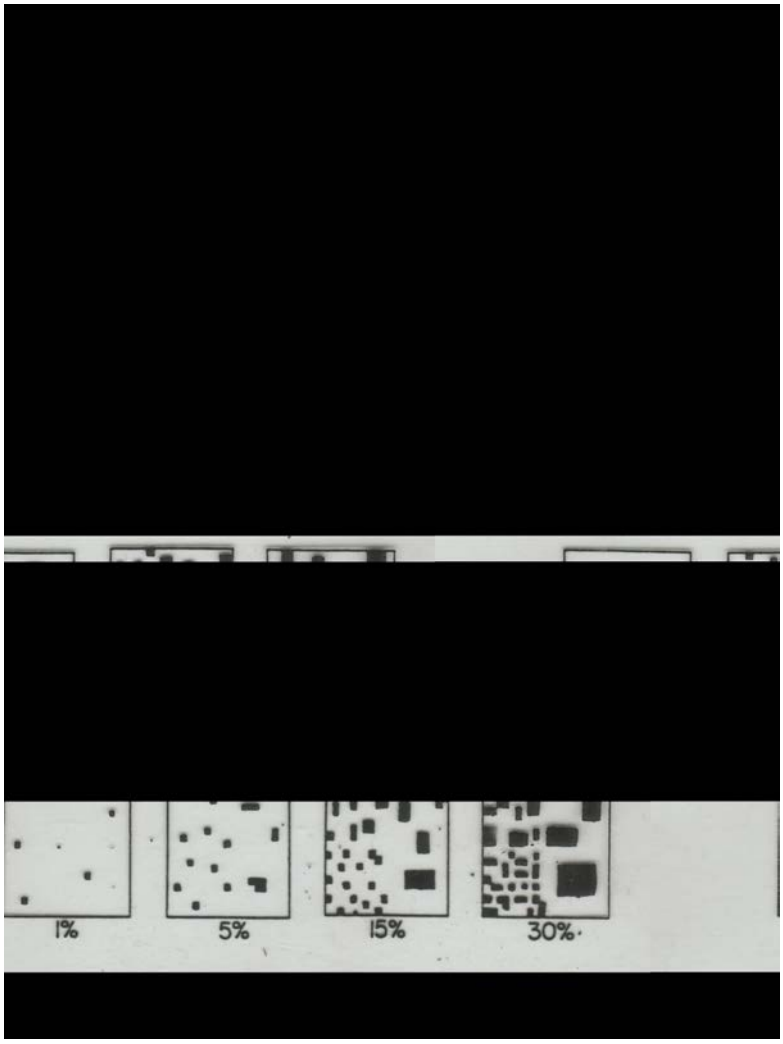


Figure 4.8.11: Estimating cover



8.4 Figure 4.8.12: Estimating Proportions in Land Cover Mapping And Classifying Land Cover



8.5 Figure 4.8.13: Charts for estimating proportions. (Each fourth of any one square has the same amount of black. The examples are printed in two different scales.

Put your name on the sheet in Figure 4.8.14 and try to estimate cover

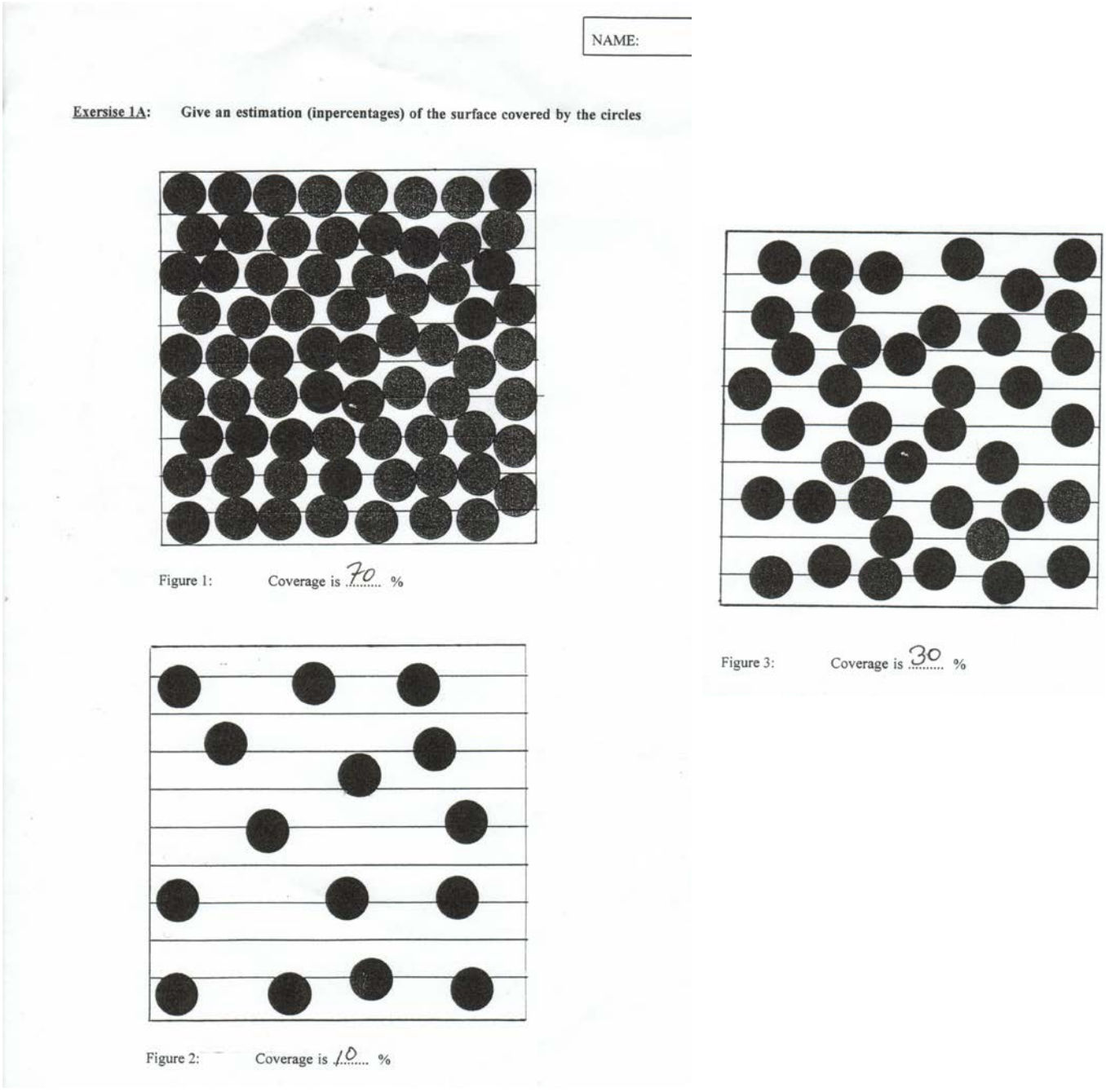


Figure 4.8.14: Exercise on estimating cover

Exercise 2: Land cover classification (classify the land cover in the pictures)

(i) Classify_____

(ii) Classify_____

(iii) Classify_____

(iv) Classify_____

(v) Classify_____

(vi)Classify_____

(viii) Classify_____

(ix)Classify_____

(x) Classify_____

Figure 4.8.15: Exercise 2 (figures (i) to (x). Land cover classification

Figure 4.8.16: Sparse shrubs

Figure 4.8.17: Bare ground

9 2.9.Concepts of Vegetation Ecology

9.1 Land Ecology (or land ecological) survey

This is the inventory and analysis of the landscapes, their components and their interrelationships

- includes an integrated survey of land forms, soils, vegetation, aspects of land use and surface hydrology
- The main products are generally a land unit map with a legend, accompanied by (derived) thematic maps and a report pointing out the most relevant ecological factors which are influencing actual (and future) land use

9.1.1 Definition

Vegetation is a general term for the plant life of a region;

- it refers to the ground cover provided by plants, and is, by far, the most abundant biotic element of the biosphere

9.1.2 Vegetation and the Purpose of Vegetation and Land Unit Maps

Man's relationship with vegetation includes the following:

- Resource –food; timber, firewood, livestock and wildlife forage (figure 4.9.1 and 4.9.2)
- Habitat and Source of Endemic Diseases – (e.g., tse-tse fly) weeds or plagues (e.g., desert locust), a hindrance to access etc
- Indicators of landscape Features (see Figure 4.9.3)

Vegetation is good forage for fauna

Figure 4.9.1:Vegetation as forage

Trees for burning charcoal

Figure 4.9.2:Vegetation as fuel

Figure 4.9.3: Vegetation along water courses

The water courses may have trees along them to farm riverine forest.

9.2 Aspects of vegetation Survey Field Work techniques

The following morphological properties of the vegetation have to be considered in the field sample design:

- Floristic (or botanical) Composition; Life form, Composition and Structure (= the three dimensional form).

Also:

- biomass or better productivity, palatability and the (physico-) Chemical Composition
- Floristic Composition of the Perennial Species is the more permanent and important property to be sampled and used for classification/typification

9.3 Measurements and Estimations of vegetation

The following measurements might be considered:

9.3.1 Composition

1. Presence/Absence of constituent (s) (plant species, plant life form (woody = trees and shrubs, herbaceous = forbs and graminoids and Lichens and Moses), etc.).

9.3.2 Structure

2. Density (abundance): the number of plants per unit area
3. (Area) Cover: relative area covered by a plant unit or vegetation expressed as a decimal of percentage class, distinguishing between foliage cover, above-ground cover and stem (basal) cover; important in rangeland and forest surveys; for vegetation structure description, the cover per layer is given.
4. Height: mean or maximum height of plant unit or vegetation in common metric units.
5. Volume: in common metric units; especially for timber, firewood or available browse.
6. Weight (phytomass): fresh and dry (air-dry or oven-dry) weight of standing crop in common metric units (gr/m2 or kg/ha)

9.3.3 Chemical Composition

Dry matter digestibility (DMD) in vitro
Crude Protein (CP) content as percentage of dry matter
Mineral (P, Ca, Na, etc) Content as percentage of Dry matter

How to Map Land Use and Land Cover

- A map should form a reliable, reproducible and thus unbiased model of reality
- When mapping, use is made of aerial photography or satellite imagery
- The spectral signature captured by aerial photograph or satellite sensors is related to the cover of the land and not to its use
- Validation of the image interpretation results is done by subsequent Field Validation (Ground Truthing)

9.4 Woody and Herbaceous Layer Estimation

- The line transect method (Heady 1983, Crocket 1963, Johnston 1957)
- The line transect measured 100m in length
- Dropping a vertical point at every 1 m interval along the line transect
- Record the species hit
- Record the nearest Herbaceous plant if no plant is hit
- Record Intercepting Woody Species
- Record mineral soil, litter or base of a plant

9.5 Herbaceous Layer Estimation

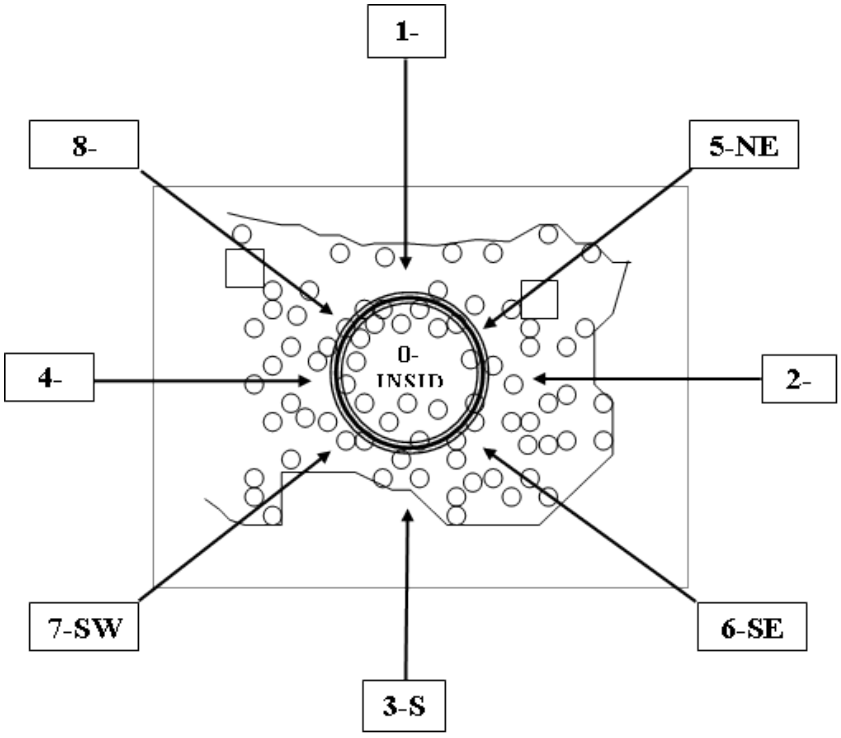
- Small herbs and tree seedlings sampled by same transects
- Quadrat measuring 0.5m x 0.5m every 20 meters along the transect used for basal Clipping of Hebaceous materials
- Clipped material oven dried at 60^{o}C for 48 hours and then weighed to determine the dry herbaceous biomass
- Data forms used to collect data on the herbaceous vegetation layer

9.6 Woody Layer Estimation

- Sampled along the same transect used for estimating the herbaceous layer above
- The woody crown interceptions (McIntrye 1953, Heady 1983 and Westman 1984) recorded
- Woody vegetation attributes determined: species name, frequency, crown cover and height class
- Data forms used to collect data on the Woody vegetation layer

Figure 4.9.4: Use and mismanagement of vegetation

In Somalia, since the breakdown of governance in 1990, there has been wanton destruction of the trees (e.g *Acacia bussei*) for charcoal burning, for example (see figure 4.9.4).



10 Figure 4.9.5: Directions of photographs taken from outside a site (choosing one of the 8 points indicated) towards the outside of the site, point 0

Whenever land cover data is collected about a sample site, photographs are taken, for record, (Figure 4.9.5) in different directions. Photographs must also be taken of specific and unique features of the landscape.

11 2.10. Introduction to the FAO Land Cover Classification System (LCCS)

11.1 Land cover mapping

- As we have previously seen, the classification system adopted strongly influence land cover mapping results.
- Generally, mapping efforts carried out until now by countries, agencies, projects, researchers etc. all over the world, have been realized adopting different classification and mapping methodologies.
- Maps produced with different methodologies are usually not comparable, impeding broad analyses and data exchange.

It is nowadays clear that *it is important to adopt common and agreed criteria to be used as underlying principles for land cover mapping and classification activities*.

- Recommendations from international agreements, treaties and conventions also support the development of a common and global reference basis.

11.2 LCCS and GLCN background

Figure 4.10.1: Discussions to formulate LCCS

Considering the problems with currently used classification systems and mapping efforts, in 1993, UNEP and FAO organized a meeting (Figure 4.10.1) to catalyze coordinated action towards *harmonization of data collection and management* for an internationally agreed reference base for land cover and land use (UNEP/FAO, 1994).
Through a regional African programme aimed at mapping a large portion of Africa (the *Africover* Programme, promoted by FAO SDRN and funded by the Italian Government) an attempt to develop a new globally useful methodology was carried out.
The new methodology was developed in order to be applicable at any scale and comprehensive, so that any land cover identified anywhere in the world can be readily accommodated in this new system.

11.2.1 The new developed system is called Land Cover Classification System (LCCS)

LCCS classification concepts were endorsed in 1996 by the International Working Group on Classification and Legend and the system benefited, since the beginning, from the valuable feedback from a range of experts from all over the world.
Moving from the *Africover* and LCCS successfully diffusion, the FAO/UNEP/Italian Government **"Global Land Cover Network"** initiative was officially launched in 2002 at Artimino (Florence). The overall objective of the **GLCN** is to increase the availability of reliable and standardized information on land cover and its changes at the global level.

11.2.2 LCCS definition and purpose

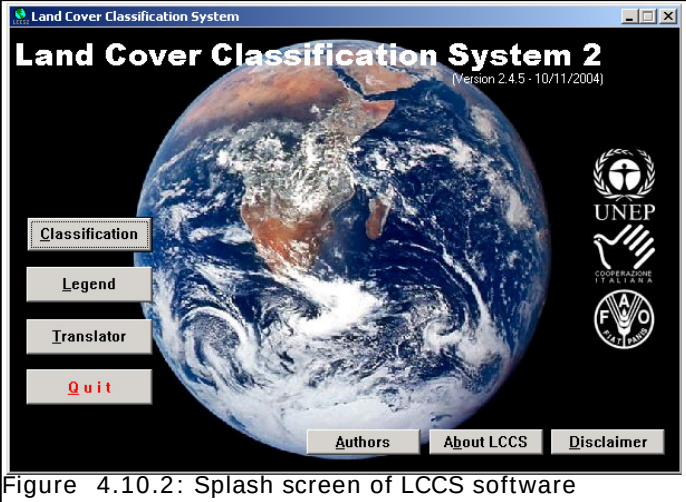


Figure 4.10.2: Splash screen of LCCS software

The **Land Cover Classification System (LCCS)** is a comprehensive, standardized *a priori* classification system, designed to meet specific user requirements, and created for mapping exercises, independent of the scale or means used to map.

The system can be used for any land cover classification initiative anywhere in the world, using a set of **independent diagnostic criteria** that allow correlation with existing classifications and legends.

Land cover classes are defined by the combination of a set of independent diagnostic criteria – the so called **classifiers** – that are hierarchically arranged to assure a high degree of accuracy.

Figure 4.10.2 is a representation of the LCCS software flash screen.

11.2.3 The objective

To produce a world-wide reference system for land cover able to combine an high level of *flexibility* (ability to describe land cover features all over the world at any scale or level of detail) with an absolute level of *standardization* of the class definition between different users.

11.2.4 The idea

A system that allows a dynamic creation of classes without obliging the user to relate to a pre-defined list of names.

11.2.5 The basic concept

In LCCS the creation of a class is done by a dynamic combination of land cover *diagnostic attributed* called *classifiers.*

11.2.6 What then is LCCS?

It is possible to state that LCCS is a new language to describe the different land cover features in a standardized way.

- As in any language, you have words and a syntax that allow you to create a semantic concept.
- The different combination of words with a given syntax provides a broad scope of concept generation.

In LCCS it is the same: the *classifiers* are the *words,* the *classification rules* are the *syntax*, and the *land cover features* are the *concepts* to be described.
As in a language, the combination of *classifiers* through the use of the *classification rules* provides the possibility of describing a broad range of land cover features.

The combinations made by different users using the same *classifiers* of the classification system will result in the same land cover class.

11.2.7 How to create classes in LCCS

As when using a language, all the concepts exist. The problem is to find the right combination of words to describe things.
The same is true for LCCS: the user has to find the correct combination of classifiers to describe a certain land cover feature.
No pre-defined list exists. The user has to create -one by one- each single class needed. This involves a process of passing from the user's idea of the class, to the creation of the representation of this idea using a meaningful sequence of classifiers that are able to precisely illustrate this idea of the specific land cover feature.

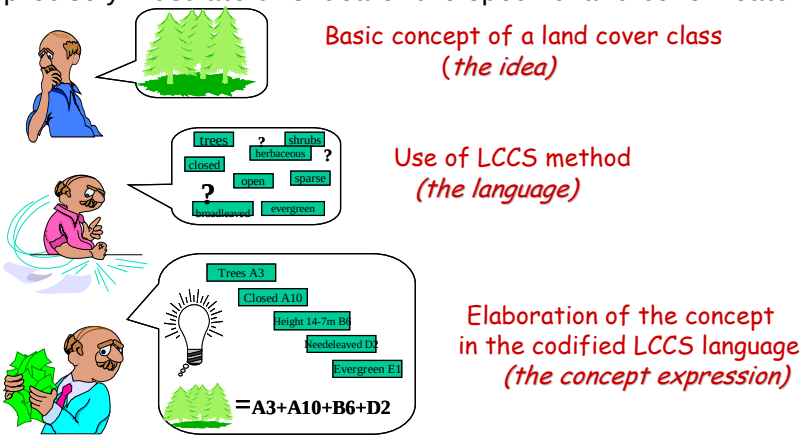


Figure 4.10.3: The basic concepts and ideas of the LCCS
The figure 4.10.3 gives a pictorial representation of the concepts and ideas of LCCS in a nutshell.

11.2.8 LCCS features

Due to the heterogeneity of land cover, the same set of classifiers cannot be used to define all land cover types. The **hierarchical** structure of the classifiers may differ from one land cover type to another. Therefore, the classification has two main phases:

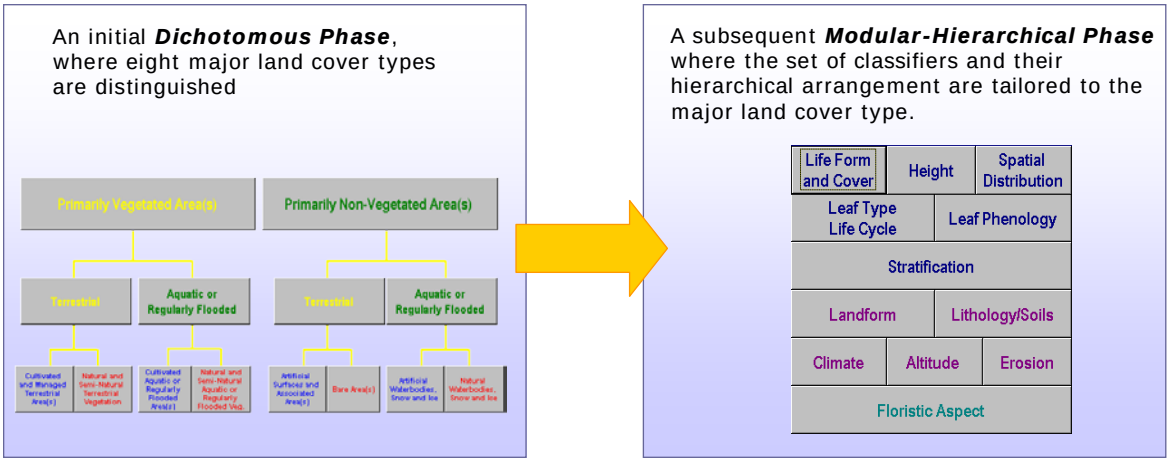
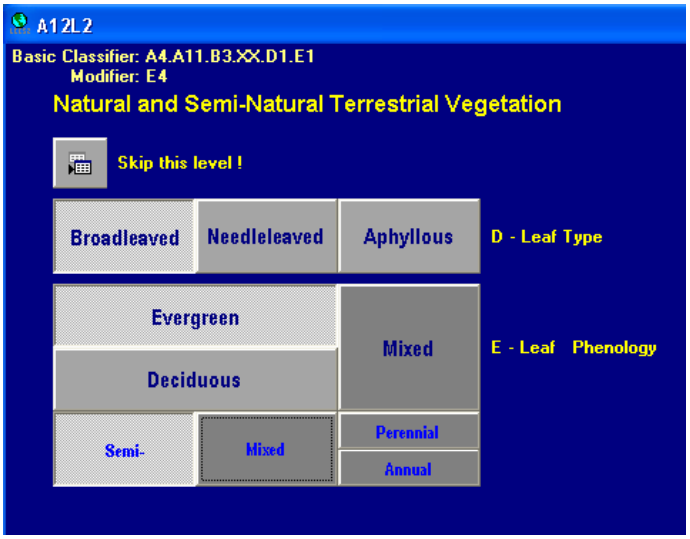


Figure 4.10.4: The hierarchical structure of LCCS
i. An initial Dichotomous Phase and ii. The Modular-Hierarchical Phase (Figure 4.10.4)

This approach allows the use of the most appropriate classifiers and prevents the use of inaccurate classifiers combinations.

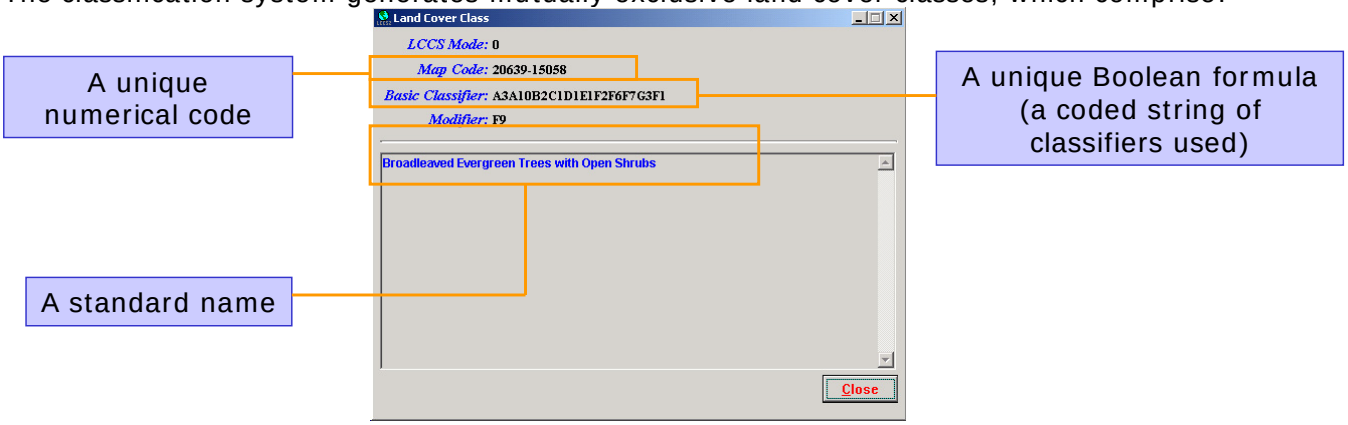
The LCCS software assists the user in selecting the appropriate class using a step-by-step process, i.e. classifier by classifier.

The flexible manner in which the classification is set up involves the creation of classes at different levels of the system through the ***classifier***s, and the optional use of ***modifiers***, ***environmental attributes*** and specific ***technical attributes*** to obtain a combination of features that univocally identify the class.



The **Semi-** feature in blue is a **MODIFER**, in this case called E4 (as explained in the upper descriptive string)

The classification system generates mutually exclusive land cover classes, which comprise:



Both the numerical code and standard name can be used to build an automatically generated Legend, with the classes that have been created being grouped according to the main land cover categories and their domains according to the level of detail.
The nomenclature can be linked to user-defined names for each class and in any language.

11.2.9 LCCS advantages

The advantages of LCCS include the following:

1) It is a real a-priori classification system

Through the use of classifiers, it covers all possible land cover without generating a huge number of classes. High level of standardization is assured keeping also high flexibility.

2) A given land cover class is always clearly and systematically defined

The system avoid unclear nomenclature and unambiguously combines pure land cover classifiers, modifiers, environmental and technical attributes. Emphasis is on a set of classifiers rather than just a name.

3) The classification system is truly hierarchical

The difference between a land cover class at a more general level and a further subdivision of it, is given through the addition of new classifiers (or a more detailed level of the one forming the previous class). The more classifiers used, the greater the detail of the land cover class defined.

4) It is designed to map a variety of scales, from small to large

The classification results are independent from the mapping source (satellite imagery, aerial photographs, field samples etc.)

5) The specific design of the classification allows easy incorporation and integration into Geographic Information System

6) It produces a real multi-user database

The database builder is obliged to follow specific rules assuring standardization and comparability, while the database user can freely define the set of classifiers of interest, re-aggregating the original polygons of the database.

7) The use of classifiers facilitates the standardization of the interpretation process and allows accuracy analyses not only at the class level but also at the classifiers level

11.3 LCCS definition and purpose

Which are in your opinion the advantages of the classifier, or parametric, approach used in LCCS?

1. The system created is a highly flexible *a priori* land cover classification in which each land cover class is clearly and systematically defined, thus providing internal consistency.
2. The system is truly hierarchical and applicable at a variety of scales.
3. Accuracy assessment of the end product can be generated by class or by the individual classifiers forming the class.
4. The modular system allow every kind of combination between classifiers in order to create every possible class.
5. All land covers can be accommodated in this highly flexible system; the classification could therefore serve as a universally applicable reference base for land cover, thus contributing towards data harmonization and standardization.

11.3.1 Summary

Key concepts of this lesson:

1) UNEP and FAO catalyzed coordinated action towards harmonization of data collection and management
2) A new methodology –LCCS- was developed in order to be applicable at any scale and comprehensive
3) In LCCS, land cover classes are defined by the combination of a set of independent diagnostic criteria the classifiers and, optionally, the modifiers and the environmental and technical attributes
4) An initial dichotomous phase is followed by a modular-hierarchical phase
5) LCCS is a hierarchical and a priori classification system