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Forest degradation: An assessment of Gedo Forest, West Shewa, Oromia Regional State, Ethiopia

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Abstract

The level of forest degradation was determined in Gedo Forest, one of the remaining Dry Evergreen Montane Forests in Ethiopia using line transects from East to West surrounding mountain escarpments locating 60 quadrats. Indicators of forest degradation eg. canopy cover, cover of forest floor, degree of damage by human activities, damage by grazing and browsing, condition of soil and moisture level were used to determine the state of degradation. About one third of the studied plots were found affected either by anthropogenic (opening of canopy cover, harvesting forest trees/parts) or by natural (aridity, poor soil) factors. The degraded forest sites had significantly low percentage of soil moisture. A total of 31 locally endangered and endemic plant species were identified in 60 quadrats of which 13 species (41.94%) were trees, 7 species (22.58%) were shrubs, 8 species (25.8%) were herbs and 3 species (9.67%) were climbers. These locally important 13 tree species were used as indicator to examine natural regeneration, only five species (*Podocarpus falcatus, Prunus africana, Rhus glutinosa, Rhus vulgaris* and *Vepris dainellii*) had fairly high number of seedlings/saplings; but the four locally rare species, *Haginia abyssinica, Cordia africana, Juniperus procera* and *Schefflera abyssinica* were not represented by seedlings/saplings only few adult trees while *Maytanus addat* and *Erthryna brucei* had no seedling and saplings and *Mellettia ferruginea* and *Dombeya longebracteolata* had only 3 and 1 saplings respectively. As height and DBH(Diameter at breast height) of the trees increased, the number of individuals decreased showing a rather sharp reversed J shape distribution indicated by *Podocarpus falcatus* and *Prunus Africana* but for *Cordia africana* and *Erthrynia brucei* no regeneration, *Juniperus procera* had few individual in lower height class but none in higher classes, whereas *Rhus glutinosa*, *Rhus vulgaris* and *Vepris dianellii* had a number of individuals in the lower height class, but no representative individual from middle and higher classes. Results indicated respondents considered regeneration of trees species has been affected by cutting of trees for fuel and timber, herbivores damage/grazing and agricultural expansion.

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Introduction

About a century ago, 35-40% of land was covered by high forests in Ethiopia whereas only less than 3% of the forest cover exists currently (Yirdaw, 1996; EPA, 1998, 2003; Bedru, 2007). The major reason for this level of deforestation and degradation of forests is human interference (Mulugeta Lemenih and Demel Teketay, 2006; Bedru, 2007; Motuma Didita *et al*., 2010). Also lack of forest management and inadequate natural regeneration had negatively affected the forest resource in Ethiopia (Tamirat Bekele, 1994; Ensermu Kelbessa and Teshome Soromessa, 2008). Ethiopia has the fifth largest floral diversity in tropical Africa (Motuma Didita *et al.,* 2010) as the diverse topography, climate and land forms have given rise to the development of wide floral and faunal diversity rich with endemic elements (Edwards and Kelbessa, 1999: Friis, Demissew and Van, Bruegel,2011).

When considering the remedies, often deforestation gets more attention while forest degradation has been occurring unabated ultimately ending up in deforestation, which is more difficult to tackle. Degraded forests, characterized by loss of forest structure, productivity and native species diversity, have also affected much of the ecological goods and services they once provided. A degraded site may still contain trees but might have lost its former ecological integrity (Lamb and Gilmour, 2003). It is difficult to identify and measure forest degradation, though loss of forest structure and canopy cover can be locally identified rather easily and quickly. To provide information regarding the state of forest health, current level of natural forest regeneration also gives good indication.

The Gedo State Forest is one of the few remaining dry Evergreen Montane forest in the high lands of Ethiopia which is one of the 58 National Forest Priority Areas (NFPA)as mentioned in the EFAP (1994). According to the State of Environment Report For Ethiopia, 2003(EPA,2003), Gedo Forest has a total area of 10,000 ha of which about 5000 ha is 'high forest, while 2000 ha was been labeled as 'slightly disturbed' and 3000 ha as 'highly disturbed' with the remaining 5000 ha regarded as 'other forest'. Although officially not designated as protected areas, the Gedo Primary Forest is protected by the State Forest Authority and guards are actively patrolling the area. But it has been continuously exploited by surrounding people for agricultural land expansion, timber harvesting, firewood collection and charcoal production, wood cutting for construction, cattle grazing and other purposes (Birhanu Kebede, 2010). As many as 25 endemic species included in the preliminary list assessed for IUCN Red Data List, out of which 1 species under Critically Endangered, 18 species in Least Concern, 4 species Nearly Threatened, and 2 species Vulnerable categories (Birhanu Kebede, 2010).

The objective of this study is to assess the state of forest health and natural regeneration using locally endangered/endemic plant species as indicator and the community perception about regeneration in the Gedo State Forest.

Materials and methods

Description of forest

Gedo Forest is located in Cheliya district, West Shewa Zone in Oromia Regional State of Ethiopia. The geographical location of the study district lies between 8°-9°N latitude and 37°-38 °E longitude having at an altitude ranging from 1700 to 3060 m.a.s.l. The annual mean minimum and maximum temperatures are 8 to 25° C with average temperatures of 16° C. Average annual rain fall is from 750 to 1000 mm (Cheliya Agricultural Office, 2014).

Survey procedure

The study involved collection of data on forest degradation and natural regeneration through field survey and vegetation analysis. Following standard vegetation sampling approach, the species composition and abundance of young regeneration (seedlings and saplings) were sampled in small quadrats within a larger plot.

A total of 60 quadrats were arranged along transects in eight directions (E, SE, S, SW, W, NW, N and NE) starting from 50 m away from the main road, near the State Forest Nursery edge. Quadrat sizes of 20 m × 20 m (400m²) were used for trees and shrubs, 5m × 5m sub plots for seedlings, saplings, and 1m × 1m for herbaceous species. The quadrats were established at about 100 m apart along the line transect, in each patch these were spread at about 400 m, covering the entire area of the forest.

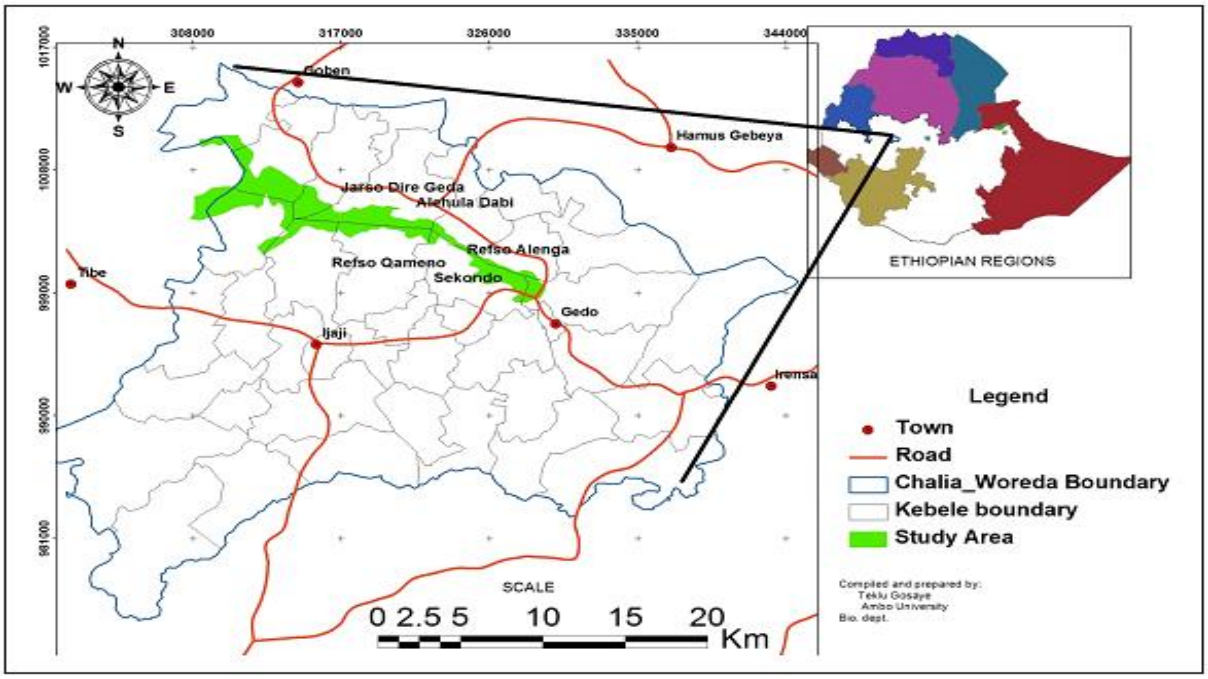

Fig 1. Map of Ethiopia and the location of the Gedo Forest.

As the direct assessments of state of the vegetation and degradation is difficult, indicators (Jontos *et al*., 2000) were used to detect the level of degradation. The purpose of this method was to calculate the combined estimate of different contributors as shown by the indicators to the present state of vegetation. To simplify the interpretation, the condition of the assessing factors on the overall vegetation/environmental condition of the sites (quadrats) were grouped into very poor, poor, fair and desirable categories and rated on a scale from one to four, with one having a maximum negative state and four considered to be the minimum. With a rapid observation, a set of indicators were identified and used to characterize the condition of the habitat/vegetation along the forest transects which included habitat, ecological and biological attributes like the existing canopy cover, soil cover of forest floor, degree of damage by human activities, damage by grazing and browsing, soil moisture level.

Data collection procedure

Following Marquis (1994) and Sander *et al.* (1976), species groupings were used for quantifying regeneration, the locally identified endemic and endangered tree species were used here. The local people, forest workers and officers were asked about important trees which were common in the past but now became rare or extinct from the area. These locally 'rare' trees were used to collect regeneration data. Regeneration status of the forest was analyzed by comparing saplings and seedlings with the matured trees according to Dhaulkhandi *et al.* (2008) and Tiwari *et al.* (2010), as follows; Good regeneration: if seedlings >saplings >adults; Fair regeneration, if seedlings> or ≤ saplings ≤ adults; Poor regeneration; if the species survived only at the sapling stage, but no seedlings (saplings may be <, > or = adults); and if a species was present only at the adult stage, it was considered as not regenerating.

As distribution of the height and diameter at breast height (DBH) classes can have an indication of natural regeneration, the data of all target individual tree species with height ≥ 2 m and DBH ≥ 2.5 cm were counted and measured for sapling and adult trees.

To explore the perception of local community regarding forest degradation and natural forest regeneration, the households near the forest were used for data collection through questionnaire survey and key informant interviews.

Results and discussion

General health of the forest

The results (Table 1) indicated that for 19 or 31.67% quadrats canopy cover of the forest was damaged (Classes 1 and 2), the forest becoming 'open' (Fig. 2). Similarly, 23 plots (38.3%) had affected forest floor, 25 plots (41.6%) had poor soil moisture, 17 plots (26.6%) had poor seedling growth and 27 plots (45.1%) had high ground disturbance.

Table 1. State of forest health of Gedo Forest, West Shewa, Ethiopia.

Sl. No.	Indicators of forest health *		Class 1	Class 2	Class 3	Class 4
1	State of canopy cover	No of plots	7	12	33	8
		% of plots	11.67	20.0	55.0	13.33
2	State of forest floor	No. of plots	5	18	25	12
		% of plots	8.33	30.0	41.67	20.0
3	Presence of soil moisture	No. of plots	9	16	30	5
		% of plots	15.0	26.67	50.0	8.33
4	State of seedling growth	No. of plots	6	10	40	4
		% of plots	10.0	16.67	66.66	6.67
5	Disturbance on ground	No. of plots	7	20	30	3
		% of plots	11.67	33.33	50.0	5.0

*Classes : 1 = Very poor; 2 = Poor; 3 = Fair; 4 = Good.

Table 2. Moisture content of the soil in Gedo forest.

Soil moisture content on degraded forest (Dp)			Soil moisture content on good forest cover (Gp)		
Sample	Plot ID	Soil moisture %	Sample	Plot ID	Soil moisture %
Dp1	1	8.04	Gp1	11	27.35
Dp2	2	13.35	Gp2	18	27.32
Dp3	10	10.88	GP3	38	13.49
Dp4	14	4.22	GP4	44	18.06
Dp5	15	7.98	GP5	50	32.30
Dp6	30	9.44	GP6	54	23.12
Mean -+ sd (log)		2.95±0.54	4.82±0.56		t = 5.92 **

These results indicated that about one third of the studied plots (i.e 110 out of 300 observations) were observed to be affected either by anthropogenic (opening of canopy cover, harvesting forest trees/parts) or by natural (aridity, poor soil) factors. Other studies on the Gedo Forest (Birhanu Kebede, 2010; Kelbessa, 2014) and Ethiopian Dry Afromontane Forests (Gebremicael Fisaha *et al.,* 2013) had recorded high levels of disturbances resulting in degradation.

For further confirmation, six of the most affected (Class 1) and six of the least affected (Class 4) plots (quadrats) were randomly identified and the soil samples from these were

collected for soil moisture content analysis. The results (Table 2) indicated degraded forest sites had low percentage of soil moisture ranging from 4.22 to13.35% whereas the non-degraded forest sites had high soil moisture varying from 13.49 to 32.30%. The mean of log moisture % were 2.95±0.54 for the degraded and 4.82±0.56 for the non-degraded samples (t = 5.92; df =10; P **).

Table 3. Factors affecting forest floor / seedlings in Gedo forest.

Factors affecting	Signs of impact present		Signs of impacts absent	
	No of plots	% of plots	No of plots	% of plots
Grazing effect	16	26.67	44	24.44
Human disturbance	27	45.0	33	18.33
Death due to Drought	7	11.67	53	29.45
Herbivore/browsing damage	10	16.67	50	27.78

Table 4. Locally endangered and endemic plants in Gedo Forest.

Scientific name of species	Local name	Family	Habit
Hagenia abssiynica (Bruce) J.F.Gmel.	Heexoo	Rosaceae	T
Cordia africana Lam.	Waddessa	Boronginaceae	T
Juniperus procera Hochst.ex.	Gaattiraa	Cupresaceae	T
Podocarpus falcatus(Thunb.)R.B.ex	Birbirsa	Podocarpaceae	T
Prunus aficana (hook.f.) kalkm.	Hoomii	Rosaceae	T
Schefflera abyssinica	Arfattuu	Araliaceae	T
Rhus glutinosa A .Rich	Laboobeessa	Anacardiaceae	T
Rhus vulgaris	Xaaxeessa	Anacardiaceae	T
Mellettia ferruginea(Hochst).Sbsp.	Sootalloo	Fabaceae	T
Maytenus addat(Loes.) sebsebe	Kombolcha	Celastraceae	T
Erythrina brucei.Schweinf.	Walleenssuu	Fabaceae	T
Dombeya longerbracteolata	Dannissa	Steraliaceae	T
Vepris dianellii	Hadheessa	Rutaceae	T
Solanecio gigas (Vetke) C.Jeffrey.	J/jaldessaa	Asteraceae	S
Acanthus sennii Chiov.	Kosorruu	Acanthaceae	S
Echinops longisetus A.Rich	Qoreeharree	Asteraceae	S
Lippia odoensis	Kusayee	Verbenaceae	S
Solanum marginatum L.f.	Hiddii	Solanaceae	S
Vernonia Leopoldi(Sch.Bip.ex	Sooyyama	Asteraceae	S
Conyza abyssinicum Sch.Bip.ex	Kisee	Asteraceae	S
Kalanchoa petitiana A.rich	Bosooqqee	Crassulaceae	H
Echinops kebericho. Mesfin	Qaraabichoo	Asteraceae	H
Justicia diclipteroideslandau.sbsp.	Darguu	Acathaceae	H
Thymus Schimperi Ronniger	Xosanyii	Lamiaceae	H
Urtica semensis steudel	Gurgubbee	Urticaceae	H
Bidenis ghedoensis Misfin.	Kelloo	Asteraceae	H
Cirsium dender Friis	Baalawaraantii	Asteraceae	H
Clematis longicauda Steud.ex.A. rich	Hidda fiitii	Rununculaceae	C
Mikaniopsis clematoides Sch.Bip.ex.	H/Hantuutaa	Asteraceae	C
Justicia abyssinicum	H/Ichilbee	Oleaceae	C

[C=Climber, S= Shrub, T= Tree, H= Herb].

Additional examination of the forest floor vegetation and seedlings/saplings in the 60 plots which for human/ animal interference and seedling death (Table 3) indicated that human/animal interferences were more important factors for incurring forest floor/seedling damage, around 45% of the plots had sign of damage from these sources.

Table 5. Regeneration of the tree species in in Gedo Forest.

Scientific name	No of seedling	No of Sapling	No of Mature tree
Haginia abyssinica	0	3	10
Cordia africana	0	0	2
Juniperus procera	0	0	3
Podocarpus falcatus	70	30	12
Prunus africana	105	39	28
Schfflera abyssinica	0	0	7
Mellettia ferruginea	0	3	8
Maytenus addat	0	0	4
Erthrinia brucei	0	0	2
Rhus glutinosa	7	36	22
Rhus vulgaris	13	7	19
Dombeya longebracteolata	0	1	8
Vepris dainellii	139	79	30
Total	334	198	155

Evidence from indicator species

With the information from the local people, field observation and literature (Ensermu *et al*., 1992; Vivero *et al*., 2005; 2006; Teshome Soromessa and Ensermu Kelbessa ,2013), a total of 31 endangered and endemic plant species have been identified in the 60 quadrants (2.4/ha) in the study area (Table 4).

Out of these, 13 species (41.94%) were trees, 7 species (22.58%) were shrubs, 8 species (25.8%) were herbs, and 3 species (9.67%) were climbers (Table 4). The 13 tree species were used, as the young trees can be good indicators of natural regeneration. Data indicated (Table 5), only 5 species (38.46%) have represented by seedlings in the 60 plots, but the remaining 8 species (61.54%) had no seedling at all, indicating that no natural regeneration is taking place. The density of seedlings and saplings would indicate the regeneration status forest, only five species (*Podocarpus falcatus, Prunus Africana, Rhus glutinosa* and *Rhus vulgaris* and *Vepris dainellii*) had fairly high number of seedlings/saplings (Table 5).

Evidence from Diameter at Breast Height (DBH) and height

DBH class distribution of the species (Class 1: 2.5-10 cm, 2) 10.01-20.0 cm, 3) 20.1-40cm, 4) 40.1-60cm, 5) 60.1-80cm, 6) 80.1-100cm, 7) DBH> 100.01cm) indicated that the density of individuals decreased abruptly after the Second DBH class onwards, thus 57.64% and 21.98% of the individuals were found in the first two DBH classes (2.5-20 cm) while the remaining five Classes together account for only 20.38% (Table 6).

Similarly, the frequency distribution of height classes of these tree species (Class 1 from 2.0-5.0 m, 2) 5.01-10.0 m, 3) 10.01-15.0 m, 4) 15.01- 20.0 m, 5) 20.01-25.0 m, 6) 25.01-30.0 m, 7) >30 m) given in Table 6 indicated the highest number of individuals in small size class, more than 85.29% of trees were less than 10 m tall (Classes 1 and 2), only 14.71% reached above height of 15 m (Table 6).

Table 6. DBH and height class distribution of the tree species in Gedo forest.

DBH Class	Class intervals	%	Height Classes	Class intervals	%
1	2.5-10cm	57.64	1	2-5m	63.52
2	10.01-20cm	21.98	2	5.01-10m	21.76
3	20.01-40cm	12.81	3	10.01-15m	7.16
4	40.01-60cm	5.24	4	15.01-20m	3.49
5	60.01-80cm	1.46	5	20.01-25m	2.04
6	80.01-100cm	0.58	6	25.01-30	1.45
7	>100cm	0.29	7	>30m	0.58

Table 7. Perception of respondents towards management control of Gedo Forest**.**

Forest management control	Frequency	Percent
Government	9	17.3
Community	27	51.9
Both government and community	15	28.8
None of them	1	1.9
Total	52	100

The distribution pattern of DBH and height reveal an inverted J-shape, which indicated species frequency distribution having the highest frequency in the lower diameter/height classes and a sharp decrease towards the higher classes. As the Montane forests are among the highly threatened ecosystems in Ethiopia (Yeshitela and Shibru, 2002; Simon Shibru and Girma Balcha 2004), such variation in the distribution indicate poor regeneration. As many as eight species with no recruitment were identified, future survival of those plant species would be at risk; as there were no individuals that replace the old trees. Mature plants were very few for species like *Prunus africana, Vepris dianellii, Rhus vulgaris, Rhus glutinosa, Juniperus procera* and *Cordia africana which* also indicate lack of local seed source.

Table 8. Seedlings survival rate between 2004-2006 Ethiopian Calender.

Source	Types of species	2004			2005			2006		
		Planted	Survived	%survive	Planted	survived	%Survive	planted	Survived	%survive
Forest Office	Indigenous	20249	11249	55.55	18700	13838	74.0	41360	27216	65.8
	Exotic	135513	113831	84.0	142743	122759	86.0	124979	108732	87.0
Agriculture	Indigenous	3870000	1530000	39.53	5865000	5353000	91.27	9342000	7800000	62.62
Office	Exotic	5161000	2041000	39.55	7820000	7138000	91.28	12156200	10400000	83.49

The forest and local communities

As the Gedo Forest has been substantially degraded and this degradation has been due more to human interference, it is important to understand the livelihood pattern of the local community living near the forest for controlling degradation and ensuring good natural regeneration.

Majority of the respondents mentioned that the current condition of the forest is 'good' and they see no 'degradation' of forest but observations and key informant interviews suggested that the respondents in the study area were entirely dependent on the forest resources for fuel wood, fodder, construction material and farm implements and they also market forest resources like fuel wood and timber to nearby towns of Gudar, Ambo and to the capital Addis Ababa.

Fig. 2. Examples of 'opened' canopy forests due to human interference.

Most of the respondents considered that the natural regeneration of the forest is important and there has been a reduction in seedlings and young trees in the forest. More than 40% identified cutting of trees for fuel wood, timber, grazing of cattle and land clearing for cropping. When asked using their local names, 40% of the respondents reported that *Cordia africana* has become rare while 34.6% reported that *Juniperus procera*, 17.3% *Haginia abyssinica*, 3.9% reported about *Podocarpus falcatus* and 3.8% about *Prunus africana* are now becme rare . According to IBCR (2003) report, *Cordia africana, Hagenia abyssinica,* and *Podocarpus falcatus* were highly threatened indigenous plant species of Ethiopia. Also, *Juniperus procera* and *Prunus africana* were reported as endangered plant species (IUCN, 1997).

Fig. 3. Seedlings planted in nursery site.

It was clear from the survey that all of the informants were against forest control and management by the government institutions explaining that already there are conflicts between the forest guards and community. Under existing management, the local people do not have benefits from state forests while about 52% of respondents wanted the natural forest to be managed by the community (Table 7). The feeling of insecurity of access to forest resources under government management is long known, which could affect the attitude of the local community towards forest management (Gibson *et al.,* 1998).

Local forest rehabilitation efforts in and around Gedo forest

The Forest Department and the District Agriculture Department in Gedo currently having a strong tree plantation programme within and around the State forest. Seedlings of selected tree species are being produced for planting in the degraded parts of the forest and in other suitable sites. The state managed Forest Department nurseries have been producing large quantities of seedlings every year for planting in the degraded forest area and its edges and some sold locally to the community (Table 8). The indigenous species include *Juniperus procera, Haginia abyssinica, Rhus glutinosa* and *Cardia africana* while the exotics include *Eucalyptus sp, Cuppressus lusitanica and Gravelia* (Fig. 3).

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