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Review

Current distribution, regeneration and management practice of *Hagenia abyssinica* in different agroforestry systems of Ethiopia: A review

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Hagenia abyssinica **is a multipurpose tree, which is sparsely distributed in the highland of Ethiopia. It is used for illness remedy, furniture, fuel, and as a soil additive. This review provides information on the present status and management practice of *H. abyssinica* in Ethiopia to give urgency care other than that given to introduced species for future conservation. The foliage and flowers have a higher quality of N and P for managing soil fertility. However, market availability is diminished. Its healing potential is widely accepted within the society and it is one of the dominant plants in the Boda Montane and Gole Forest. The plant in Hararge of Ethiopia is highly threatened through settlement changes and agriculture expansion. The Gemechis and Menagesha Amba Mariam forest is comprised of seedlings and saplings, but the Chilimo and Gole Natural Forest shows poor regeneration. The Doshke and Gedo forest is represented by aged trees; and the species is under risk. In some areas of Kofele, Bale, Holeta, Legambo and Debark of Ethiopia, it is cultivated in the homegardens for multiuse. Therefore, the diversity is highly shrinking and urgent actions will be needed to conserve it.**

Key words: Conservation, forest, *Hagenia abyssinica,* homegarden, regeneration, threatened.

INTRODUCTION

Hagenia abyssinica (Bruce) J.F. Gmel. is a multiuse tree that belongs to the genus *Hagenia* and family Rosaceae. It is one of the Afromontane endemism tree plants in Ethiopia. However, its abundance and distribution are highly reduced by anthropological factors and the tree is sparsely distributed in Montane Africa (Feyissa et al., 2005). It is found in Sudan, Ethiopia, Malawi, Zambia, Zimbabwe, Tanzania, Kenya, Uganda, Burundi, Rwanda and Democratic Republic of Congo (Tariku, 2018). The tree was once abundant in the semi-humid mountain woodlands of Ethiopia with an altitudinal range between 2,450 and 3,250 m.a.s.l (Feyissa et al., 2005). According to Ayele et al. (2017), the species were growing within an altitudinal range of 1,850 to 3,700 m.a.s.l. It plays a great role for the economic, ecological, and social aspects, serving as a source of medicine, construction, furniture, income generation, fencing, Bee and animal fodder, fuel wood, and soil fertility (Akale et al., 2019).

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Table 1. Macronutrient composition of the foliage, flower, and stem in *Hagenia abyssinica.*

Foliage (mg g^{-1} dry matter)		Flower bud (mg g^{-1} dry matter)		Stem (mg g^{-1} dry matter)	
N	30.07	N	27.20	N	12.94
P	3.71	P	4.54	P	1.54
K	21.22	K	22.04	K	16.05
Ca	9.69	Ca	5.54	Ca	8.57
Mg	2.38	Mg	2.53	Mg	1.68
S	2.03	S	2.70	S	1.50
Ratios of C, lignin and soluble phenolics to N (mg g^{-1})					
Foliage		**Flower bud**			
C:N	15.49	C:N			17.99
Lignin:N	1.79	Lignin:N			2.84
Soluble phenolics:N	5.71	Soluble phenolics:N			8.80
Soluble phenolics + lignin:N	7.50	Soluble phenolics + lignin:N			11.64

Source: Kindu et al. (2008).

The enormous significance of the species for these purposes leads to its being threatened in the country due to over-exploitation (Bekele and Reddy, 2014). The main aim of this review was to give brief information on the present status of *H. abyssinica* in different agroforestry systems of Ethiopia to give attention to the urgency of its conservation beyond that of introduced species.

ECOLOGICAL SIGNIFICANCE OF *H. ABYSSINICA*

The species is mostly used for soil conservation and as reported by Kiros et al. (2016), who also indicated that the translocation rates of major nutrients in the green leaves of *Hagenia* trees were in the order of N > P > K (56 to 61% for N, 54 to 59% for P, and 31 to 42% for K) (Table 1). This shows that the concentration of N and P is higher in the green leaves and C to N ratio was highest in the foliage (Kindu et al., 2008). This reveals that the species has high quality of foliage and flower bud for managing soil fertility. The plant is comprised of large crowns that continually shed leaves; and it is easily decomposable. Similarly, Akale et al. (2019) observed a high amount of leaf foliage and shedding at the base of the plants, which can act as a soil additive in Legambo district of South Wollo, Ethiopia. Therefore, it is advisable to apply green leaves in order to improve soil quality. However, the report by Cronin et al. (2013) stated that the land covered by *H. abyssinica* at Jeldu (Blue Nile basin) transitioned too sparsely with a spread and rapid expansion of *Eucalyptus globulus*. Therefore, the government gives priority for afforestation of the species to recover the previous ecology.

COMMERCIAL STATUS OF *H. ABYSSINICA*

According to Akale et al. (2019), female informants gave high value for *H. abyssinica* due to its preferred marketable value, which accounted for around 1500 (ETB) Birr per single stem. Helmut et al. (2014) reported that each seller sold an average of 2.9 taenicides (*H. abyssinica*) in 1973, but the extent diminished to 0.2 in 2014 at Merkato, Addis Ababa (capital city of Ethiopia). In 2010 at Bale, a quarter of kilo-dried flowers were sold for one Ethiopian Birr and also used quintals to exchange, which were sold with a range of 60 to100 Ethiopian Birr per quintal (Assefa et al., 2010). Lulekal et al. (2013) reported that a jug of inflorescence was sold for four Birr in Ankober District, North Shewa Zone of Amhara, Ethiopia. As indicated by farmers in the study of Soromessa and Kelbessa (2014), the seeds of the plants were purchased for 12 Birr per kg, which is a low price when compared to: *Juniperus procera* (50 Birr/kg), *Podocarpus falcatus* (20 Birr/kg), and all are more expensive than *Prunus africana* (7 Birr/kg) at Chilimo Forest of Central Ethiopia. According to Ethiopia Forestry Research Center (IBC, 2012), 9,004,788 *H. abyssinica* seedlings were grown from 61.2 kg of seeds within a period of five years (2006/2007-2010/2011). Results in all the study sites showed that the medical value of the species is still available in the national and local markets for a low price, but the amounts are reduced due to overutilization of the plant in the past and present time.

MEDICINAL VALUE OF *H. ABYSSINICA*

Many people of the countries of Africa, Asia, and Latin America depend on medicinal plants to meet some of their primary health care needs (Bekele and Reddy, 2014). According to Assefa et al. (2010), more than 80% of the Ethiopian people are reliant on plants for their health service. Many studies confirm that the species are used to treat several human and livestock ailments (Assefa et al., 2010; Tariku, 2018). Similarly, Assefa et al.

(2010); Reta (2013); Bekele and Reddy (2014) and Atnafu et al. (2018) confirming that all parts of the species (Bark, Leaf, Flowers, Seeds, Fruits, and Wood) were used to treat ailments by the local people. In Selale (North Shoa, Ethiopia), the society used the fruit and seeds to treat tapeworm (Reta, 2013). Mekuria et al. (2018) reported that extractions of flowers and leaves were used to treat hepatotoxicity, diarrhea, gastritis, and optic atrophy. Currently, many traditional healers used the species to treat ailments in the countryside (Table 2).

In the study of Mekuria et al. (2018) at a Teaching Hospital in Gondar of Ethiopia, 26.9% of 240 respondents used the species as a traditional remedy. Similarly, in the Ankober (North Shewa Zone, Ethiopia), 93.75% of the total respondents used the plant as a remedial agent and it provided the best healing potential in the area (Lulekal et al., 2013). Assefa et al. (2010) stated that 43% of the respondents in Bale, 40% in Kofele and 30% in Debark used self-made remedies and it is widely accepted within the society for its hygienic effect. Now, most societies in all of the study areas are utilizing case remedy. However, many studies have shown that the tree is shrinking in occurrence, and is over exploited, through various anthropogenic impacts, due to the practical usefulness of the species in its many forms.

CURRENT POPULATION OF *H. ABYSSINICA* AND ITS CONSERVATION STATUS

In the Gole Forest, *H. abyssinica* is a highly dominate plant, next to *Juniperus procera, Myrsine melanophloeos* and *Hypericum revolutum*; each with an importance value index of 78.2, 41.3, 31.1 and 29.1, respectively (Hailemariam and Temam, 2018). The large basal area (8.8 m^2/ha) of *H. abyssinica* contributed to its status as a high relative dominance species (17.9), next only to *Juniperus procera* (33.3) (Hailemariam and Temam, 2018). Therefore, it is one of the most dominant and ecologically important tree species in the Gole Forest. Similarly, at Boda dry evergreen mountain forest, West Shewa of Ethiopia, *H. abyssinica with Podocarpus falcatus* and *Juniperus procera* are the dominant dry evergreen trees in the montane forest (Fikadu and Melesse, 2014). The published report for Legambo District (Chiro Kebele) South Wollo, Ethiopia by Akale et al. (2019) revealed that *Hagenia* is the dominant native tree species next to *J. procera*.

However, in the Hararge Area of Eastern Ethiopia, *H. abyssinia* was highly threatened and all the respondents classified such indigenous plants under highly vulnerable species (Abdala et al., 2017). As Bekele and Reddy (2014) reported, the current population of the species is declining through settlement changes and land clearing for agriculture. The Borana communities, recalling their childhood times, reported that there were originally plenty of *H. abyssinica* trees in the surrounding forests, but has now become reduced significantly (Bekele and Reddy, 2014). Similarly, in the reports of Getachew and Biruk (2014), the Yeraba Priority State Forest (Amhara Region, Ethiopia) is represented by the least frequent occurrence of *H. abyssinica;* and this implies that this particular species is rare and it may be extinct from the area in the near future. Currently, the diversity and abundance of such endemic plants are highly decreased. According to the result of Wami et al. (2016), the Forest Department and District Agriculture Department in Gedo, West Shewa of Ethiopia, have established a strong tree plantation programme for replenishment of trees such as *J. procera, H. abyssinica, Rhus glutinosa* and *Cordia africana* in every year in the degraded forest area. Therefore, other areas of the country will use similar tree farm programmes as developed by Gedo, West Shewa of Ethiopia in order to recover the species

Most studies confirm that conservation of the species and its planting programs have been given little attention. However, certain aspects of traditional thought play a significant contribution to the conservation of indigenous trees. For example, in the report of Belay et al. (2014), the farmers in Debark District, northern Ethiopia believed that *H. abyssinica* attracts lightning during the rainy season, thereby preventing lightning strikes of people, livestock, or houses.

CURRENT REGENERATION STATUS OF *H. ABYSSINICA* IN ETHIOPIA

The occurrence of *H. abyssinica* trees were the least recorded species, in the Menagesha Amba Mariam Forest (Central Highlands of Shewa, Ethiopia) compared to the other trees (Tilahun et al., 2015), and it is one of the most important tree species in the area, which was represented by both seedlings and saplings. Similar studies at Gemechis Natural Forest (West Hararghe Zone, Oromia, Ethiopia) by Dawud et al. (2018) showed, the presence of seedlings (11.5) and sapling (4.5) indicated they were more numerous than mature or older ones of the species. This showed that *H. abyssinica* has good regeneration status in the Gemechis and Menagesha Amba Mariam Forest than the other studied areas. Similarly, in the homegardens at Legambo district of south wollo Ethiopia both shrubs and trees of the species were recorded by Akale et al. (2019). In some homegardens, also consist of both seedling and sapling stages of growth, thus further revealing its regeneration status.

However, Tegene et al. (2018) revealed that seedlings and saplings of *H. abyssinica* in the Doshke Forest of Chencha, Gamo Gofa Zone of Ethiopia, are absent among the regeneration group. Similarly, Wami et al. (2016) confirm that the species in the Gedo Forest (West Shewa of Oromia, Ethiopia) were not represented by seedlings or saplings. This showed that the aged trees of *Hagenia*, are the only ones of the species represented in the forests, and *H. abyssinica* is under high risk of loss

Table 2. Medicinal value of parts of *Hagenia abyssinica* in the different area of Ethiopia.

Bale (Oromiya National, Regional State, Southeastern Ethiopia)				
Barks	**Flowers**	**Roots**	**Leaves**	**Woods**
Fever/cough Stomachache Cold (bronchitis) Livestock disease	Intestinal Worms Healing Wound Epilepsy* Evil eye	Stomachache	Diarrhea Typhoid Cough Livestock disease	Stomachache
Kofele (Oromiya National Regional State, Southeastern Ethiopia)				
Bark	**Flower**	**Root**	**Leaf**	**Wood**
Dermatology Malaria Stomachache Livestock disease	Intestinal Worms Hepatitis* Sexual Transmitted Diseases Harms related to Bile	Stomachache Abdominal pain Throat disease Cancer*	Diarrhea Livestock disease	Stomachache
Debark (Amhara Regional State, Northern Ethiopia)				
Bark	**Flower**	**Root**	**Leaf**	**Wood**
Livestock disease	Intestinal Worms	Severe stomach pain	Healing injured	-
Abaya (Borana Zone, Oromia Regional State, Ethiopia)				
Bark	**Flower**	**Root**	**Leaf**	**Wood**
Fever/ Cough Stomachache Cold/ bronchitis Dermal diseases	Intestinal Worms Wound healing Epilepsy Hepatitis	Stomachache Abdominal pain Throat disease Cancer	Diarrhea Typhoid Cough Healing injured	Stomachache
Hawassa (College of Teacher Education campus, SNNPRS)				
Leaf	**Flowers**	Seeds		
Tapeworm, Wound	Ascariasis	Tapeworm, Typhoid		

Source: Assefa et al. (2010); Bekele and Reddy (2014); Atnafu et al. (2018)

(Figure 1). Therefore, these situations call for conservation actions through prioritizing. Similarly, as shown by the results of Hailemariam and Temam (2018), the species in the Gole Natural Forest (West Arsi Zone, Oromia Regional State of Ethiopia) exhibited poor regeneration status and the forest includes mainly seedling stages of *H. abyssinica*. Likewise, in the Chilimo Forest of Central Ethiopia, the species were represented by the seedling stage (Soromessa and Kelbessa, 2014). Therefore, both the Gole and Chilimo forests show poor regeneration potential, and the ecosystem is mainly represented by aged trees.

The status of *H. abyssinica* in the Homegardens

According to Akale et al. (2019), 62 individuals of the species were recorded from 32 out of 75 informants in their homegarden at Chiro kebele of Legambo district, South Wollo Ethiopia. In the report of Assefa et al. (2010), 30% in Kofele, 26% in Bale, (Oromiya, Southeastern Ethiopia) and 7% of the informants in Debark (Amhara, Northern Ethiopia) have planted *H. abyssinica* in their home garden and include transplanted seedlings from nearby forests in their backyards. Nevertheless, the majority of the informants (74% in Bale, 70% in Kofele and 93% in Debark) have not planted this *H. abyssinica* in their homegardens and this fundamental problem is due to the lack of seedlings in their nearby sites. Therefore, the societies in the study areas have endless interest in planting the indigenous tree in their homegardens (Assefa et al., 2010). Similarly, Mekonnen et al. (2014) reported the presence of *H. abyssinica* in the farmer's homegardens of Holeta Town, Oromia National, Regional State, Ethiopia, which are used for medicinal purposes. Therefore, cultivation in the homegardens plays a crucial role in the conservation of the species and the government supports and encourages homegarden cultivation practices.

CONCLUSION

H. abyssinica is highly distributed in the highlands of

Figure 1. Status of Kosso in homegardens at Chiro kebele, South Wollo of Ethiopia (Akale et al., 2019).

Ethiopia such as Boda dry evergreen montane forest, Chilimo, Doshke, Gedo, Gole, Gemechis, Hararge, Yeraba Priority State Forest and Menagesha Amba Mariam forest. The species has a high nutrient quality of foliage and flower buds for managing soil fertility. The shed leaves are easily decomposable and it is advisable to apply the green leaves in order to improve the soil quality. In all the study sites, the medicinal value of *H. abyssinica* is still available in local markets for a low price. Most of the traditional healers used the Bark, Leaf, Flowers, Seeds, Fruit, and Wood of the plant to treat several ailments. The Gemechis and Menagesha Amba Mariam Forest is largely comprised of seedlings and saplings, and has good regeneration status. However, the Doshke, Gedo and Hararge Forests were not described as having seedlings or saplings; and these forests are under risk of loss. The status of *H. abyssinica* in Gole and Chilimo forests is represented largely by seedling stages; and this shows poor regeneration ranks. Thus, the situation calls for conservation measures through prioritization. Some societies in the Kofele, Bale, Debark, Legambo and Holeta Town cultivated the species in their homegardens and seem to have endless interest. Such tasks should be encouraged and there is a need for agricultural experts to help them. However, most of the previous studies confirm that the *H. abyssinica* are under risk in the highlands of Ethiopia and need a high conservation priority in the case of Ethiopia.

RECOMMENDATIONS

According to the above published evidence, because of the diversity and frequency of *H. abyssinica* at the country level it is overexploited and shrinking over time. Formerly, such indigenous species were the dominant tree in the upper Montane forest belt, but now they are only found as scattered trees and restricted in the highlands. This is due to the over dominance of an exotic species (*Eucalyptus* tree) occurring in Ethiopia; and the Agroforestry sectors have given little attention to the indigenous plants. Therefore, the government and Agroforestry sectors have to give high priority for plantation programs to conserve the native species:

(1) Lowland adaptability techniques of the species should be expected (range shift gaps).
(2) The highly vulnerable forest should be given priority conservation.
(3) National and international *ex-situ* conservation gaps of the species should be achievable.
(4) Homegarden plantations should be given high attention.
(5) Implementing of *H. abyssinica* nursery sites in each region should be established for the rehabilitation and conservation programs.
(6) Implementing *H. abyssinica* plantation programs in the country.

(7) Building tissue culture academic institution for the preservation of the species.
(8) Finally, people need to be encouraged to have *H. abyssinica* in their gardens.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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