# Sustainable Management and Promotion of Forest Coffee in Bale, Ethiopia

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**Submitted to:**

**Bale Eco-Region Sustainable Management Programme**

**SOS Sahel/FARM-Africa**

**August 2008**

**Addis Ababa**

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# 1 Introduction

## *1.1 Coffee as a commodity: global demand and supply*

Coffee is one of the world's largest traded commodities after oil, accounting for trade worth approximately US$ 5.6 billion in 2000/2001 (ITC 2002). Coffee, however, suffers from sharp variations in supply that can cause wide and violent fluctuations in price. Over the last few decades there were periods of coffee price boom and burst, characterizing the market. For example, prices boomed in 1986 and 1987 in response to a perceived shortage due to drought in Brazil, and shortly declined in 1989 due to collapse of the quota system of the International Coffee Organization (ICO). Due to such fluctuations, producing countries have seen their export revenues slump from an estimated US$ 14.3 billion in 1986/87 to US$ 5.4 billion in 1992/93, rise again to reach a high of US$ 12.4 billion in 1996/97, then dwindle back to US$5.6 billion.

It is produced in more than 70 countries and is the mainstay of most of these countries, accounting for over a large proportion of their total export earnings. Over 97% of the total coffee production in the world is, however, produced by 45 producing. For most of these coffee producing countries, it is the major source of foreign currency earnings as well as a significant proportion of tax income and gross domestic product. Ethiopia is one of the countries which heavily depend on coffee. Coffee takes the lion's share of the foreign exchange earnings, fetching up to 35% the total.

During the past few years, the world coffee price has shown an increasing trend. Given the emerging economies like Eastern Europe, Russia, China and many Asian countries, the prospects for the prices to remain high is highly probable. For instance, the price of Arabica coffee has increased from 89.40 US cents per lb in February 2005 to 138.82 US cents per lb during same month in 2008 (ICO 2008). The world's supply and demand are presently in very tight balance, with a lot of new consumption coming up, and production not necessarily keeping pace in the coming 10 years. Statistics from the ICO indicates that production from the African continent has actually shown declining trends since the year 2000. This is also manifested in declining share of the continents coffees in the world market, falling from as high as 32% of total world exports to the current level of 12%. On the other hand, annual production of Ethiopia is on an

increasing trend from 3,693,000 bags in 2002 to 5,733,000 bags in 2007 (ICO 2008). This shows that there is a growing importance of the country in coffee export. However, this is still below the country's potential, since Ethiopia has the largest highland plateau suitable for Arabica coffee production in the world.

### *1.2 Coffee production in Ethiopia: social, economic and environmental importance*

The southwestern and southeastern highlands of Ethiopia are the birth place and home to Arabica coffee. Apparently coffee is at the centre of Ethiopian culture and economy, and contributing to about 35% of country's foreign currency earnings. It accounts for *ca*. 10% of the gross domestic product, and support the livelihoods of around 25% of the population of Ethiopia (representing around 20 million people) in one way or another. In Ethiopia, coffee grows over a wide range of agro-ecology zones and geographical regions. Alongside, it is apparent to observe different coffee production systems that are mainly managed by smallholder farmers. These systems are mostly forest-based traditional coffee production systems. The forest-based traditional coffee production systems mainly include: forest coffee (FC), semi-forest coffee (SFC) and forest garden coffee (FGC). The level of management intensities varies from a little (none) to significant influences in these different coffee production systems. For instance, forest coffee production system accounts for about 25% of the total production, which is directly from wild populations in its natural habitat, i.e., the montane rainforests. In this case, the farmers simply pick the cherries when it is ripe, with very little management of the undergrowth of the forest vegetation for access during harvesting. This has contributed a lot to biodiversity conservation and promoted environmental/biodiversity-friendly coffee production. Today, over 60% of Ethiopia's remaining forests are found in the coffee forest areas in the southeast and the southwest (Figure 1). Almost 90-95% of the Ethiopian coffee is produced by smallholder coffee farmers with an average farm-size of 0.5ha.

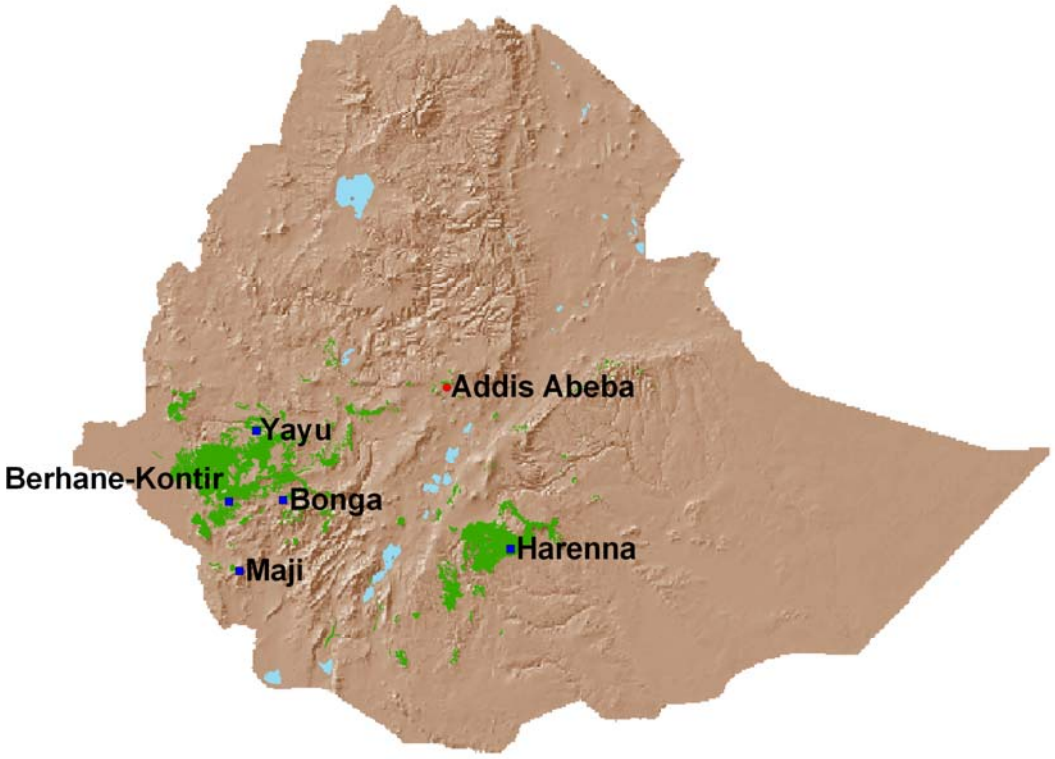


**Figure 1. Map showing the coffee forest areas and remnant forests of Ethiopia. Coffee and Forest cover with dark shade, and the major coffee forest areas are labeled**

## *1.3 Problems in coffee production in Ethiopia: technical, marketing and quality*

Notwithstanding their economic, social and environmental importance, the traditional forest-based coffee production systems face a number of challenges. The coffee forests are frontiers for expansion of agricultural land for the growing local population and establishment of big monoculture plantation or farms by large-scale investors. For the coffee forests to continue to exist, the revenue from forests products should be competitive with other alternative land use types. With the current poor processing and management practices, the forest and coffee genetic resources will face continuous degradation from time to time. Hence, an integrated approach of improving coffee quality and management practice, coupled with appropriate marketing has to be in place, to serve both conservation and livelihood improvement.

However, the majority of Ethiopian coffee is prepared using a dry processing (natural/sun-dried) system, which means cherries are harvested and sun-dried as a whole. After drying, the cherries

are sold to local collectors (sebsabis), traders (akrabis), or co-operatives, which operate the secondary processing facilities. The sun-dried method which is practiced by the majority of farmers can cause fermentation process to take place, due to slow or poor drying systems, and as a result may spoil the natural aroma and sweetness characteristics of coffee. This in turn reduces income to the small-scale farmers as the price paid for sun-dried coffee is very low compared with coffees processed using improved processing methods.

The second method of processing is the washed method where cherries are pulped immediately after picking. The washing stations are generally operated by state farms, who process their own production, or in the case of small-holder cherry, by co-operatives, or individuals. After washing, parchment coffee is fermented, washed and dried, ready for transport to Addis Ababa, where it is sold in the auctions. In Bale, there is no single wet processing station, and all coffee from the area is poorly handled sun-dried coffee.

### *1.4 The forest coffee production system and biodiversity conservation*

Being the center of origin and diversification of coffee, *Coffea arabica* L.*,* Ethiopia possesses diverse genetic resources of the crop. This is partly due to the diversity of traditional coffee production systems employed by the Ethiopian farmers for over 2000 years. Coffee production systems in Ethiopia can be grouped into four broad categories as: forest coffee, semi-forest coffee, garden coffee and coffee plantations. The first three are traditional production systems by small-scale subsistent farmers. The three traditional systems, i.e., forest, semi-forest and garden coffee production systems account for 5-6%, 20%, and 68-69% of the total coffee production in Ethiopia respectively, summing up to 94% of the national produce.

Coffee naturally occurs as an understorey shrub or small tree in the Afromontane rainforests. Hence, coffee production is associated with other plant species which serve as shade trees. This nature of coffee has contributed for the survival of most remnant forests in Ethiopia. Large forested landscapes in the country are found only in the major coffee growing areas in the southwestern, southern and southeastern parts of the country, including the Haranna forest in Bale. These remaining forest areas have already been globally recognized as hotspot areas for conservation, as the Eastern Afromontane Biodiversity Hotspot (Mittermeier et al. 2005). The Eastern Afromontane is one of 34 globally important priority areas for biodiversity conservation.

Given the fact that over 50% of the Afromontane region higher than 1500 m and about 80% of the Afromontane region surpassing 2000 m is found within Ethiopia, the coffee forests and other traditional coffee production system in the highlands of Ethiopia are very crucial for biodiversity conservation both at regional and international levels.

Recent studies on some coffee forests of Ethiopia revealed that coffee forests are rich in plant biodiversity (Gole 2003; Schmitt 2006; Senbeta 2006, Gole et al. 2008). From data collected from four areas in Bale, Bonga, Sheko and Yayu, over 700 species plants were recorded, representing about 10% of the countries flora. The genetic diversity of the wild populations of coffee showed high variability within and among populations is very (Tefaye 2006). All wild populations also had higher level higher genetic diversity as compared to cultivated coffee in plantations and home gardens (Tesfaye 2006). The wild populations also had high functional diversity in terms of disease tolerance (Adugna et al 2005) resistance to pest and drought tolerance (Kufa 2006; Beining et al. 2005). These forests are also important for the livelihoods of millions of people. These studies by researchers from different disciplines concluded that the best way to conserve the coffee forests and coffee genetic diversity is a strategy which strikes the balance between use and conservation (Gole et al. 2006). That means, sustainable management of the coffee forests can only be achieved if there is a balance between conservation and use the forest for coffee production can be achieved. This particular study, therefore, aims at outlining strategies for sustainable management and promotion of the forest coffee production one of the remnant forests, the Haranna forest in Bale.

## *1.5 Objectives of the study*

The objectives of this study area:

- To assess the Bale forest coffee resources, making reference to any available secondary data, and through field visits.
- To produce a coffee forest map for Bale
- To document existing coffee management practice from planting to sales, and develop a coffee management practice calendar
- To identify and review the value chains involved in Bale Forest Coffee production and marketing

- ❖ Write up an outline strategy, including step by step activities for the BERSMP to follow in order to improve the sustainable management of in-situ forest coffee and basic production

# 2 Materials and methods

## *2.1 Description of the study area*

### 2.1.1 Location of the area

The study was conducted on coffee forest areas in Haranna forest. Haranna forest located at about 550 km south of Addis Ababa, in the Bale Zone of Oromia state. The study area falls within two Woredas of the Bale zone, namely Dalo-Mana and Haranna-Bulluk. Both Woredas have 14 peasant associations (kebele) each. A detailed description of the study area is given in the following section.

Of the total Kebeles in Dalo-Mana Woreda, 4 Kebeles, namely: Chiri, Wabaro, Burkitu, Irba were visited for the present study. In Haranna-Bulluk, only two Kebeles, namely: Qumbi and Angetu were visited. There are 8 dry coffee processing mills, seven in Dalo-Mana and one in Haranna-Bulluk.

### 2.1.2 Topography and climate

The area is characterized by flatlands; moderately steep rolling hills with valley bottoms and waterways. The majority of the study area is covered with Afromontane rainforest, which constitutes the largest part of the Bale Mountains National Park. The Haranna forest lies between 1300 and over 3000 m; however, forest coffee only occurs in the lower lying areas of the forest between 1300 and 1850 m a.s.l. The forest soil of the area is dark reddish-brown silt-clay, rich in basic exchangeable cations (Mesfin and Lisanework 1996). The soil in the coffee zone is acidic to slightly acidic with a pH between 5.3 and 6.6. The rainfall pattern in the area is the bi-modal type, i.e., March through April (short rain season) and August through October (long rain season). Mean annual rainfall in the area actually varies from around 700 to over 1200 mm and the mean annual temperature is 18 $^{0}$C.

### 2.1.3 Settlement pattern

In both Woredas, the majority of the populations are settled (farming community) in the lower edging of the forest (southern side of the forest) and with a small proportion of population residing in the forest. There are around seven small villages in the forest: Manyate, Chefa Dera, Yadot1, Yadot2, Hebubi, Qanqicho, and Oda Guda. They all together consist of about 250 households, with a total of 11,035 family members. Despite the minor differences in the style of settlement patterns, almost all people are dependent on the forest and forest products. Regardless of the location, all have coffee plots and beehives in the forest and also graze their livestock's in the forest, especially during dry season. Very recently, new settlers from different parts of the country have started to occupy the area, especially from Hararge and Sidama; and putting immense pressure on the remaining forest and it resources. All these have contributed to continuous reduction of the forest of the area according to local respondents. The BERSMP may induce sustainable natural resources management strategy to reduce loss of the forest resources of the area.

### 2.1.4 Demography/population

According to local sources, the total population of the study area is increasing. Immigration from other parts of the country and the polygamous marriage system in the area contributed to high rate of population growth in the area. Apparently, population is rising continuously and putting huge pressure on the remaining forest fragments. The major immigrant populations in Haranna-Bulluk are from Sidama of the Southern Nations, Nationalities and People Regional State, while in Dalo-Mana it is from Western Hararge Zone of Oromia state. Tables 1 and 2 show the population of Dalo-Mana and Haranna-Bulluk Woredas, respectively. Currently, the total population of Haranna-Bulluk is 68,094, with population density of 30 persons/$km^2$. The total population of Dalo-Mana Woreda, on the other hand, is 96,161, with a population density of 21 persons/$km^2$.

**Table 1. Population of Haranna-Bulluk Woreda by Kebele.**

| **Kebele name** | **No. of Household** | | | **Total Population** | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Angetu | 553 | 36 | 589 | 2562 | 2733 | 5295 |
| Kumbi | 872 | 25 | 897 | 2495 | 2662 | 5157 |
| Hawo | 540 | 25 | 565 | 2805 | 2887 | 5692 |
| Bulluk | 703 | | 703 | 3034 | 3216 | 6250 |
| Hero | 265 | | 265 | 1407 | 1627 | 3034 |
| Sorbira | 230 | | 230 | 1307 | 1837 | 3144 |
| Sodu-welmel | 525 | 25 | 550 | 1789 | 1899 | 3688 |
| Shawe | 781 | | 781 | 3060 | 3564 | 6624 |
| Anole | 512 | 16 | 528 | 1934 | 2160 | 4094 |
| Melke-arba | 984 | 96 | 1080 | 3848 | 4647 | 8495 |
| Mekane-gobele | 606 | | 606 | 2037 | 1894 | 3931 |
| Bekaye | 562 | 8 | 570 | 2277 | 2649 | 4926 |
| Sodu-lelaftu | 684 | 10 | 694 | 2182 | 2206 | 4388 |
| Gerbi galo | 459 | 2 | 461 | 1707 | 1669 | 3376 |
| **Total** | **8,276** | **243** | **8,519** | **32,444** | **35,650** | **68,094** |

Sources: HBWARDB

**Table 2. Population of Dollo-Mana Woreda by Kebele**

| **Kebele name** | **No. of Household** | | | **Total Population** | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total* | Male | Female | Total |
| Webero | 962 | 64 | 1026 | 2470 | 3278 | 5748 |
| Chiri | 1185 | 204 | 1389 | 4079 | 4289 | 8368 |
| Erba | 899 | 35 | 934 | 2615 | 3236 | 5851 |
| Burkitu | 513 | 52 | 565 | 1418 | 1942 | 3360 |
| Melka-Amana | 950 | 110 | 1060 | 3398 | 3407 | 6805 |
| Berak | 546 | 67 | 613 | 2336 | 2555 | 4891 |
| Nanigadhera | 430 | 84 | 514 | 2490 | 2279 | 4769 |
| Haya Oda | 341 | 93 | 434 | 1597 | 1453 | 3050 |
| Sonti Kera | 540 | 54 | 594 | 2182 | 2324 | 4506 |
| Deyu | 853 | 158 | 1011 | 3495 | 3810 | 7305 |
| Bobiya | 160 | 571 | 731 | 4792 | 2727 | 7519 |
| Oda Dima | 465 | 17 | 482 | 1849 | 1624 | 3473 |
| Kele Golba | 1280 | 430 | 1710 | 5555 | 5150 | 10705 |
| Gomgoma | 581 | 105 | 686 | 2073 | 2295 | 4368 |
| Mena Town | - | - | | 7566 | 7877 | 15443 |
| Total | | | | | | 96161 |

### 2.1.5 Means of livelihood

There are various sources of livelihoods and income for local communities living in both Woredas. These include coffee, honey, crops, hunting and gathering, livestock production, timber and other non-timber forest products. The importance of the different items keeps changing over time due to social and environmental factors. These products serve either for household consumption or for cash income or both. For example, honey and coffee are exclusively for income and fields crops and livestock are mainly for household consumption.

### 2.1.6 Land use/ land cover

In both Woredas, natural forest and wood lands still accounts the largest share of the land use types (see Table 3 below). In Dalo-Mana Woreda, the highest land use type is woodland (46.4%) followed by high forest (ca. 20.5 %). In Haranna-Bulluk high forest is the dominat land use type (ca. 49.5%) followed b woodland (ca. 21.6%). The proportion of grass land is low in both Woredas. Hence, livestock grazing is mainly inside the natural forest and woodland.

**Table 3. Land use types and proportion share for the two Woredas.**

| | | **Dalo-Mana** | | **Haranna-Bulluk** | |
|---|---|---|---|---|---|
| Major category | Type of land use | Total (ha) | % of Total | Total (ha) | % of Total |
| Agriculture/settlement | Farm land | 36,549 | 7.9 | 8,173.0 | 3.6 |
| | Settlement | 7,033 | 1.5 | 741.5 | 0.3 |
| Forest | Dense | 94,802 | 20.5 | 111,830.1 | 49.5 |
| | Disturbed | - | - | 30,490.1 | 13.5 |
| | Wood land | 214,166 | 46.4 | 48,758.5 | 21.6 |
| Grass land | Grass land | 86,452 | 18.7 | 5,050.5 | 2.2 |
| | Hills and others | 22,663 | 4.9 | 20,950.3 | 9.3 |
| | Total | 461,665 | | 225,994.0 | |
| Agro-ecology (%) | Dega | - | - | - | 27.9 |
| | Woina Dega | - | 13.3 | - | 37.6 |
| | Kola | - | 86.7 | - | 34.5 |

Sources: DMWAPDO & HBWARDB

## *2.2 Methods of the study*

A rapid forest conditions assessment was carried out in some selected kebeles to list major plant species characterizing the coffee forest, major forest uses by the local community and observe management practices. Besides, detailed study on the flora of the forest vegetation under different management intensities were taken from a recent study by Senbeta (Senbeta 2006). For the detailed study, data was collected using systematic method, lying sample plots along transect

lines. The two major forest types based on management intensities in the area are undistributed forest coffee (FC) and disturbed semi-forest coffee (SFC) systems. In the FC system, human influence is limited to coffee- berry collection without changing the floristic and structural complexity of the forest. However, seasonally, cattle are allowed to graze in all forest areas during dry seasons every year. In contrast, in the SFC system, selective cutting of competing trees, shrubs and lianas to promote the productivity of coffee has been taking place for a number of years beside coffee-berry collection.

Along transects in each forest type, square plots of 20 m x 20 m were laid down to collect vegetation data. A total of 59 plots (FC, n = 24 and SFC, n = 35) were established, henceforth abbreviated as: Harenna Forest Coffee (HAFC) and Harenna Semi-Forest Coffee (HASFC). In each study plot, all vascular plant species were identified and counted. In addition, height and diameters of all woody plants with dbh > 2 cm and > 0.5 m height were measured. Furthermore, environmental data such as slope, altitude, aspect, and disturbance factors were recorded for each plot. Diameter at breast height and height of the coffee plants were measured and the plants categorized into seedlings (< 0.5 m high), saplings (0.5-1.5 m) and trees (> 1.5 m).

**PRA/RRA based Rapid Biodiversity Assessment**

Open-ended questions for interviews and group discussions were used to gather data from local community members, development agents and experts at woreda offices of agriculture and pastoralist development. The checklists of questions used in the FGD included topics like use of forest resources, farming systems, livelihood systems, coffee production and marketing, honey production and marketing, infrastructure and services and socio-economic problems. To map the coffee forest areas, current forest cover from satellite images and known altitudinal distribution range of coffee in the area were used.

**Review of secondary data**

Problems associated with coffee quality and ways to improve it were reviewed with emphasis on Ethiopia conditions. Steps to improve quality and estimates of associate costs were based on model coffee quality improvement projects implemented and found to be successful in the country.

# 3 Results and discussion

## *3.1 Traditional coffee production and forest conditions*

### 3.1.1 Current forest conditions

The Haranna coffee forest is one of the montane forest fragments located in southeastern Ethiopia (Senbeta et al. 2005; Senbeta and Denich 2007). Geographically, this montane forest is isolated from the rest of the Afromontane rainforests by Great Rift Valley system. The flora of Haranna forest differs from the southwestern rainforests in terms of dominant canopy tree species. This forest supports many vascular plant species (over 300 species) and many endemic plant species than other rainforests (Senbeta 2006). Some of the unique floristic composition of this forest includes *Podocarpus falcatus, Ocotea kenyensis, Filicium decipiens* and *Warburgia ugandensis.* In particular, *P. falcatus* is one of the few best-quality timber species that dominate the Haranna forest. Annex 2 shows the major trees, shrubs and climber species recorded in the Haranna forest. There is a clear vegetation zonation in the Haranna forest. The lowest most portion of the coffee forest, between 1400 m and 1500 m, is relatively dry and dominated by *Podocarpus falcatus-Strychnos mitis*; and the understory is chiefly dominated by coffee trees. The major associated trees and shrubs species of this community include *Podocarpus falcatus, Maytenus undata, Acanthus eminens, Cassipourea malosana, Fagaropsis angolensis, Croton macrostachys, Erythrococca abyssinica, Alangium chinense, Celtis africana, Coffea arabica, Ocotea kenyensis, Filicium decipiens, Warburgia ugandensis*, and *Strychnos mitis.* The common climber species of the community are *Oncinotis tenuiloba* and *Landolphia buchananii.* The herbaceous layer mainly consists of *Thalictrum rhynchocarpu, Panicum monticola, Hypoestes forskaoli, Desmodium repandum* and *Achyranthes aspera.* At higher elevations, between 1600 m and 1800 m, is the zone of relatively high humidity with the *Podocarpus falcatus-Syzygium guineense* community. In this community, coffee is also found in the understory.

According to local informants, Haranna forest also supports diverse wild animal species. These include lion, leopard, baboon, reedbuck, bushbuck, colobus monkey, fox, bushpig (two types: grey and black types), warthog, kudu, nyala, duiker, hunting dog and different bird species.

Despite all these richness, the Haranna forest is experiencing serious human pressure, mainly through agricultural expansion, settlements, overgrazing, forest fire and conversion of the undisturbed forest into intensively managed coffee forest.

Based on satellite image of forest cover and ecological range of coffee, the total area of land where coffee may occur in the forest is about 112,500 ha. This forest area can further be categorized as potential (ca. 42, 609 ha), dense (ca. 34,439 ha) and semi-forest (35,453 ha) (Figure 2; Table 4). The areas circumscribed as potential are higher elevation areas with some wild coffee, but very important for biodiversity conservation. Those circumscribed as dense are optimal ecological range for coffee, which is important for both forest biodiversity and coffee genetic diversity conservation. The semi-forest part covers areas which are currently managed by farmers for coffee production, and those which can be put under such management.

**Table 4. Coffee forest area based on altitude zones in each kebeles of Dollo Mena and Harena Buluk districts.**

| **WOREDA** | **KEBELE** | Area of Coffee Forest (Ha) | | | **TOTAL** |
|---|---|---|---|---|---|
| | | **1400-1600 m asl** | **1600-1700 m asl** | **1700-1850 m asl** | |
| **Haranna Buluk** | Garbi Galo | 1315 | 3036 | 2842 | **7193** |
| | Shawe | 5553 | 949 | 0 | **6502** |
| | Hawao | 828 | 8720 | 11617 | **21165** |
| | Kumbi | 3045 | 7303 | 3735 | **14083** |
| | Sodo Welmel | 3837 | 395 | 0 | **4232** |
| | Sodo lalafto | 2931 | 3384 | 2294 | **8609** |
| | Buluk_hurufa | 0 | 0 | 1023 | **1023** |
| | Bakaye | 2148 | 0 | 0 | **2148** |
| | Anole | 572 | 0 | 0 | **572** |
| | Angetu | 114 | 0 | 0 | **114** |
| **Sub total** | | **20343** | **23787** | **21511** | **65641** |
| **Dollo Manna** | Haya Odaa | 770 | 482 | 672 | **1924** |
| | Irba Walda | 783 | 266 | 330 | **1379** |
| | Wabero | 3031 | 1809 | 4068 | **8908** |
| | Burkitu Darara | 10217 | 2673 | 4319 | **17209** |
| | Bobiya | 128 | 364 | 404 | **896** |
| | Odo Dima | 273 | 583 | 2323 | **3179** |
| | Chiri Harawa | 4336 | 3338 | 727 | **8401** |
| | Deyou | 2728 | 1137 | 1099 | **4964** |
| **Sub total** | | **22266** | **10652** | **13942** | **46860** |
| **TOTAL** | | **42609** | **34439** | **35453** | **112501** |

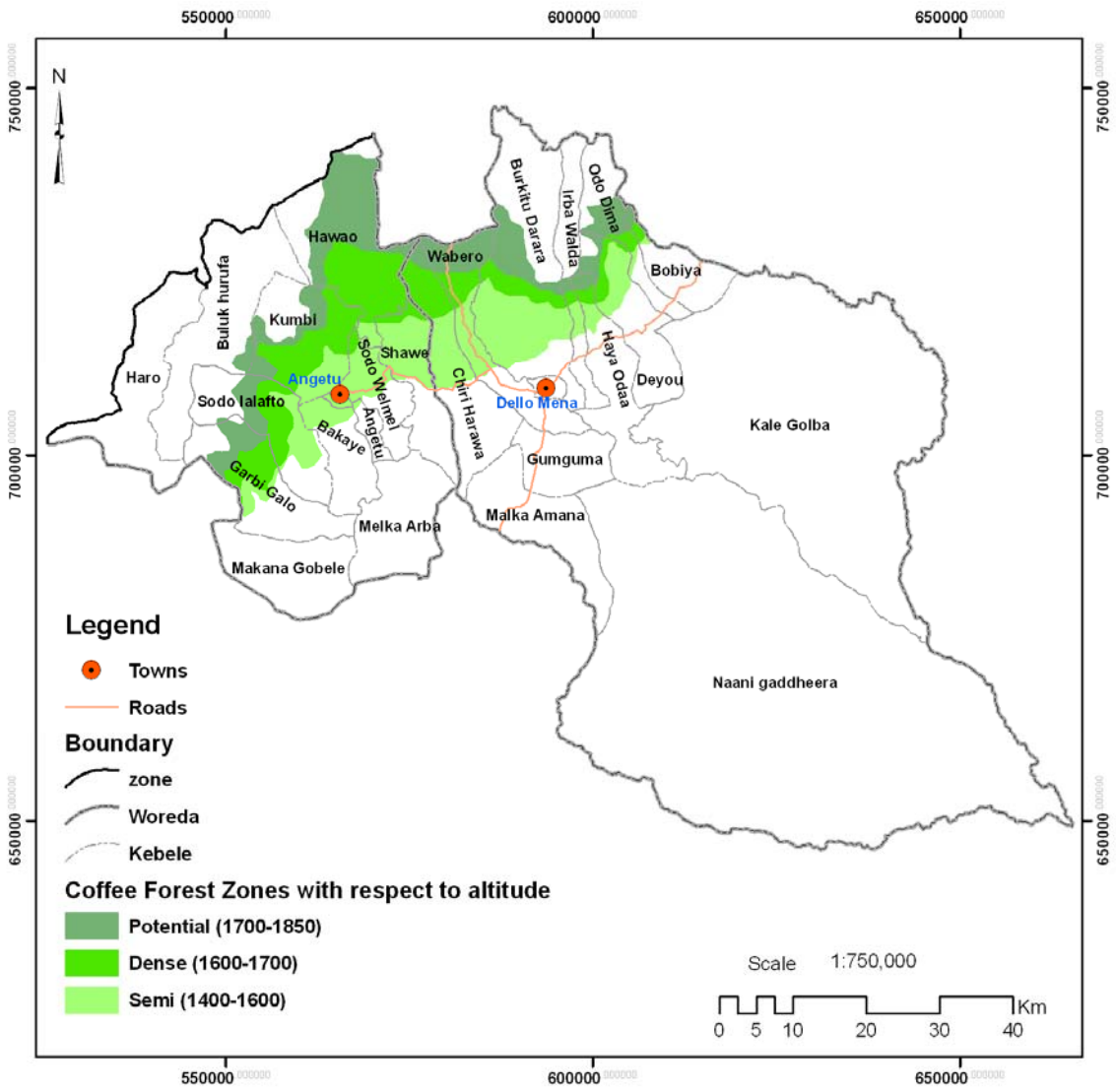


**Figure 2. Potential and actual area of coffee forest in both woredas.**

### 3.1.2 Traditional management practices/ operations

The traditional coffee production system in the area is a forest-based system. Harenna forest is one of the remnant coffee forest areas in the country. Similar to other coffee forest areas, the semi-forest coffee system is the main coffee production system. However, coffee productions like garden coffee and plantations are not significant, even though some settlers coming from Hararghe began garden coffee production around homestead and on farm lands.

#### *3.1.2.1 Initial opening up/ clearing*

In semi-forest coffee production system, farmers manage forest areas with wild populations of coffee. The first step in management of forest for coffee production is opening up undisturbed by

clearing undergrowth vegetation competing with coffee and cutting some shade trees to open up canopy. Coffee yield is highly correlated with the number and size of the branches of coffee trees. This in turn is related to the amount of solar radiation reaching the lower strata and the presence or absence of small trees and shrubs competing with coffee. Hence, to increase coffee yield to economically feasible level, clearing the undergrowth vegetation and opening up canopy is inevitable. During opening up phase, small trees, shrubs, and herbaceous vegetation competing with coffee are totally cleared as much as possible. There is no preferential selection what so ever, whether the species is endemic or threatened. Among the canopy trees, those species with big leaves and dense canopy are targeted. However, if there are no preferred tree species within the plot, any canopy tree available is retained. In newly opened up forests for coffee production, the amount of vegetation removed at initial stage can be critically high. Table 5 summarizes the vegetation characteristics of semi-forest managed for coffee production and relatively undisturbed forest areas in Haranna forest.

**Table 5. Vegetation characteristics of semi-forest and undisturbed forest areas in Haranna, Bale**

| | Parameter | Managed (Semi-forest) | Undisturbed Forest |
|---|---|---|---|
| 1 | Mean number of species per plot | 27 | 30 |
| 2 | Total number of sampled plots | 35 | 24 |
| 3 | Total number of species in all plots | 175 | 194 |
| 4 | Number of plant species by category | | |
| | Canopy trees | 5 | 5 |
| | Small trees | 27 | 26 |
| | Understorey/ shrubs | 50 | 60 |
| | Climbers | 40 | 45 |
| | Herbs | 46 | 48 |
| | Epiphytes | 22 | 25 |
| 5 | Structure | | |
| | Basal Area (m2/ha) | 47 | 49 |
| | Density (#/ha) | | |
| | Samplings/shrubs | 256 | 1077 |
| | Medium size trees | 178 | 291 |
| | Canopy trees | 340 | 181 |

As it can be seen from Table 5, most significant changes in managed forest is the huge reduction the density of samplings, small trees and shrubs level. In managed forest (semi-forest), the only dominant stand is that coffee. In most traditionally managed forests for coffee production, the

changes in vegetation structure and composition are very drastic. For instance in Yayu, the number of species in managed or semi-forest declined by 50% as compared to the undisturbed forest (Gole 2003). Senbeta (2006) has also reported a similar trend for Sheko forest. In Haranna forest of Bale, however, the difference between managed and undisturbed forest is relatively minimal. This can be due to damage to the so called undisturbed forest by seasonal grazing of cattle. Unlike the forests in SW Ethiopia, Haranna forest is used as grazing area during dry season. Pastoralists in the lowlands of Bale seasonal migrate to the forest areas at higher altitude. This damages regeneration and ground vegetation, which can be comparable to the annual weeding operations in forest areas managed for coffee production, the semi-forest.

#### *3.1.2.2 Weeding operations*

Weeding is one of the regular annual management operations carried out by all farmers. Weeding operations can be 2-4 times per year, varying from farmer to farmer, which also depends on the proximity of the forest plot the home village of the owner. The two major weeding seasons are beginning of the rainy season and beginning of the harvesting season. Few weeks after onset of the main rainy season, most herbaceous vegetation, emerge and compete with coffee and should be cleared. During harvesting as well, weeding is must to create access to pick coffee cherries from the trees, and also to allow picking of early maturing coffee cherries dropped to the ground. Along with herbaceous vegetation, small seedlings of trees, climbers and shrubs are also cleared.

#### *3.1.2.3 Shade trees management*

When some canopy trees are removed to open the forest up for coffee production, the canopies of some of the remaining trees expand, and gradually close up after some years. Hence, even in old semi-forest coffee productions systems, farmers continue to reduce the number of canopy trees. For instance, in Yayu forest, the number of trees per 400 m2 plot in undisturbed forest, new semi-forest (< 5 years), old semi-forest (> 10 years) were 50, 41 and 36 respectively (Gole 2003). Even though distinctions between old and new semi-forests were not made in this stud, it is assumed to follow a similar trend. To reduce shade trees, farmers often debark trees at the bottom, which gradually dries. Trees preferred by farmers for coffee shade are *Cordia africana, Croton macrostachyus, Millettia ferruginea*, *Ekebergia capensis, Podocarpus falcatus, Pouteria adolfi-friederici, Diospyros abyssinica, Olea capensis,* and *Olea welwitschii*. Tree species which

are not preferred for shade include *Vepris dainellii*, *Strychnos mitis*, *Warburgia ugandensis*, *Chionanthus mildbraedii, Celtis africana*, *Ocotea kenyensis*, *Syzygium guineense* and *Ehretia cymosa*. A more detailed list of trees that are target at initial opening up as well as shade management are indicated Appendix 2.

#### *3.1.2.4 Enrichment planting*

The distribution pattern of wild coffee is not regular, and uniform throughout the forest. It is dense in some areas, and very sparse in other areas. In areas where the coffee trees are sparsely distributed, farmers often plant with coffee seedlings to fill the gap. The sources of seedlings are mostly the wild seedlings collected from the forest itself, from those areas where there is high density. In recent years, however, the department of agriculture began distributing seedlings to farmers, from state-run nurseries. Caution should be taken to avoid introduction of new coffee types not indigenous to the forest, which can lead to genetic erosion.

#### *3.1.2.5 Disease management*

In both Woredas, different coffee diseases are prevalent. The major once include Coffee Wilt Disease (CWD), Coffee Berry Disease (CBD), Coffee Leaf Rust (CLR) and Coffee insect/pest. Although the farmers were trained in coffee diseases management by the experts of agricultural and rural development offices, they are not exercising the management practice. Especially with coffee wilt disease, it is not practical, since farmers are expected to disinfect machetes after cutting every diseased coffee tree, dig out all parts of disease coffee tree and burn it at the spot. It is very routine, labor intensive and can cause forest fire if it is not handled with care. Unlike other diseases, CWD kills the whole plant, and can also be disseminated by water movement as well as people during different management operation. This disease is the greatest threat to coffee genetic resources as well.

#### *3.1.2.6 Home garden and on-farm coffee management*

The local communities produce coffee principally in the semi-forest coffee production system. However, there is a growing number of new settlers' population coming from Hararghe and Sidama areas. The new settlers come with different culture of agricultural practices. The settlers from Hararghe began planting coffee in open farm areas without shade, mixed with cereals. Such coffee types are not indigenous to the area, and were brought from Hararghe by the settlers.

Settlers from Sidama also plant coffee with other perennial crops like Ensete, with some shade trees. Such practice may have two negative impacts: (1) it give a precedence that coffee can grow without forest, and may lead to deforestation; (2) it also threatens the wild coffee population, through replacement with new cultivated varieties, which are often of lower genetic variability.

### *3.2 Traditional coffee processing practices and quality*

Quality coffee is coffee that has desirable clean raw and roasted appearance as well as attractive aroma and good cup-taste. The quality of coffee is primarily determined by agro-ecology, genetic make-up, and management practices applied to the coffee trees and post-harvest processing and handling practices. The agro-ecology is excellent quality coffee production since it within the ecological range of coffee where there is still wild population. Hence, most problems of quality in the area are attributed to the pre- and post- harvest practices employed. This includes problems related to harvesting, processing, and storage of dry coffee. Generally, post-harvest handling attribute to up to 40% of the quality.

**Figure 3. Traditional sun-drying of coffee on ground: note also mixture of coffee cherries**

Coffee producers in the area come from far away villages or even far away woredas. They come to harvest coffee for few weeks, during which they strip of all coffee cherries, mixing mature and immature. This significantly affects the quality of coffee. The next stage which affects coffee quality is affected is processing. There are two processing methods: dry and wet processing methods. Dry processing is the only method used in the area. Even the dry processing is not optimal to ensure quality final product. The coffee cherries are dried on bare ground in most

cases, or on polythene sheet. The sun-dried method practiced by the majority of farmers can cause fermentation process to take place, due to slow or poor drying systems, and as a result may spoil the natural aroma and sweetness characteristics of coffee. It affects the quality of coffee very significantly. It may even lead to okra toxin contamination. The dried coffee is also stored in the living rooms of the produces, packed in polythene bags. There is no special store where humidity and other conditions are controlled, leading to more degradation of the coffee quality. This in turn reduces income to the small-scale farmers as the price paid for sun-dried coffee is very low compared with coffees processed using improved processing methods.

### *3.3 Current coffee marketing chains*

The farmers in both woredas are not well organized and lack a cooperative or cooperative union engaged in coffee marketing. The marketing chain tends to be long. Hence, the existing coffee marketing channel involves a number of intermediaries. The dried coffee cherries are sold to local collectors (sebsabis) or small collectors in villages, and coming from town who buy coffee from farmers and supply to bigger collectors (sebsabi) in town. The collectors (akrabis) operate the secondary processing facilities. After depulping the dried coffee cherries, the krabis supply coffee to the central market in Addis Ababa. Major exporters buy coffee from the central market, though auction. Such long market chain contributed to unfair/ unproportional benefit farmers get from their coffee, which also plays its own role in affecting the quality of coffee through its effect on farmers' capacity to invest in processing facilities.

In Haranna-Bulluk, there are no licensed Akrabis. The Woreda administration also does not allow traders with license from other woredas to buy coffee from local market, to increase its income from trade license. Beside the inaccessibility problem, farmers are facing lack of buyers for their coffee.

The other problem to all producers in 2007/2008 was government interference on the time to sell coffee. In order to improve quality, the government agencies told farmers to harvest coffee at later stages in the harvesting season. However, coffee cherries do not mature equally. Farmers were not allowed to sell early maturing coffee cherries after harvest. Those who attempted were punished. Dry coffee processing mills in town were only allowed to begin work around the third week of December. This led farmers to depulp the dry coffee cherries with ordinary grain mill,

and sell the coffee to illegal traders. It has negative effect both on quality of the coffee and supply to formal market. Coffee beans are broken during process. The illegal traders also sell the coffee they collect illegally across boarders to Somalia.

## *3.4 Sustainable management of forest coffee in the area*

### 3.4.1 Optimal forest management for coffee production and conservation

For optimal forest management for coffee production and biodiversity conservation, different activities and operations have to be carried by developing guidelines, standards and indicators for monitoring. These include capacity building practitioners through training, baseline inventory of forest conditions, initial opening or clearing, weeding, enrichment planting, monitoring and rehabilitation of degraded forest areas. The activities are described as in the following sub-sections.

#### *3.4.1.1 Training of para-ecologists/ botanist*

Forest management practices for coffee production to date are based on individual farmers' decision. There is no guideline to follow, to ensure sustainability. The impacts on the forest, therefore, vary from one farmer to another. For sustainable management of the forest and coffee genetic resources, there is a need for standardized management guideline. To implement such guideline, capacity building of the local farmers or some representatives is requires, to enable them assess the resource base, follow the management guideline and also be able to monitor changes over time. In this case, basic ecological and plant identification skills are required for the farmers' representatives to be able to communicate with development agents and natural resource managers. Hence, the first step for optimal forest management for coffee production and conservation is to train selected farmers from each coffee producing village in basic ecological skills to make forest inventory and plant species identification, and monitor changes in forest condition over time.

#### *3.4.1.2 Plot inventory/ stocktaking*

The second step to take forest conditions inventory, including list of major plant species, density of canopy trees, and the coffee stand. This is the base for making management decisions like shade trees management, coffee stand management, clearing regime, weeding operations and monitoring over the course of forest management. This activity should be done by the trained

para-ecologists, with close supervision of relevant government regulatory bodies like the forestry team of zonal and woreda department of Agriculture and Rural Development, Bale Forest Enterprise and Bale Eco-Region Sustainable Management Programme. During the inventory stage, trees, shrubs and climbers to be removed during the opening, weeding or further reduction of shade trees in old managed forest should also be identified and marked. Those species of high conservation value should also be identified.

#### *3.4.1.3 Initial opening up/ clearing*

To manage new forest areas for coffee production, the next step is opening up or carryout initial clearing to reduce canopy cover and the undergrowth vegetation competing with coffee. The major indicators to consider in initial clearing should be based on certain standard indicators for sustainable management. Up to know, there is no such standard for coffee forest management. However, some indicators have been identified by the Ethiopian Coffee Forest Forum, based on studies of traditional management practices in different coffee forests of the country. The major indicators are: number of species, number of shade trees, basal area, forest area, and key species of special conservation importance. As the first step, the vegetation characteristics to be used as criteria and the recommended minimum values are summarized in Table 6.

**Table 6. Vegetation characteristics and minimum indicator values**

| No. | Indicator | Minimum value |
|---|---|---|
| 1 | Number of species (#/ plot) | 25 |
| 2 | Number of shade trees (#/ha) | 250 |
| 3 | Basal Area ($m^2$/ha) | 40 |
| 4 | Canopy cover (%) | 65 |
| 5 | Density of saplings representing shade trees (#/ha) | 150 |
| 6 | Seedlings of tree species than coffee (#/ha) | 200 |

The forest area that can be managed for coffee production in Haranna forest is the part marked as dense and semi-forest zones in Figure 2. The forest area demarcated as 'potential' in the same figure should be a set-aside area for *in-situ* conservation both coffee and other forest biodiversity. Besides, attempt should be made to maintain the natural species mix as much as possible. The shade tree species to be cleared should only be those identified and marked during the inventory. For both canopy trees and undergrowth shrubs, attention should be given to keep reasonable individuals of endemics, Afromontane endemics and threatened species (Appendix 2).

#### *3.4.1.4 Weeding*

Weeding is one of the critical management practices in coffee production. Yield loss due to weeds can reach up to 65% (Eshetu and Zeleke 2008). The area experiences a bimodal type of rainfall, with short rain in March and April, and the main rain season from August through October. In this situation, there is a need to carryout weeding at least three times per year: around end of March, August, the third on at just before harvesting season at the end of October. During weeding, care should be not to clear the seedlings of key plant species of conservation importance. Some individuals of such species can be reduced if the density is found to be too high after monitoring/inventory. Attempt should also be made to use the removed biomass as organic fertilizer through on site composting. For species of conservation importance, refer to Appendix 2, especially those endemic to Ethiopia and the Afromontane endemics.

#### *3.4.1.5 Enrichment planting*

In coffee forests, the density of coffee trees per hectare can be very high, as high as 20,000 stems, including saplings. However, coffee trees are not regularly distributed, forming clusters in some parts, and sparsely distributed in other parts. Enrichment planting should be carried out in areas where the coffee stand is sparse. The spacing of 1.5 m between individual coffee trees can be used, since the branching nature of coffee in forest is not so wide. At this spacing, up to 4500 stem of mature coffee trees per hectare can be expected. The planting stock should seedlings of the local coffee types. This can be obtained from the wild seedlings in the forest or seedling raised in nurseries using the local forest coffee as seed source. This is with concept of maintaining the natural genetic variability of the local coffee populations, since the objective of sustainable management is also to conserve the coffee genetic resources of the wild populations. Strict regulation should be in place to avoid planting seedlings of improved varieties or cultivars introduced from other coffee growing areas.

#### *3.4.1.6 Monitoring of coffee / forest conditions*

In any ecosystem managed for economic use, change is inevitable. In order to achieve sustainability, regular monitoring of changes must be conducted so that corrective measures are taken in cases of deviations from the plan.

Two types of monitoring are suggested:

- Annual inspection: simple measurements like canopy density, and visual assessment of the forest conditions;
- Detailed inventory every second year.

The focus of the inspection should be on species composition, shade trees condition, coffee stand condition, and suggestions of better management practice for both conservation and sustainable use.

#### *3.4.1.7 Degraded forest rehabilitation and planting coffee*

Forest areas are declining from time to time due to expansion of agriculture, damage by cattle grazing and other anthropogenic factors. Besides, even those managed as semi-forest coffee production areas can be degraded after several years, in terms of structure and species composition. Rehabilitation can be achieved if it is economically attractive to the local community. In any case, the best option is managing the rehabilitated forest areas for coffee production. Degraded areas at forest edges should be rehabilitated by planting indigenous shade tree species and coffee. Degraded semi-forest coffee areas should also be rehabilitated enrichment planting of both coffee and shade trees.

### 3.4.2 Improved coffee harvesting, processing and storage

#### *3.4.2.1 Improved coffee harvesting*

Harvesting is one of the important stages that have considerable impact on quality. Poor harvesting practices contribute significantly to quality problems and influence the subsequent processing stages and the final cup quality of the coffee. To ensure best quality coffee, the following points are recommended:

- Wait for the green berries to fully mature and ripen;
- Selectively pick only ripe, read, healthy cherries;
- Undertake picking at several intervals so as to avoid dropping of cherries, over-ripening and drying.

The following should be avoided during harvesting:

- Indiscriminate stripping of cherries on the whole branch;
- Early harvesting of the cherries before they are fully mature;

- Mixing cherries dropped to the ground with those freshly picked from the trees;
- Maintaining cherries in plastic bags, or long periods in piles, as fermentation can occur.

The consequences of harvesting green cherries are:

- Insufficiently developed seeds, resulting in reduction in weight and total yield;
- Poor organoleptic qualities (astringency and absence of the chemical elements which generate the typical coffee aroma);
- Pulping difficulty, and fermentation problem;
- Many defective beans;
- Shrunk beans leading to roasting difficulty (easily burnt); and
- A general adverse effect on the quality of the beverage.

***3.4.2.2 Improved coffee processing***

Coffee processing is a critical operation and should be undertaking with great care. Quality can be enhanced or compromised in the course of processing. Generally, there are two coffee processing methods: the dry and the wet methods. The wet processing method often gives better quality. Improved processing methods of both types are described in the following section.

**A Dry processing method**

This method involves drying red cherries, without using water at any stage. The harvested ripe cherries are thinly spread over a raised bed and raked at regular intervals to prevent fermentation and to ensure even drying. The cherry is dried from a moisture content of about 65% to 12%.

The cherries are dried on beds constructed from chicken wire and fixed on wooden frames raised about 80 cm above the ground. A synthetic black shade net is then placed over the chicken wire before the cherries are spread on top of it. A Hessian cloth is used to cover the drying coffee during mid-day to protect from strong sun. In the night and during rain, the Hessian cloth also serves to protect the coffee from coming in contact with the overlying polythene sheet.

The following are steps and processes to be followed in dry processing:

- Pick only fully ripe red cherries;
- Perform sorting- to remove undesirable objects such as dry or damaged fruits, leaves, etc;

- Start sun drying on the day of harvest by spreading cherries on raised beds. Coffee harvested on different days should be dried separately;
- The cherries must be spread into thin layers (maximum 3 cm) when still fresh. Otherwise, there is a risk of mould developing and black beans forming;
- The drying cherries must be raked regularly several times a day to ensure even drying;
- At night and in adverse weather conditions, drying cherries should be moved to the center of the bed and covered with materials like Hessian cloth followed by opaque polythene sheet to avoid moisture absorption and rewetting;
- Take dry coffee to store when it attains optimum moisture content (below 12%). Drying cherries takes 10-15 days depending on the prevailing temperature.

Figure 4. Drying bed and coffee cherries being turned on drying bed

**Figure 5. Covered drying cherries over night and during rain to avoid rewetting.**

The following are precautions to be taken during sun drying coffee cherries:

- Avoid mixing cherries harvested on different days;
- Never heap cherries as this leads to fermentation, minimize the thickness of the drying layer;
- Drying cherries should not be exposed to wet conditions as this encourages growth of moulds;
- Coffee should not come in contact with soil and unclean surfaces; and
- Do not attempt to store coffee that is not fully dry.

**B. Wet processing method**

The wet method involves use of water in most stages. This method involves several stages whereby ripe cherries are transformed into parchment coffee. In fully-fledged conventional wet processing, red cherries are pulped, fermented under water until the mucilage is degraded so that it can be easily washed off. Fermentation period in most cases varies from 12 to 48 hours depending on the temperature of the locality. The parchment is then washed and dried to attain a moisture content of 10-11.5%. However, in view of the situation of the small-scale coffee producers in Ethiopia, simple, low-cost and environmentally friendly machines that simply separate the pulp from the parchment have been introduced by CABI Africa, Illycafé SPA and the Ministry of Agriculture and Rural Development. This can produce washed natural coffee, and was found to improve quality significantly. It is also found to be affordable if farmers are organized into small groups. This method of using small-scale pulping machines is described in the following section.

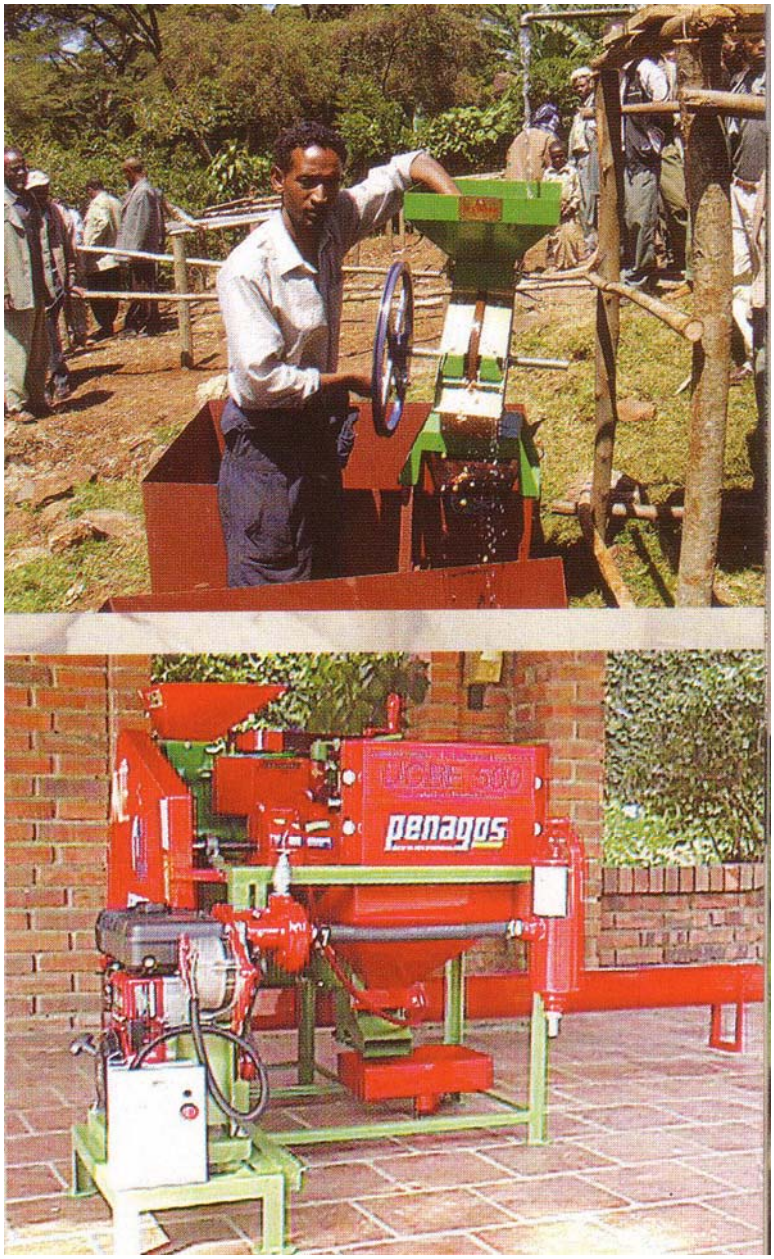


**Figure 6. Manual and hand-driven pulpers**

**B.1 Small-scale pulping machines**

Pulpers can be classified either drum or disk pulper which may be motorized or manually operated (Figure 6). The CABI Africa-MoARD project introduced the disk type manually operating hand-pulpers in Ethiopia. The hand pulpers have a capacity of 50 kg cherries/hr and separate the coffee pulp from the wet parchment which is ready for drying.

**B.2 Stages in wet processing**

***I. Selective picking of cherries***: coffee cherries for wet processing should be mature and fully ripe. Ripe cherries have adequate pulp and mucilage which facilitate pulping. Cherries in mixed stages of maturity would cause pulping and fermentation problems, which have series negarive consequences for the quality of the product.

II. Sorting: the first operation in coffee processing following picking is sorting, the puprpose of which is to remove undesirable objects such as leaves, twigs, stones, as well as diseased or pest infected, immature, over ripe and dry cherries. Under-sized cherries which would escape pulping are also removed and processed by dry method, and may be used for own consumption. Use clean material such as canvas, drying trays or mesh wire beds; cherries should not come into contact with the soil during sorting.

***III. Checking and adjusting the pulper***: checking and making the necessary adjustment to the pulping machinery is crucial activity prior to pulping. Pulpers are adjustable to be able to pulp different size of cherries. Perform test run with sample cherries and do adjustment of the machine based on the beans or passage of many unpulped cherries together with the pulped ones. Adjustment is normally done three times during the processing season: at the beginning, middle and end season. The pulper should be kept in clean and good mechanical order.

***IV. Pulping:*** pulping is the mechanical removal of the red outer skin and pulp from the cherry to produce parchment coffee. This is performed by squeezing the cherry to release the parchment coffee out of the pulp, and facilitated by the lubrication from the mucilage formed between the pulp and the parchment. But in over-ripe cherries, the mucilage layer is dried up, while in the green cherries, it is not fully developed. So, pulping under both conditions will result in large number of damaged beans due to lack of adequate mucilage. Pulping is done via a stream of

water which helps the cherries to be fed to the pulper. The water also facilitates separation of the parchment coffee and the pulp.

The following are precautions for pulping:

- Harvested cherries should be kept in cool (under shade) and clean place until pulping starts;
- Harvesting, sorting and pulping should be carried out on the same day. Never ever pulper harvested cherries kept overnight. This causes considerable damage to the product as it encourages fermentation and drying up of the mucilage, and inhibits easy pulping, and results in large number of broken beans. This also seriously affects the beverage.
- Use clean water, preferably river water which is free from chemicals, to avoid undesirable tastes and odors.
- When pulping is completed, clean the area and the machine to avoid contamination and stinkers.

***V. Drying parchment***: Freshly harvested and pulped coffee has high moisture content. For example, after the parchment coffee has been washed and drained, it will have a moisture content of 50-65%. Drying is thus the process of reducing the moisture content of this product down to 10-11.5%. Drying of pulped coffee is a critical operation and should be done with care, as coffee of excellent origin can lose its quality if drying is not done properly. Under-drying causes rapid fading of bean color while over-drying leads to unnecessary weight losses and quality degradation. At 10.5% moisture content the parchment is fully dry and safe for storage. At this moisture content and 60% relative humidity, the coffee suffers no quality losses if properly stored. Though similar methods are used for drying both cherry and parchment coffee, drying area requirement for dry method is, however, larger for the same quantity of drying cherries.

**VI. Procedure in drying parchment coffee**: Drying should be done on raised beds to allow aeration and avoid getting into contact with soil. Drying of parchment can be categorized into two: skin drying and final drying. During skin drying, clean portable hand trays (of 2 x 1 m) made of 4 mm mesh wire nailed on wooden frames are used. Pulped/ washed parchment is thinly spread over the tray (maximum 3 cm to give 10 kg/$m^2$) to promote thorough drainage of moisture and skin drying (Figure 7). Frequently stir, and remove pulps, unpulped and any defective beans,

since all these are clearly seen at this stage. At this stage, all the moisture adhering to parchment is removed and the skin dries. Since pulped coffee remains with mucilage, which can easily get mould and fermented, special care has to be taken during skin drying. Skin drying should be accomplished within a short period of time (within 4 hours for fully washed coffee, about 1-2 days for pulped ones) to prevent fermentation. The parchment is then transferred to bigger raised drying beds made of chicken wire and plastic net for final drying.

**Figure 7. Drying parchment coffee after pulping**

The following are procedures to be followed in skin drying:

- After completing the skin drying, transfer the parchment to the final drying beds- the purpose of which is to reduce moisture content from about 47% to 10-11.5%. The parchment should be thinly spread on the drying bed (thickness should be more than 2 cm), to ensure even drying. As the parchment dehydrates, the thickness may gradually increase;
- Regularly stir the drying parchment as this facilitates full exposure of beans to sunlight and ensures homogenous drying;
- Continuously pick defective and damaged beans and any other impurities;
- Heap parchment coffee towards the middle and cover by Hessian cloth during mid-day and open in late afternoon, as high temperature at noon will cause shrinking and cracking to the drying parchment. At early heaping might not be advisable as this leads to fermentation;

- To protect parchment from rain and night dew, pile the coffee in the middle and cover with Hessian cloth followed by plastic sheets;
- Store the dry coffee preferably in the morning to avoid unnecessary hulling. The duration of the drying period depends on several factors such as, temperature, sun intensity, relative humidity, and the stirring condition. In general, drying parchment will take about 7-10 days to attain a moisture content of about 10-11.5%.

***VI. Determine proper dryness of coffee***: when the back side of the bean is dark and the remaining part is green, its moisture content is estimated to be 10-13%. Fully dry coffee will attain light blue green color and hard to break. At this stage the moisture content is about 10-11.5%. It is also possible to test the degree of dryness of the beans by biting them. If the teeth leave a mark on the beans it is not dry enough; if it breaks, it is an indication of dryness. Similarly, when one tries to cut the bean using a knife, fully dry bean will slip away. Moreover, dry parchment coffee is light and gives a hash sound when one moves a batch of coffee in his/her hand.

**C. Storage of dry coffee**

Coffee storage and handling is one of the crucial processes influencing quality, and thus needs due care. The dried coffee should not be stored in an environment where it can pick up or lose moisture and undesirable smell. Dry coffee should not be stored in sisal bags placed on wooden battens raised 15-20 cm above the ground level (see Figure….), and about 30 cm away from the wall or roof to encourage ventilation, as well as about 1m away from corrugated iron sheet roof. In general, storage facilities should be clean, cool, shaded, dry and well ventilated. In conditions of high relative humidity and temperatures, coffee beans will absorb moisture and develop mould. They may be bleached out in color and lose some desirable flavor. Storage temperature of about $20^{O}C$, and relative humidity of 50-60% are recommended. Dry cherry coffee can be stored longer in relatively similar conditions than parchment without deteriorating in quality.

Given the small scale coffee production in the area, it is difficult to build such storage facilities by individual farmers. However, such storage facility can be built by cooperatives if the farmers are organized. It is also possible to arrange collection of dried coffee by coffee buys immediately, so as to avoid quality deterioration due to poor storage at farmers' homes.

#### *3.4.2.3 Basic investment for quality improvement*

Lack of working capital and funds for investment is a commonly sighted constraint limiting investment in improved processing practices. Smallholder farmers often lack working capital and funds for investment that is suitable to their level of production. Many financial institutions target business organizations that are taking large amount of money to minimize administrative costs. Hence, special arrangement needs to be made through development projects to make financial services accessible to smallholder coffee farmers.

Most farmers in the area cannot afford to buy basic coffee processing materials like chicken nets, jute strips and plastic sheets before the harvesting season. Most materials for improved coffee processing are also not available on local market. During this study, many farmers stressed that they need jute sacks (Joniya) to store coffee in. Most also prefer to get materials on loan. From the experiences of pilot coffee quality improvement project implemented by CABI Africa and MoARD in the southwestern parts of Ethiopia, a coffee farmer producing around 250 kg of coffee on average needs an average initial investment of about 1100 USD (See appendix 4). Such investment in quality improvement can only be achieved through projects, by partial subsidy and partially arranging loan facilities from financing organizations. To be able to repay loan and make the investment feasible, differential price for quality coffee and conservation efforts should arranged as incentives like premium price. Besides, the loan repayment period should also be longer, at least 5 years. Estimated capital investment by group and individual farmers in improved coffee processing is given in Annex 4.

### 3.4.3 Improved coffee marketing

To overcome the problems of existing long-marketing chain, one possible option is to bring farmers together as a group and produce better quality coffee which thus attracts buyers (especially exporters) both in terms of quantity as well as in quality. This will allow producers establish direct and sustainable link with exporters and avoid the problems of associated long chain of intermediaries.

Bale coffee is special since it is forest coffee. Maintenance of such production system contributes conservation of associated plant species diversity and coffee genetic diversity, and watershed and other ecosystem services. The production system is free from any chemical in puts as well.

Hence, efforts have to be made to certify the coffee from the area as a specialty coffee, which can fetch premium price. Hence, the coffee production in the area can fetch higher price for the farmers by both cutting the market chain short and promoting it as specialty coffee with premium price. This can promote conservation of biodiversity as well as investment by farmers in quality improvement.

# 4 Conclusions and recommendations

## *4.1 Conclusions*

Large parts of the Haranna forest in Dalo-Mana and Haranna-Bulluk woredas of the Bale zone have wild populations of coffee. These forests are important for both biodiversity conservation and livelihoods of the local people. Coffee harvested from these forests also contributes to the national economy since it is an important export commodity.

However, the management practice by the farmers varies from one individual to another. It is not optimized to meet the two main objectives of forest management in the area: conservation of coffee genes and biodiversity, and coffee production for the livelihood of the community. If sustainably managed, there is larger area suitable semi-forest coffee production in the two woredas than currently utilized. The quality of coffee produced in the area is also poorly taken care off. There is no single wet processing plant in the area. Besides, the drying method used by the farmers exposes coffee to defects. Most farmers dry coffee on ground, mixing green, red and dried cherries in one lot. Using aerated/ ventilated drying mats on elevated drying beds could improve the quality of dry-processed coffee, following appropriate drying procedures.

The income of farmers can also be better if the coffee from the area is certified and supplied directly to the consumers. However, both certification and organized farmers group or cooperatives are lacking. Due to poor road infrastructure, coffee traders are also paying low prices for coffee in most areas, specially in Haranna-Bulluk. Farmers also lack credit facilities to procure production and improved processing facilities to improve management and quality of coffee.

## *4.2 Recommendations*

Based this baseline study results, the following are recommended:

1. Preparation of coffee forest management guidelines for optimal conservation and production
2. Detailed study to clearly demarcate forest areas currently managed for coffee production, identify individual users, demarcated unmanaged natural forest, and distinguish between core areas for conservation, buffer zones for conservation and use, and transition areas for intensive management and development.
3. Train farmers on management of the different forest zones, sustainable coffee production, and the like to meet the requirement of forest coffee certification
4. Train farmers on forest conditions assessment/ inventory and regular forest conditions monitoring, as part of internal audit for certification
5. Train farmers on dry coffee processing and processing facilities construction from local materials
6. Introduce manual coffee pulper for the smallholder farmers as an alternative to wet processing
7. Organize farmers into cooperatives and cooperative unions to access direct coffee markets on the consumers side
8. Provide credit facilities or revolving fund to farmers to enable them buy necessary material inputs for coffee production, processing and storage
9. Setup strict regulations on the management of the different coffee forest zones
10. Carryout regular monitoring, and also build the capacity of farmers to carryout such monitoring, which can also be a sort of internal control for certification.

**Acknowledgements**

The authors would like to extend their gratitude to Mr. Mulugojam Beyene, Mr. Mohammed Hussen, Mr Kana Dida, Mr. Ayele Girma, Mr. Feyissa Megerssa and the BERSMP team of Robe for their kind assistance during the field work and data collection. Special thanks to Mr. Zeleke for the preparation of the map of the area.

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# Appendices

## *Appendix 1. ToR of the study*

**Bale Forest Coffee Sustainable Management and Promotion study**

Working with the BERSMP team, in Bale. Assignment duration 15 working days – Working with the Coffee production and marketing specialists (Mr. Surendra Kotecha).

- To assess the Bale forest coffee resources, making reference to any available secondary data, and through field visits.
- Produce a coffee forest map for Bale (working with the BERSMP planning specialist).
- Document existing coffee management practice from Planting to Sales. Develop a Coffee management practice calendar.
- Identify and review the values chains involved in Bale Forest Coffee production and marketing-working from the field site end of production.
- Write up an outline strategy, including step by step activities for the BERSMP to follow in order to improve the sustainable management of in-situ forest coffee and basic production.

## *Appendix 2. Distribution type and conservation status of the major trees and shrubs of Harenna forest.*

The abbreviations used are the following: AfrM = Afromontane species; AfrM/n-e = Afromontane near endemic; AfrM/e = Afromontane endemic; ZI/e = Zanzibar-Inhambane endemic; Sub-AfrM/n-e = Sub-Afromontane near endemic; GC/n-e = Guineo-Congolian near endemic; GC-SZ-AfrM = Guineo-Congolian –SudanoZambezian Afromontane; lin = Linking species; Growth forms (MT-Medium tree; TT- Tall tree; SS- shrubs; ST- Small tree; WC- Woody climber, HH-Herb, GG-Grass, EP-Epiphyte). ***Conservation status** is meant to indicate the present population status of the species. For highly over utilized species, immediate conservation measures are recommended and for less threatened species conservation is not urgently recommend.

| Species | Family | Distribution type | Common name | Conservation status* | Growth forms |
|---|---|---|---|---|---|
| *Alangium chinense* (Lour.) Harms | Alangiaceae | lin | | Vulnerable to damage due to continue thinning for opening up space for coffee plants | ST |
| *Allophylus abyssinicus* (Hochst.) Radlkofer | Sapindaceae | AfrM/e | | Conservation measures is not urgently required as the species widespread in many places | ST |
| *Apodytes dimidiata* E. Mey. ex Arn. | Icacinaceae | AfrM/n-e | Chalalaqa | Highly threatened because of over harvesting for timber and need immediate conservation measures | MT |
| Bersama abyssinica Fresen | Melianthaceae | AfrM/e | Lochissa | Conservation measures is not urgently required | ST |
| *Botheriocline* schimperi Oliv. & Hiern ex Benth | Asteraceae | AfrM/e | | Conservation measures is required | HH |
| *Calpurnia aurea* (Ait.) Benth | Fabaceae | AfrM/n-e | | Conservation measures is not urgently required | ST |
| *Cassipourea malosana* (Baker) Alston | Rhizophoraceae | AfrM/n-e | Tilo | Conservation status is good for the time being | MT |
| *Celtis gomphophylla* Bak. | Ulmaceae | lin | | Need immediate conservation measures | MT |
| *Celtis africana* Burm.f. | Ulmaceae | lin | Mata-koma | Conservation measures is not urgently required | MT |
| *Chionanthus mildbraedii* (Gilg & Schellenb.) Stearn | Oleaceae | lin | | Conservation measures is not urgently required | ST |
| *Clausena anisata* (Willd.) Benth. | Rutaceae | lin | Ulmayi | Conservation measures is not urgent required | ST |
| *Coffea arabica* L. | Rubiaceae | AfrM/e | Buna | Widely occurring | ST |
| *Conyza abyssinica* Willd | Asteraceae | AfrM/e | | Conservation measures is required | HH |
| *Cordia africana* Lam. | Boraginaceae | lin | Wadessa | Widely distributed and also widely harvested for timber | MT |
| *Croton macrostachyus* Del. | Euphorbiaceae | ZI/e | Bakanissa | Widely occurring throughout the forest and elsewhere too; no foreseen threats as species rapidly reproducing | MT |
| *Deinbollia kilimandscharica* | Sapindaceae | AfrM/e | | Conservation measures is not urgently required | |
| *Diospyros abyssinica* (Hiern) F. White | Ebenaceae | lin | Loko | Highly threatened due to over exploitation for timber and need conservation measures | MT |
| *Diospyros mespiliformis* Hochst. Ex A.DC | Ebenaceae | lin | Loko | Highly threatened due to over exploitation for timber and | MT |

| | | | | | |
|---|---|---|---|---|---|
| | | | | need immediate conservation measures | |
| *Dodonea angustifolia* | Sapindaceae | lin | | Conservation measures is not urgently required | SS |
| *Dombeya torrida* (J.F.Gmel.) P. Bamps | Sterculiaceae | AfrM/e | | Threatened because of over harvesting for its bark which is used for beehive making and other uses | SS |
| *Dracaena fragrans* | Dracaenaceae | lin | | Conservation measures is not urgently required | SS |
| *Droguetia iners* (Forssk.) Schweinf. | Urticaceae | AfrM/e | | Conservation measures is required | HH |
| *Ehretia cymosa* Thonn. | Boraginaceae | lin | Ulaga | Widely distributed | ST |
| *Ekebergia capensis* Sparrm. | Meliaceae | lin | Sombo | Highly threatened due to over exploitation for timber and need immediate conservation measures | MT |
| *Elaeodendron buchananii* (Loes)Loes. | Celastraceae | Sub-AfrM/n-e | | Highly threatened due to over harvesting for construction and need immediate conservation measures | MT |
| *Erythrina brucei* Schweinf. | Papilionaceae | AfrM/e | | Conservation measures is required | MT |
| *Erythroxylum fischeri* Engl. | Erythroxylaceae | GC/n-e | | Because of natural and/or human factors the population is very much threatened | ST |
| *Euphorbia omariana* M. Gilbert | Euphorbiaceae | AfrM/e | | Conservation measures is required | HH |
| *Fagaropsis angolensis* (Engl.) Milne | Rutaceae | AfrM/e | Sisa | Less distribution probably related due to ecological factors and need conservation measures | MT |
| *Ficus exasperata* Vahl. | Moraceae | lin | | Widespread in many montane forests | ST |
| *Ficus sur* Forssk. | Moraceae | lin | Harbu | Widespread in many montane forests | MT |
| *Ficus sycomorus* | Moraceae | lin | Odaa | Widespread in many montane forests | MT |
| *Ficus thonningii* Blume | Moraceae | lin | Dambi | Widespread in many montane forests | ST |
| *Filicium decipiens* (Wight & Am.) Thw. | Sapindaceae | lin | Chana | Conservation measures is required as the habitat changing | MT |
| *Flacourtia indica* (Burm.f.) Merr. | Flacourtiaceae | GC-SZ-AfrM | | Conservation measures is not urgently required | ST |
| *Galiniera saxifraga* (Hochst.) Bridson | Rubiaceae | AfrM/e | | Widespread in many montane forests | ST |
| *Hagenia abyssinica* (Bruce) J.F.Gmel. | Rosaceae | Afrm/e | Kosso | Highly threatened due to overexploitation and need immediate conservation measures | MT |
| ***Halleria Lucida*** L. | Scrophulariaceae | AfrM/n-e | | Widespread in many montane forests | TS |
| *Hypericum revolutum* Vahl | Guttiferae | AfrM/n-e | | Conservation measures is not urgently required | ST |
| *Impatiens rothii* Hook.f. | Balsaminaceae | AfrM/e | | Conservation measures is required | HH |

| | | | | | |
|---|---|---|---|---|---|
| *Juniperus* ***procera*** Endl*.* | Cupressaceae | AfrM/n-e | Gatira | Conservation measures is not urgently required | MT |
| *Kalanchoe petitiana* A. Rich. | Crassulaceae | AfrM/e | | Conservation measures is required | HH |
| *Laggera tomentosa* (Sch.Bip. ex A.Rich.)Oliv. & Hiern | Asteraceae | AfrM/e | | Conservation measures is required | HH |
| *Lepidotrichilia volkensii* (Gurke) Leroy | Meliaceae | AfrM/e | Mandhissa adi | Conservation measures is not urgently required | SS |
| *Macaranga capensis* (Baill.) Sim | Euphorbiaceae | Afrm/n-e | | Distributed widely within the forest and elsewhere | MT |
| *Maesa lanceolata* Forssk. | Myrsinaceae | lin | | Conservation measures is not urgently required | ST |
| *Margaritaria discoidea* (Baill.) Webster | Euphorbiaceae | lin | | Only few patches of individual populations is observed and need immediate conservation measures | ST |
| *Maytenus undata* (Thunb.) Blakelock | Celastraceae | lin | | Widespread and less urgency is required | ST |
| *Millettia ferruginea* (Hochst.) Bak. | Fabaceae | AfrM/e | Dhadhato | Conservation measures is required | MT |
| *Mimusops kummel* A. DC. | Sapotaceae | lin | | Need immediate conservation measures | MT |
| *Nuxia congesta* R. Br. ex Fresen | Loganiceae | AfrM/n-e | | Conservation measures is not urgently required | ST |
| *Ocotea kenyensis* (Chiov.) Robyns & Wilczek | Lauraceae | AfrM/e | Gigicha | Threatened due to repeated thinning to reduce shading effect on coffee; conservation measures is highly required | MT |
| *Olea capensis* L. ssp. Macrocarpa (C. H. Wright) Verdc. | Oleaceae | AfrM/n-e | Segeda | Threatened for timber uses | MT |
| *Olea welwitschii* (Knobl.) Gilg & Schellenb. | Oleaceae | AfrM/n-e | Guduba | Highly threatened for timber uses and need urgent conservation measures | MT |
| *Olinia rochetiana* A. Juss. | Oliniaceae | AfrM/n-e | | Unknown status | ST |
| *Oncoba routledgei* Sprague | Flacourtiaceae | Sub-AfrM/e | | Conservation measures is not urgently required | ST |
| *Oxyanthus speciosus* ssp. Ssp. Stenocarpus (K. Schum) Bridson | Rubiaceae | AfrM/n-e | | Widely distributed | ST |
| *Panicum ruspolii* Chiov. | Gramineae | AfrM/e | | Conservation measures is required | GG |
| *Phyllanthus mooneyi* M. Gilbert | Euphorbiaceae | AfrM/e | | Conservation measures is required | HH |
| *Pittosporum viridiflorum* Sims | Pittosporaceae | AfrM/n-e | | Conservation measures is not urgently required | ST |
| *Podocarpus falcatus* (Thunb.) Mirb. | Podocarpaceae | AfrM/n-e | Bribissa | Vulnerable, need regeneration enhancement | TT |
| *Polyscia fulva* (Hiern) Harms | Araliaceae | AfrM/n-e | Koriba | Highly threatened for beehives making and need immediate conservation measures | MT |
| *Polystachya caduca* Rchb.f. | Orchidaceae | AfrM/e | | Conservation measures is required | EP |
| *Pouteria adolfi-friederici* (Engl.) Baehni | Sapotaceae | AfrM/e | Guduba | Highly threatened because of over harvesting for timber extraction | TT |

| | | | | | |
|---|---|---|---|---|---|
| *Prunus africana* (Hook.f.) Kalkm. | Rosaceae | AfrM/n-e | Suke | Highly threatened because of over harvesting for timber extraction and need urgent conservation measures | TT |
| *Psydrax schimperiana* (A. Rich.) Bridson | Rubiaceae | Sub-AfrM/m-e | Galo | Commonly occurring | ST |
| *Ritchiea albersii* Gilg | Capparidaceae | AfrM/e | | Due to habitat changes it can be vulnerable to damage anytime | ST |
| *Rothmannia urceliformis* (Hiern) Robyns | Rubiaceae | lin | | Commonly occurring | ST |
| *Sageretia thea* (Osbeck) M.C.Johnston | Rhamnaceae | Sub-AfrM/n-e | | It is widely distributed in the forest | WC |
| *Schefflera abyssinica* (Hochst. Ex A. Rich.)Harms | Araliaceae | AfrM/n-e | Gatama | Conservation measures is not urgently required | MT |
| *Solanecio gigas* (Vatke) C.Jeffrey | Asteraceae | AfrM/e | Homba | Conservation measures is required | SS |
| *Strychnos mitis* S. Moore | Loganiceae | lin | Mulqa | The co-existence of this species with coffee is less liked by farmers and hence in the long run there could a threats | MT |
| *Suregada procera* (Prain) Croizat | Euphorbiaceae | Sub-AfrM/n-e | Muka-adi | It is widely distributed in the forest | ST |
| *Syzygium guineense* ssp. afromontanum F. White | Myrtaceae | AfrM/n-e | Badessa | Widespread for the time being | MT |
| *Teclea nobilis* Del. | Rutaceae | AfrM/n-e | Hadhessa | Widespread in many montane forests | ST |
| *Teclea simplicifolia* (Engl.) Verdoon | Rutaceae | AfrM/n-e | Hadessa | Conservation measures is not urgently required | ST |
| *Trema orientalis* (L.) Bl. | Ulmaceae | lin | Tala'a | Have wide distribution | ST |
| *Trichocladus ellipticus* Eckl. & Zeyh. | Hamamelidaceae | AfrM/n-e | | Widely distributed in the forest | SS |
| *Urtica simensis* Steudel | Urticaceae | AfrM/e | | Conservation measures is required | HH |
| *Vepris dainellii* (Pichi-Serm.) Kokwaro | Rutaceae | AfrM/e | Arabe | Conservation measures is required | ST |
| *Vernonia leopoldi* (Sch. Bip. ex walp) Vatke | Asteraceae | AfrM/e | | Conservation measures is required | SS |
| *Warburgia ugandensis* Sprague | Canellaceae | AfrM/e | Befti | Threatened due to repeated thinning; need conservation | MT |

## *Appendix 3. Useful plant species recorded in the Harenna forest.*

(T = Timber; F = Food; M = Medicine; S = Spice; BH = Beehives/honey); ✓ = indicate use type

| Species | Family | T | F | M | S | BH |
|---|---|---|---|---|---|---|
| *Carissa spinarum* | Apocynaceae | | ✓ | | | |
| *Landolphia buchananii* | Apocynaceae | | | | | |
| *Polyscia fulva* | Araliaceae | | | | | ✓ |
| *Schefflera abyssinica* | Araliaceae | | | | | ✓ |
| *Phoenix reclinata* | Arecaceae | | ✓ | | | |
| *Vernonia amygdalina* | Asteraceae | | | ✓ | | |
| *Cordia africana* | Boraginaceae | ✓ | ✓ | | | |
| *Warburgia ugandensis* | Canellaceae | ✓ | | ✓ | | |
| *Hippocratea africana* | Celastraceae | | | | | ✓ |
| *Hippocratea goetzei* | Celastraceae | | | | | ✓ |
| *Juniperus **excelsa*** | Cupressaceae | ✓ | | | | |
| *Croton macrostachyus* | Euphorbiaceae | ✓ | | ✓ | | |
| *Ricinus communis* | Euphorbiaceae | | | ✓ | | |
| *Millettia ferruginea* | Fabaceae | | | ✓ | | |
| *Flacourtia indica* | Flacourtiaceae | | ✓ | | | |
| *Apodytes dimidiata* | Icacinaceae | ✓ | | | | |
| *Ocotea kenyensis* | Lauraceae | ✓ | | | ✓ | |
| *Strychnos mitis* | Loganiaceae | | ✓ | | | |
| *Ekebergia capensis* | Meliaceae | ✓ | | | | |
| *Ficus sur* | Moraceae | | ✓ | | | |
| *Embelia schimperi* | Myrsinaceae | | | ✓ | | |
| *Myrsine africana* | Myrsinaceae | | | ✓ | | |
| *Syzygium guineense* | Myrtaceae | | ✓ | | | |
| *Olea welwitschii* | Oleaceae | ✓ | | | | |
| *Phytolacca dodecandra* | Phytolaccaceae | | | ✓ | | |
| *Podocarpus falcatus* | Podocarpaceae | ✓ | | | | |
| *Clematis simensis* | Ranunculaceae | | | ✓ | | |
| *Rhamnus prinoides* | Rhamnaceae | | ✓ | | | |
| *Rhamnus staddo* | Rhamnaceae | | ✓ | | | |
| *Hagenia abyssinica* | Rosaceae | ✓ | | ✓ | | |
| *Prunus africana* | Rosaceae | ✓ | | | | |
| *Rosa abyssinica* | Rosaceae | | ✓ | | | |
| *Rubus apetalus* | Rosaceae | | ✓ | | | |
| *Rubus steudneri* | Rosaceae | | ✓ | | | |
| *Coffea arabica* | Rubiaceae | | ✓ | | | |
| *Citrus aurantium* | Rutaceae | | ✓ | | | |
| *Clausena anisata* | Rutaceae | | | ✓ | | |
| *Dodonea angustifolia* | Sapindaceae | | | ✓ | | |
| *Mimusops Kummel* | Sapotaceae | ✓ | ✓ | | | |
| *Pouteria adolfi-friederici* | Sapotaceae | ✓ | | | | |
| *Brucea antidysenterica* | Simaroubaceae | | | ✓ | | |
| *Solanum nigrum* | Solanaceae | | ✓ | | | |
| *Urtica simensis* | Urticaceae | | ✓ | | | |

## *Appendix 4. Estimates of investment costs for improved small-scale coffee processing**

**Estimated cost for Pulped coffee processing unit (US$):**

Maximum drying time: 15 days
Daily cherry pulping output: 60 kg
Average total production/farmer: 240 kg green coffee
Number of farmers expected to use: 3

| | Unit price | Total |
|---|---|---|
| 1 pulper | | 400 |
| 1 treadle pump | | 150 |
| Set of pipes (50m) and pump accessories | 3,5 | 175 |
| 24 chicken net (2x6,5 m) (8 each farmer) | 45 | 1,080 |
| 18 hand trays (2x0,9m) (6 each farmer) | 15 | 270 |
| 24 shade net (2x6,5m) (8 each farmer) | 20 | 480 |
| 24 jute strips (2x6,5m) (8 each farmer) | 9 | 216 |
| 24 plastic sheet (2x6,5mx0,15mm) | 20 | 480 |
| 120 jute bags (8 each farmer) per year | 1,5 | 180 |
| 9 metallic container (0.6x0.4x0,5m) | 17 | 153 |
| 1500 nails (4x80mm) (500 each farmer) | - | 35 |
| 3 set of tools (hammer, saw, etc) | 15 | 45 |
| | | |
| Total cost (for three farmers) | | 3520 |
| **Estimated cost per each farmer** | | **1,221.33** |

**Estimated cost for Sun dried processing unit (one farmer) (US$):**

Maximum drying time 25 days
Daily cherry processing: 60 kg
Average total production/farmer: 340 kg green coffee

| | Unit price | Total |
|---|---|---|
| 12 galvanized net (2x6,5m) (mesh 4x4mm) | 50 | 600 |
| 12 jute strips (2x6,5m) | 9 | 108 |
| 12 plastic sheet (2x6,5mx0,15mm) | 20 | 240 |
| 13 jute bags per year | 1,5 | 19,5 |
| 720 nails (4x80mm) | - | 50 |
| 1 set of tools | 15 | 15 |
| **Estimated cost per each farmer** | | **1,110.5** |

* Expected loan repayment on investment is 5 years in both pulped coffee and dry processed coffee