JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
ISSN: 2339-076X (p); 2502-2458 (e), Volume 4, Number 4 (July 2017): 863-871
DOI:10.15243/jdmlm.2017.044.863

Research Article

Growth and survival rate of endemic trees of Ethiopia: *Olea africana* and *Hagenia abysinicca* in the degraded lake of Haramaya Watershed, Ethiopia

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Received 21 April 2017, Accepted 16 May 2017

Abstract: The study was conducted to explore the growth and survival rate of the native tree species of Ethiopia, *Olea africana* and *Hagenia abysinicca* in the degraded Lake Haramaya Watershed, eastern Ethiopia. Three sub watersheds of Lake Haramaya Watershed, namely: Bachake, Damota, and Tinike were selected purposefully on the basis of their extreme degradation and nearby vanished Lake Haramaya. In each sub watersheds, a total of about 12 main standard quadrats have been applied and the required data has been recorded. The result of the study indicated that *Olea africana* performs well at Damota sub watershed, accounting 38% of survival rate followed by Tinike sub watershed having a survival rate of 37%. Only 29% of the total planted *Olea africana* were survived at Bachake sub watershed. Furthermore, it has been revealed via this study that about 55.6% of *Hagenia abysinicca* were survived at Damota sub watershed. Comparing the survival rate of the two species, *Hagenia abysinicca* were better withstand and grow under an extreme pressure of local peoples intervention at all sub watersheds. Therefore, the study indicated that growing and maintaining of these two endemic trees in all sub watersheds were difficult task unless much awareness will be made at grass root level. Lastly, the study encourages mega projects on growth and survival rate of other native trees species in the degraded areas of Ethiopia.

Keywords: *endemic trees, Hagenia abysinicca, Olea africana, sub watershed, survival rate*

To cite this article: Sorecha, E.M. 2017. Growth and survival rate of endemic trees of Ethiopia : *Olea africana* and *Hagenia abysinicca* in the degraded lake of Haramaya Watershed, Ethiopia. J. Degrade. Min. Land Manage. 4(4): 863-871, DOI: 10.15243/jdmlm.2017.044.863.

Introduction

Ethiopia is very known by its heterogeneous higher plant species estimated to be around 6500–7000, of which more than 12–19 % are native (WCMC, 1992; Teketay, 2001; Hurni, 2007; CBD, 2008). This is due the fact that the country has a wide variety of ecological characteristics associated with ample diversity of plant and animal species (Alemayehu, 2002). However, a number of studies indicated that almost all of the natural vegetation of Ethiopia is under an extreme pressure of anthropogenic threats (Yirdaw, 1996; Million, 2001; Tesfaye, 2015; Newton and Cantarello 2015). Given about 85% of the population Ethiopia is living in the rural areas, their livelihood system is either directly or indirectly depends on agriculture, which provides about 52% of the country's GDP (World Bank, 2000; CIA, 2001).

The speedy decline of forest resources in Ethiopia has resulted in reduction of their biodiversity and on the verge of extinction of certain tree species (Tekle and Hedlund, 2000; WRI, 2001; Alemayehu, 2002a). *Olea africana* and *Hagenia abysinicca* is the major endemic tree species mainly found in Ethiopia, basically on the highland areas of the country. Currently, these tree species are under a big threat of human influences. The local name of *Olea africana* is

Ejersa in Afan Oromo *and Weyira*in Amharic. This species is well known by the local people for its traditional medicine preparation, tooth brush and sometimes for charcoal production. Moreover, *Hagenia abysinicca* is locally known as *Muka Heexoo* in Afan Oromo and *Yekoso Zaf* in Amharic and well known for its medicinal value. The climate of Ethiopia has been changing as a result of global and local effects of vegetation degradation. Loss of forest cover and biodiversity owing to human-induced activities is a growing arena of many parts of the world including our country, Ethiopia (Sebsebe, 1980).Thus, frequent drought, crop failure and famine are becoming common events in the highlands, like eastern Hararghe which are the symbols of desertification (Teketay, 2001). In line with this, Haramaya University, Ethiopia via Lake Haramaya Watershed project has given deep attention to these endemic trees and grows the seedlings to use them as a main rehabilitation tree of the degraded lands of Lake Haramaya sub watersheds. This is for the sake of maintaining the species in to the environment though it was a challenging task. Therefore, this study was undertaken to explore the growth and survival rate of the endemic tree species of *Olea africana* and *Hagenia abysinicca*, so as to put baseline information about the status of the two tree species in the watershed.

Materials and Methods

Description of the study area

Lake Haramaya Watershed is located in Haramaya and partly in Kombolcha districts, Eastern Hararghe Zone, Oromia National Region State, and East Ethiopia (Figure 1). The Watershed lies between 9°23´12.27´´- 9°31´9.85´´ N and 41°58´28.02´´- 42°8´h10.26´´ E (UTM Zone 38) and covers an area of 15,329.96 ha. The elevation ranges from 1800 to 2345 meters above sea level.

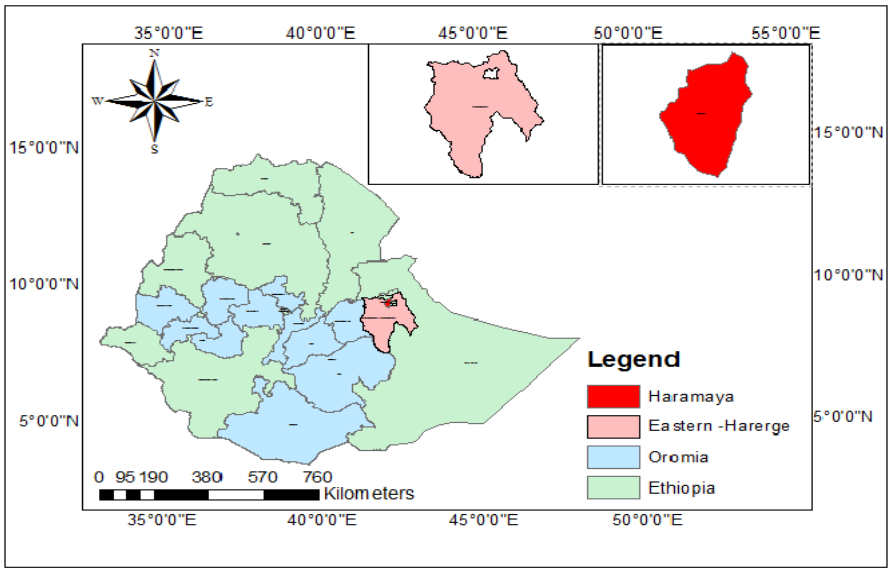

Figure 1. Map of the study area

Information obtained from Ethiopian National Meteorology Agency indicates that the mean annual rainfall and mean maximum and minimum temperatures of Haramaya watershed are 847.9 mm, 24.7 °C, and 11.5 °C, respectively (Fgure 2). The area received bimodal pattern of rainfall.

This study was conducted in particular at Bachake (3 ha), Damota (2.75 ha) and Tinike (3 ha) sub-watersheds, which are among the 28 sub watersheds of Lake Haramaya watershed. The reason for choosing the three of the sub-watersheds were due to their presence under the extreme pressure of anthropogenic factors; local communities were using these lands as a common grazing lands, expansion of agriculture to plant cash crops like *Khat* (*Catha edulis*) and to lesser extent Coffee (*Coffee arabica*). Generally, many socio-economic activities were well notified as per the preliminary field observation of this study and key informant informal interview (not presented in this paper). Furthermore, of the 28 sub-watersheds, three of them are very nearby vanished Lake Haramaya, (on average 5 km away from the lake).

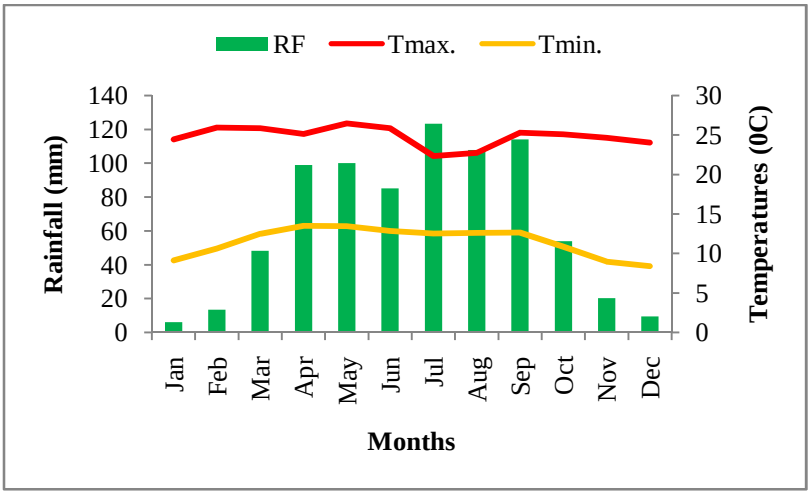

Figure 2. Monthly rainfall and temperature during 1980-2013 in Lake Haramaya Watershed

Seedlings preparation techniques

Seedling preparation has been conducted at Rare Nursery site, Haramaya University, Ethiopia. In the processes of seedlings preparation, forest soil, compost /farm yard manure, sand, and local top soil were used by mixing all the substrates at different ratios. The most used ratio is 3 local top soils: 2forest soil/compost/farm yard manure: 1 sand. The mixed up media were added in to a pot having a diameter size of 8cm to support the sown seeds. Most potting mixes were soilless to avoid soil borne diseases and promote good drainage and suitable environment with sufficient water-holding capacity, nutrient content, and aeration for plant growth and development. Therefore, the pot-planted seedlings were stayed on nursery site for at least six months begging from their planting time and all the required management were undertaken till plantation time. Then after, the seedlings of both *Olea africana* and *Hagenia abysinicca* were taken to the field via tractor-vehicle used for transportation of seedlings. The height of *Olea africana* at the time of planting was estimated to be 35 cm and that of *Hagenia abysinicca* was estimated to be about 45 cm, just the height above the ground.

Site preparation techniques for plantation

All the selected sub watersheds have been delineated and to lesser extent area closure has been done accordingly, though not effective. Additionally, physical soil and water conservation structures have been built by the local people with the coordination of Lake Haramaya Watershed Project, early before the main rainy season of Ethiopia (June, July, August, and September). The work of constructing the physical structure was better in Damota sub watershed. Finally, pits having an average depth of 30 cm and width of 40 cm were prepared along the physical structures across the slope within 2 m distance from one another. Majority of the pits were prepared by the respective farmers of the sub watersheds and seedlings plantation campaign was made by the local people in collaboration with Lake Haramaya

Watershed Project run under Haramaya University.

Transect establishment, data collection and analysis

For each specific study site (Bachake, Damota, and Tinike), four subplots has been established systematically across the slope, one with its center located at the center of the spoke and the remaining three located at 20.5 m away from the center subplots (Figure 3). Each subplot has a 7.5 m radius. The operation has been multiplied 12 times with same transects size and design for all specific study sites at an interval of 50 m. Therefore, a total of about 12 main quadrats have been laid out for each sub watersheds and the required data has been recorded (Figure 4). Mortality rate and survival rate were calculated for both endemic tree species at all sub watersheds in the study area. The formulas used were:

$$\text{Mortality rate} = \frac{\text{Number of saplings recorded dead during a given year}}{\text{Total number of saplings in a given year}} \text{ x } 100 \text{ (Megan, 2013)}$$

Survival Rate = 100 – Mortality Rate

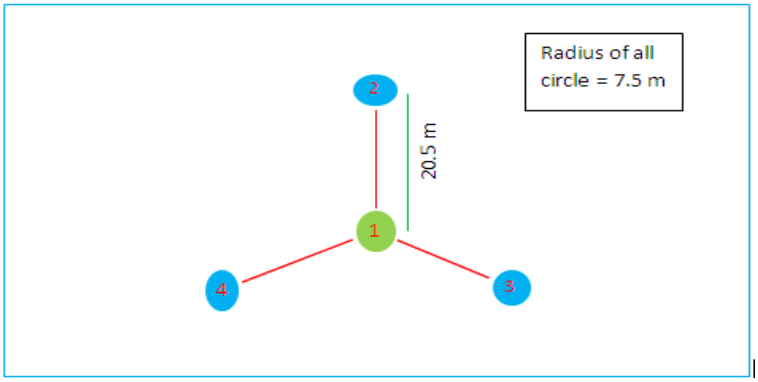

Figure 3. Sample data collection design
Source: (USDA Forest Service, 2003; Schulz et al., 2009)

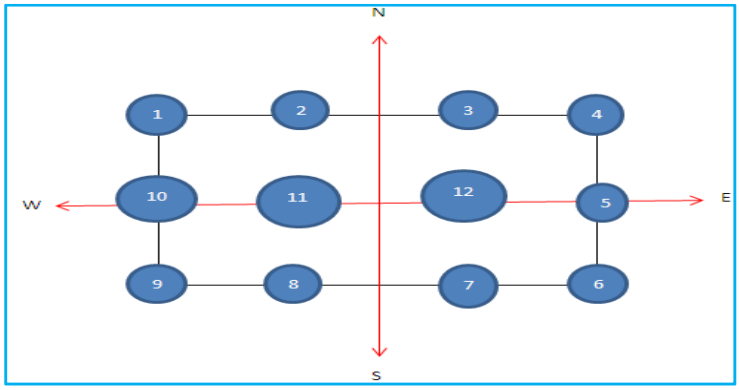

Figure 4. Sampling spot design for each sub watersheds

Results and Discussion

The results of the study depicted that of the transects established at all sub watersheds, *Olea africana* performs well at Damota, accounting about 38%of survival rate, followed by Tinike sub watershed having a survival rate of 37%. However, at Bachake sub watershed little survival rate of *Olea africana*has been recorded, only 29% (Table 1). The reasons for the variation of survival rate at all sub watersheds were due to high interference of local peoples. However, some studies are indicating that conservation and management of plants dominated by farming communities are getting attention nowadays (Garrity and Verchot, 2008; Lemenih and Kassa,

2014). Furthermore, it has been noticed during the study that the perception of local people in all sub watersheds, particularly, in Bachake sub watersheds, towards the growth of considered endemic tree species was so poor though they use these trees for traditional and other purposes (Table 2). Rather, they need to use the lands for free grazing. Thus, of the total number of seedlings planted during 2015/16 rainfall season, majority of them have been died. Late plantation due to late onset of rainfall and early cessation, poor ways of plantation, little commitment by local people in monitoring after plantation, farmer's preferences of other commercial trees like, *Eucalyptus* species, *Grevillea robust* and fruit trees are also another factor. Soil as a factor of seedlings growth has been kept constant in this particular work. The other negligible challengesof seedlings plantation in this work was those seedlings die or at risk while transportation for plantation. The above constraints are similar to those facing the forest development in Ethiopia as noted by Derero et al., (2011) which include: Transportation of seedlings, poor seedling quality and inappropriate silviculture, poor research extension linkage and poor coordination in the sector.

Table 1. Total number of seedlings planted, number of saplings dead, mortality and survival rate of *Olea africana* and *Hagenia abysinicca* at Bachake, Damota and Tinike during 2015/16

Olea africana				
Site	**Total tree seedlings planted during 2015/16**	**Number of saplings dead**	**Mortality rate (%)**	**Survival rate (%)**
Bachake	4500	3200	71.0	29.0
Damota	4700	2900	61.7	38.3
Tinike	4500	2960	63.0	37.0
Hagenia abysinicca				
Bachake	3000	1760	58.7	41.3
Damota	2700	1200	44.4	55.6
Tinike	2500	1320	52.8	47.2

On the other hand, the study indicated that of the total Hagenia abysinicca planted 3000 seedlings during 2015 rainfall season , about 41% were survived at Bachake sub watershed. Whereas, it was 55.6 and 47.2% for Damota and Tinike sub watersheds, respectively. Comparing the two tree endemic species, *Hagenia abysinicca* performed well at all sub watersheds. This could be due the reason that *Hagenia abysinicca* has a natural ability to withstand and grow under an extreme pressure of human influence. Furthermore, (Negash et al. 2012; Tadesse et al. 2014) suggested that it may be the result of socio-culture, land use and management intensities, and farmers' perceptions on the specified tree in the area that leads the allowance of trees to grow. Furthermore, Table 2 shows a simple descriptive statistics of number of saplings dead for *Olea africana* at all sub watersheds considered for this study.

In all quadrats established at all sub watersheds, Bachake sub watershed shows the highest number of saplings dead, about 400 plants. However, the study revealed that the average value for saplings dead at Damota sub watershed was estimated to be lower than the other two sub watersheds, accounting about 241.7 saplings of the planted 4700 (Table 2). The same pattern has been noticed for *Hagenia abysinicca* where the average saplings dead at Damota sub watershed were less, about 100 saplings followed by Tinike sub watershed which is about 110 saplings (Table 3). The reason for this could be due a bit commitment of the local people towards the management of the respective sub watersheds.

It has been recognized via this study that of planted saplings of *Olea africana* 13700 at all sub watersheds considered in this paper, about 9060 have been already died due to many reasons in the areas (Table 4). The average value of dead saplings of *Olea africana* at all sub watersheds has been estimated to be 3020 (Table 4). Moreover, of the total of planted saplings at all sub watersheds of *Hagenia abysinicca* 8200, about 4280 saplings were died. The dead saplings at all sub watersheds considered ranges from 1200 to 1760 having the mean value of 1427 saplings (Table 5).

Table 2.Descriptive statistics of number of saplings dead of *Olea africana*

	Qua1	Qua2	Qua3	Qua4	Qua5	Qua6	Qua7	Qua8	Qua9	Qua10	Qua11	Qua12	Mean	Min.	Max.	SDE
Bachake	300	400	266	250	351	240	305	275	294	169	150	200	266.7	150	400	71.90
Damota	277	350	266	230	300	231	235	275	320	169	127	120	241.7	120	350	72.46
Tinike	200	234	342	230	329	231	321	275	248	270	170	110	246.7	110	342	67.53

Qua is Quadrat

Table 3. Descriptive statistics of number of saplings dead of *Hagenia abysinicca* at all sub watersheds in all quadrats established

	Qua1	Qua2	Qua3	Qua4	Qua5	Qua6	Qua7	Qua8	Qua9	Qua10	Qua11	Qua12	Mean	Min.	Max.	SDE
Bachake	130	134	218	222	245	17	130	129	190	129	116	100	146.7	17	245	62.9
Damota	100	145	111	100	145	123	123	40	145	100	23	45	100	23	145	42.4
Tinike	200	190	56	100	160	123	90	40	120	100	59	82	110	40	200	51.4

Qua is Quadrat

Table 4. Descriptive statistics of number of saplings dead at a composite of three sub watersheds of Lake Haramaya watersheds for *Olea africana*

	Qua1	Qua2	Qua3	Qua4	Qua5	Qua6	Qua7	Qua8	Qua9	Qua10	Qua11	Qua12	Total
Bachake	300	400	266	250	351	240	305	275	294	169	150	200	**3200**
Damota	277	350	266	230	300	231	235	275	320	169	127	120	**2900**
Tinike	200	234	342	230	329	231	321	275	248	270	170	110	**2960**
Mean	259	328	291	237	327	234	287	275	287	203	149	143	**3020**
Min.	200	234	266	230	300	231	235	275	248	169	127	110	**2900**
Max.	300	400	342	250	351	240	321	275	320	270	170	200	**3200**
SDE	52.4	85.2	43.9	11.6	25.6	5.2	45.7	0	36.5	58.3	21.5	49.3	**158.7**
Sum	777	984	874	710	980	702	861	825	862	608	447	430	**9060**

Qua is Quadrat

Table 5. Descriptive statistics of number of saplings dead at a composite of three sub watersheds of Lake Haramaya watersheds for *Hagenia abysinicca*

	Qua1	Qua2	Qua3	Qua4	Qua5	Qua6	Qua7	Qua8	Qua9	Qua10	Qua11	Qua12	Total
Bachake	130	134	218	222	245	17	130	129	190	129	116	100	**1760**
Damota	100	145	111	100	145	123	123	40	145	100	23	45	**1200**
Tinike	200	190	56	100	160	123	90	40	120	100	59	82	**1320**
Mean	143	156	128	141	183	87.7	114	70	152	110	66	76	**1427**
Min.	100	134	56	100	145	17	90	40	120	100	23	45	**1200**
Max.	200	190	218	222	245	123	130	129	190	129	116	100	**1760**
SDE	51	30	82.4	70.4	54	61	21.4	51.4	36	16.7	47	28	**294**
Sum	430	469	385	422	550	263	343	209	455	329	198	227	**4280**

Qua is Quadrat

Conclusion and Recommendation

It could be generalized from the results of the study that the growth and survival of endemic tree species, *Olea africana* and *Hagenia abysinicca* have been widely intervened by the human activities at all sub watersheds. Of three sub watersheds, both trees perform well at Damota, survival rate about 38 and 55.6% for *Olea africana* and *Hagenia abysinicca*, respectively. In contrast, little survival rate for both tree species have been observed at Bachake sub watershed. In line with this, much has to be done on the local communities' awareness creation about the importance of these endemic trees. Training and participatory nursery development is proven methods of building farmers awareness, leadership and technical skills (Carandang et al., 2006). Efforts by Haramaya University via Lake Haramaya Watershed project to rehabilitate these degraded watershed using Endemic trees has been done, however, little attention has been given by woreda administrative. Therefore, the study encourages strong linkage between the woreda administrative and University, one to rehabilitate the degraded watersheds, two to maintain such an endemic tree species with the watershed in specific and with the country in general.

Acknowledgement

I thank Mr. Ayele Shewangizawu and Mr. Abduraman Abdullahi for their cooperation while conducting field data collection for this work. Also it is my pleasure to thank Mr. Teferi Taddese, Coordinator of Lake Haramaya Watershed Project for his financial issue facilitation.

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