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Resource Assessment of *Acacia seyal* in Eastern Amhara Region, Ethiopia

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ABSTRACT

The alarming rate of the population growth is causing the decline of the forest cover in Ethiopia. This is due to the unmanaged destruction of tree species found in scattered on farmlands for fuelwood and charcoal production. The distribution of *Acacia seyal* and their current regeneration status was evaluated based on the *A. seyal* structure on the farmlands. The study was conducted in the selected sites in Eastern Amhara with an aim to assess the resource potential of *A. seyal*. The field survey was conducted to collect vegetation data using point center quarter methods. The Shannon Weiner Diversity Index was used to see the diversity across the study sites. The result showed that the sites vary in the density of *A. seyal* per hectare, diversity and species richness. *A. seyal* structure in all study sites showed an inverted J-shape except Lastie-Gerdao (Gubalafeto). The result of this study indicated that almost in all sites, there is no promising regeneration status of *A. seyal*. Thus, it needs conservation measures, sustainable utilization, and management of the resource.

Keywords: *Acacia Seyal,* Conservation measures, Diversity, Point center quarter methods, Resource potential.

INTRODUCTION

The retaining of trees naturally grown in the cropland is a traditional land use approach developed by subsistence farmers throughout the tropics. The amount of tree cover on the agricultural land increased by 6.7% in south Asia, and 2% in the sub-Saharan Africa (Zomer et al., 2014).

Acacia species are important in afforestation program and for producing non-timber forest products in arid and semiarid zones (Amelework et al., 2010). *Acacia seyal* belongs to the genus *Acacia*, which is one of the largest genera within the family *Mimosaceae*. The genus *Acacia* includes about 800 species widely distributed in the Africa semi-arid Zone (Talaat & Abdurahman, 2014).

A. seyal is found in both western and Eastern Africa on the Arabian Peninsula; while variety fistula is found in the Eastern parts of Africa indicate that variety seyal is native to many African countries (Sara et al., 2016). According to Elbadawi et al. (2013) *A. seyal* is native to Egypt, Eritrea, Ethiopia, Ghana, Iran, Israel, Kenya, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Saudi Arabia, Senegal, Sudan, Syrian Arab Republic, Tanzania, Uganda, Yemen, Republic of, Zambia, Zimbabwe. It is a small to medium tree attain a maximum height up to 17 m high and 60 cm in diameter, occurs in areas with 500-1200 mm rain year $^{-1}$ and a distinct dry season and grow up to 2000 m in upper elevation limit range (Eqbal & Aminah, 2013*)*.

A. seyal is grown in different growing niches like a homegarden, farmlands, and woodlands (Eshete, 2000; Yemenzework et al., 2017). In most parts of Ethiopia, the most common practice is like integrating agricultural crops with the tree are common practice (Zemede, 2001). Different scholars also documented that farmers manage woody species including *A. seyal* within their homegardens and on their farms to derive a range of benefits such as firewood, fuelwood, charcoal, fodder (Belaye et al., 2014). *A. seyal* used for quality gum production, fuelwood, charcoal, improve soil fertility, and vital for the paper industry and in turn helps to alleviate poverty and enhance rural development (Elbadawi et al., 2013; Mohammed et al., 2014; Hanadi & Claus, 2014). However, the estimated annual natural forest cover decline rate was increased from 62,000 - 200,000 hectare in Ethiopia. The household sector accounts for about 93% of the biomass fuel consumption and there are ample signs of shortages of fuel-

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wood in both urban and rural areas (FAO, 2003).

There is no study about the resource assessment of *A. seyal in Eastern Amhara*. Therefore, the vegetation survey was carried out with an aim to determine the resource potential of *A. seyal* in Eastern Amhara.

MATERIALS AND METHODS

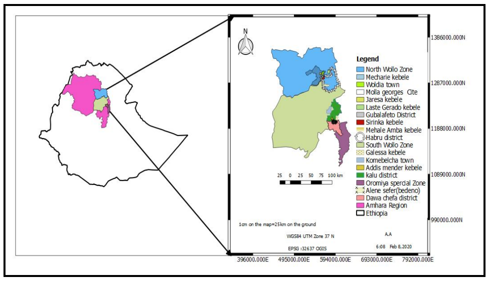

Fig.1: Location map of *Acacia seyal* sites in Amhara region

Study area:

The study area (Fig. 1) is located in North Wollo Zone (Gubalafeto, Habru and Woldia District), South Wollo Zone (Kalu and Kombolcha) and Oromia zone (Dawa-chefa). They are located between 10°76'45"-11°74'04"N latitude and 39°54'.87"to 39°87'18"N longitude. The distance between Addis Ababa and the study areas namely Gubalafeto, Woldia, Habru, Kombolcha, Kalu, and Dawa-chefa is 520, 512, 482, 377, 360 and 327 km respectively. They have also an altitude range from 1,394 m^{-1},876 m a.s.l, temperature of 18-30°C, rainfall from 300-1400 mm annually.

Sampling design:

For the vegetation assessments of *A. seyal*, representative sites were selected purposively and ten quadrants from each site were laid systematically measuring 50 m X 50 m (2,500 m^2), and in each quadrate, the total individuals counted and recorded. The distance between quadrate and transact line was 100 m and 1000 m, respectively. In addition, the height and Diameter at Breast Height (DBH) of *A. seyal* were measured using hypsometers and diameter tape, respectively.

Trees were considered with height >2 m and DBH >2 cm, sapling with height 1-2 m and DBH<2 cm and seedling with less than 1m height and no DBH (Tegenu & Simon, 2018).

According to Donald et al. *(*2008); Kevin (2015), point center quarter was applied for the purpose of the vegetation data collection in farmlands. The species composition, density, and size structure, at points along transects were assessed. The transect direction was determined randomly by selecting a bearing from the center of farmland, with another transect perpendicular to the first transect (i.e. two cross-cutting transects at 90 degree). A series of points were systematically located along each transect, 100 m apart, and was spatially captured with the aid of GPS. There were 10 point center quarters points in transects which normally become 1 Km in length. At every sampling point, four quadrants (90 degrees) were created, using the transect line and a line perpendicular to it.

Data collection method:

Measurements and recording of species in each quadrant were done by selecting the *A. seyal* and sampled with all sizes that were closest to the sampling point in each of the four quadrants and then measuring its distance from the central point. Tree diameters were also measured. This first part of the assessment was made to measure our target trees in all sizes classes including seedlings, saplings and mature trees.

Materials required to conduct the assessment were caliper, hypsometers, diameter tape, GPS and graduating ruler.

Data analysis:

Species diversity and evenness are often calculated using the Shannon-Wiener diversity index (Kent & Coker, 1992).

$$H' = -\sum \frac{ni}{N} \times \ln \frac{ni}{N} - - - - - - (1)$$

Where H' is Shannon diversity index, ni is the total number of individuals of species i and N is the total number of individuals of all species in that stand& Ln=natural logarithm. Possible values of the H′ range between 1.5 and 3.5 and only rarely exceed 4.5, where high values indicate high diversity.

Species evenness was calculated as the:

$$J = \frac{H'}{Hmax} = \frac{H' = -\sum \frac{ni}{N} \times \ln \frac{ni}{N}}{\ln s} - - - - - - (2)$$

Where J=species evenness H' = observed Shannon diversity index; S = the number of species. H max is the maximum level of diversity. Species richness is defined as the number of species per unit area.

Stand characteristics of the scattered trees in farmlands:

To describe the horizontal stand structure of tree species in the farmlands, basal area, density, frequency, height, DBH, importance value index and basal area were calculated using the formulas below;

Basal area*:*

It is the cross-sectional area of all of the stems in a stand at breast height (1.3 m above ground level). This basal area per unit area is used to explain the crowdedness of a stand of forests. It is expressed in square meter/hectare (Jim and Becky, 2012).

The basal area was computed as:

$$BA = \sum \frac{3.14 \times DBH^2}{4} -------- (4)$$

Where, BA= basal area, DBH= average diameter at breast height.

Therefore, Relative basal area (RBA) farmlands as:

$$\text{RBA} = \frac{\text{Total basal area of A. seyal}}{\text{Total basal area of all species}} \times 100 ----- (5)$$

Density is defined as the number of plants of a certain species per unit area.

$$\text{Density} = \frac{\text{Total number of A. seyal}}{\text{n} \times \text{plot area}} ----- (6)$$

For density/ha calculation, the sum of individuals per species was calculated and analyzed the following methods (Muller & Ellenberge, 1974).

Relative density (RD) is the study of the numerical strength of a species in relation to the total number of individuals of all the species.

$$\text{RD} = \frac{\text{Density of Acacia seyal}}{\text{Total density of all species}} \times 100 ----- (7)$$

Frequency is defined as the chance of finding a plant species in a given sample area or quadrat (Kent & Coker, 1992).

$$\text{Frequency} = \frac{\text{Total number of quadrats in which the species occur}}{\text{Total number of quadrats studied}} \times 100 ---- (8)$$

Relative frequency (RF) is the degree of dispersion of individual species in relation to the number of all the species that occurred.

$$\text{Relativefrequnecy} = \frac{\text{Frequncy of Acacia seyal}}{\text{Sum of frequency of all species}} \times 100 ----- (9)$$

The importance value index (IVI) was computed using the formula (Muller and Ellenberge, 1974).

$$\text{IVI} = \text{RD} + \text{RF} + \text{RBA} ----- (10)$$

The data collected were analyzed using descriptive statistics and presented using tables and graphs.

Ethical consideration:

All applicable field vegetation survey guidelines for the resource assessment of *Acacia seyal* were followed.

RESULTS

The status of scattered Acacia seyal stands status across farmlands of Eastern Amhara:

The resource assessment of *A. seyal* result showed (Table 1) that the highest average distance between *A. seyal* trees and sampling points was observed in Mehale-Amba (36.5 m). While the least average distance between *A. seyal* and sampling point was occurred in Lastie-Gerardo (10 m). This implies the distances between the target species and sampling point increases, the distribution of *A. seyal* in Mehale-Amba farmlands is less dispersed compared to that of Lastie-Gerado. In other words, *A. seyal* distribution in more close relative to the studied sites in increasing order; Mehale-Amba, Addis mender, sirinka, Galesa, Alene-Sefer, Mehale-Mecharie, Molla-George's, Jaresa and Lastie-Gerdao.

As shown in Table 1, Relative frequency of *A. seyal* was highest in both Jaresa and Lastie-Gerado (95%), while, the least was found in Mehale-

Table 1: Comparing *A. seyal* densities from resource potential sites of Eastern Amhara

Parameters from Point center quarter methods	In Mehale-Mecharie	In molla-George's	Jaresa	Lastie-gerado	Mehale-amba	sirinka	Addis mender	Galesa
Average distance b/n trees & sampling point (m)	21.6	17.9	16.7	10.0	36.5	34.2	34.3	22
Absolute frequency	1	1	1	1	0.9	0.8	1	0.4
Relative frequency (%)	93	77.8	95	95	43	70	79	77.8
Relative density (%)	8	15	8	5	20	10	13	15
Density (Stems ha^{-1})	148	84	152	144	68	112	124	84

Amba. The relative density of *A. seyal* was highest in Alene-Sefer (31%). but the least one was Lastie-Gerado (5%). The highest density of *A. seyal* was found 148 trees ha^{-1} in Mehale-Mecharie. Whereas, the least density of *A. seyal* occurred 52 tree ha^{-1} in Alene-Sefer.

The life forms of *Acacia seyal* stand across farmlands in Eastern Amhara:

Comparing the study areas in terms of tree density, the highest was Molla-George's. The highest sapling density area was Lastie-Gerado. However, the highest seedling density was observed in Lastie-Gerdao. While the least in tree, sapling and seedling densities were shown in Mehale-Amba. *A. seyal* structure in all study sites showed an inverted J shape except Lastie-Gerdao (Gubalafeto). Therefore, *A. seyal* deserves immediate conservation and appropriate management measures which showed an abnormal population structure in order to get sustainable products and services from the species (Fig. 2).

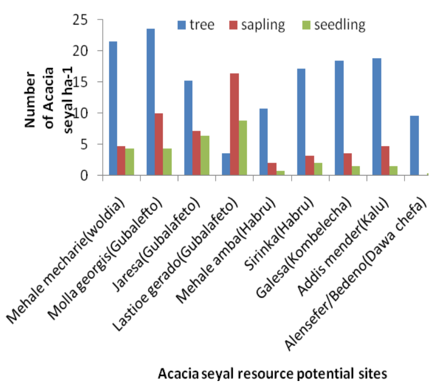

Fig. 2: Life form status of Acacia seyal in Eastern Amhara

Diversity indices across the *A. seyal* resources sites in Eastern Amhara:

As shown in Table 2, the highest Shannon Weiner Diversity, species richness and species evenness were observed in Alene-Sefer (Dawa-Chefa district) followed by Mehale-Amba (Habru). While, the least Shannon Weiner Diversity, species richness and species evenness were found in Molla-George's (Gubalafeto district). This implies the number of tree species in addition to *A. seyal* is found in Alene-Sefer.

The higher importance value index (IVI) is attained by *A. seyal* (300%) in Molla-George's than (252%) Mehale-Mecharie in the case of Woldia. This implies *A. seyal* is a keystone species. IVI values of *A. seyal* ranged from 85 to 300%, and the importance of *A. seyal* is higher than other species that were found in the farmland of the study areas of Eastern Amhara (Table 3).

DISCUSSION

In general, the distribution of *A. seyal* showed uneven distribution across sites, the status of population and regeneration (Table 1). This finding is in line with (Yemenzework et al., 2017; Getahun et al., 2017) showing that farmland tree species diversity and spatial distribution pattern in semi-arid East Shewa, Ethiopia and central Ethiopia respectively.

The average number of seedlings (98 ha^{-1}) reported by (Getachew, 2000) from Acacia woodlands of the Rift Valley of Ethiopia is higher than the number of seedlings (3 ha^{-1}) found in the present study areas (Fig. 2). This could be expected due to the location of the trees are found in their farmland and during plowing the seedlings may be disturbed and hence their number declines compared to Acacia woodland.

The total number of species found in the present study area (N=13) in (Table 3) is higher than the study reported by (Omar et al., 2018) small holder farms (N=10) in southwest Ethiopia. However, the present finding is less than to Abreha we Atsebeha (15 species) in croplands (Etefa & Antony, 2013).

Table 2: The diversity index status across the *Acacia seyal* resource sites in Eastern Amhara

Index	Mehale-Mecharie	Molla-Georgie's	Jaresa	Lastie-Gerdao	Mehale-Amba	Sirinka	Addis-mender	Alene -Sefer	Galesa
Shannon wiener diversity	0.34	0.05	0.24	0.21	1.44	0.78	0.64	1.46	0.57
Species evenness	0.28	0	0.22	0.3	0.67	0.56	0.39	0.61	0.41
Species richness	3	1	3	2	8	4	5	10	4

Table 3. The distribution of A. seyal in terms of relative density (RD), relative basal area (RBA), relative frequency (RF) in Eastern Amhara

Species name	North Wollo Zone																		South Wollo Zone						Oromiya zone		
	Woldia District			Gubalafeto District									Habru district						Kalu district			Kombolcha			Dawachefa District		
	Mehale-Mecharie kebele			Molla-George's kebele			Jaresa Kebele			Lastie-Gerado Kebele			Mehale-Amba Kebele			Sirinka kebele			Addis-Mender kebele			Galesa kebele			Alene-Sefer kebele		
	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF	RD	RBA	RF
Acacia abyssinica	-	-	-	-	-	-	-	-	-	-	-	-	3	11	4	-	-	-	-	-	-	-	-	-	2	3	7
Acacia polyacantha	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	3	7	4	11	10	13	-	-	-	5	16	7
A.seyal	**76**	**83**	**93**	**100**	**100**	**100**	3	82	95	95	6	9	43	4	38	**70**	**58**	**53**	83	4	67	84	32	71	65	8	40
Acacia tortilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	30	14	12	9	7
Cordia africana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	40	7	-	-	-	2	6	7
Acacia nilotica	-	-	-	-	-	-	-	-	-	-	-	-	5	9	8	3	2	7	-	-	-	-	-	-	-	-	-
Ziziphus mauritiana	10	8	5	-	-	-	96	9	3	-	-	-	35	6	29	25	36	33	-	-	-	-	-	-	5	6	13
Euphorbia tirucalli	-	-	-	-	-	-	-	-	-	-	-	-	3	40	4	-	-	-	-	-	-	-	-	-	-	-	-
Ehretia cymosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	42	7	-	-	-	-	-	-
Eucalyptus camaldulensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	34	7	2	3	7
Croton macrostachyus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	7	2	48	7
Leucaena leucocephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	7	-	-	-	-	-	-
Pterolobium stellatum	14	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The species diversity of the present study found in Mehale-Amba (1.44) and Alene-Sefer (1.46) in (Table 2) is higher than a case study reported from Tigray (Etefa & Antony, 2013) that shows the diversity of tree species in the farmland (1.12). While, the species evenness values of the present study are comparable from the case study reported from the Tigray region. The total number of tree species recorded per site ranged from 1 to 10 species which disagrees with the tree species from Agricultural landscapes from sub-humid Oromia region, Ethiopia range as reported by (Dawit et al., 2017).

The higher species importance value observed for A. seyal (300%) was found in Molla-George's. While the least in importance value index was found in Mehale-Amba (85%). Hence, *A. seyal* deserves immediate conservation measures in the farmlands of Mehale-Amba (Table 3). The importance value index of the present study sites is higher than woodland vegetation in West Shewa which ranges from 0.54 to 26% (Gadisa, 2019).

The conservation measure for the least importance value Index in the present study areas is required as the use of *A. seyal* on sustainable base to satisfy the demand of farmers for fuelwood, firewood and charcoal was the key to successful retaining *A. seyal* species in farmlands of Eastern Amhara. Hence improving the income as well as food self-sufficient environment for the farmers can be achieved after conserving and sustaining via undertaking appropriate *A. seyal* management. According to (Grubb et al., 1963), IVI is a good measure for summarizing vegetation characteristics of a given habitat and also useful to compare the ecological significance of species and for conservation practices.

In conclusion from the result**,** the present study sites vary in the density of *A. seyal* ha^{-1}, diversity, and richness and regeneration status. *A. seyal* structure in all study sites showed an inverted J shape except Lastie-Gerdao (Gubalafeto). Mehale-Mecharie, Molla-George's and sirinka were selected as the best *A. seyal* resource potential sites due to the highest importance value. There should be awareness creation on the values and management of *A. seyal* for fuelwood, and charcoal production via a participatory forest management approach for sustainable use of *A. seyal* trees on farmlands.

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REFERENCES

Amelework, K., Ricardo, A., Wubalem, T., Valentin, & Felipe, B. (2010). Seed germination and viability in two African Acacia species growing under different water stress levels. *African Journal of Plant Science*, *4(9),* 353-359.

Belay, M., Gebru, S., Sea, J., & Woo, K. (2014). Socio-Ecological Niche and Factors Affecting Agroforestry Practice Adoption in Different Agro ecologies of Southern Tigray, Ethiopia. *Sustainability Journal*, *11(13)*, 1-19.

Dawit, S., Abayneh, D., Zerihun, K., & Kiros, M. (2019). Tree species diversity and spatial distribution patterns on agricultural landscapes in sub-humid Oromia, Ethiopia. *Agro Forest Systems Journal*, *93(3),* 1015–1029.

Donald, G., Ruch, B., & Kemuel, S. (2008). Point-Centered Quarter Analysis of Four Forest Types at Hayes Arboretum in Wayne County, Indiana. *Proceedings of the Indiana Academy of Science, 117(2),* 136-141.

Elbadawi, M., Osman, Z., Paridah,T., Nasroun, T., & Kantiner, W. (2013). Properties of Particleboards made from Acacia Seyal Var. Seyal Using Uf–Tannin Modified Adhesives. *Journal of Cellulose Chemistry and Technology*, 369-374.

Eqbal, D., & Aminah, A. (2013). Utilization of Gum Arabic for Industries and Human Health. *American Journal of Applied Sciences, 10(10),* 1270-1279.

Etefa, G., & Antony, J. (2013). Assessment of biodiversity in cropland agroforestry and its role in livelihood development in dry land areas: A case study from Tigray region. Ethiopia. *International Journal of Agricultural Technology*, *9(4)*, 829-844.

FAO. (2003). Role of Planted Forests and Trees Outside Forests in Sustainable Forest Management in the Republic of Ethiopia. *Planted Forests and Trees Working Papers*, Working Paper 29.

Gadisa, D. (2019). Woody Species Diversity and Composition of Dry Woodland Vegetation in West Shewa, Central Ethiopia: Implications for Their Sustainable Management. *American Journal of Agriculture and Forestry*, *7(6)*, 282-289.

Getachew, E. (2000). Population Structure and Regeneration of the main Tree species in the Acacia Wood lands of The Rift Valley of Ethiopia. *Journal of Tropical Forest Science*, *12(4)*, 747-760.

Getahun, H., Mulugeta, L., Feyera, S., & Fisseha, I. (2017). Plant diversity and determinant factors across smallholder agricultural management units in Central Ethiopia. *Journal of Agro Forestry System*, *91*, 677–695.

Grubb, P. J., Penigton, D., & Whitmore, T. C. (1963). A Comparison of Montane and Lowland Rainforests in Ecuador. *Journal of Ecology*, *51*, 567-601.

Hanadi, M., & Claus-Thomas, B. (2014). Acacia seyal var. seyal: A Multipurpose Tree Species for Rural Development, Hunger and Poverty Alleviation in Sudan. *Tropentag, Czech Republic* September, 17-19.

Jim, E., & Becky, B. (2010). Basal area: A measure made for management, Published by the Alabama Cooperative Extension System (Alabama A&M University and Auburn University), an equal opportunity educator and employee, *Alabama Cooperative Extension System*, ANR-1371.

Kent, M., & Coker, P. (1992). Vegetation Description and Analysis: A Practical Approach. Belhaven Press (a division of Pinter Publishers), London, 355.

Kevin, M. (2015). Quantitative Analysis by the Point-Centered Quarter Method, Http://people.hws.edu/Mitchell.

Mohammed, S.A., Abdalla, I., Abubakr, M., & Kamal, F. (2014). Potential Nutrient Composition of Acacia seyal Fruits as Fodder for Livestock in the Dry Lands in Sudan. *Development in Analytical Chemistry*, 1, 25-30.

Mueller, D., & Ellenberg, H. (1974). Aims and methods of vegetation ecology, *John Willey and Sons*, Inc, USA, 547.

Omar, S., Jemal, D., & Meine, V., (2018). Local Agroforestry Practices for Food and Nutrition Security of Smallholder Farm Households in Southwestern Ethiopia. *Sustainability Journal*, 10(8), 2722, DOI: 10.3390/su10082722.

Sara, S., Awad, A., Rabah, A., Hassan, I., Ali, T., & Mahmoud, E. (2016). Acacia Seyal Gums in Sudan: A Review, *Proceedings on Annual Conference for Postgraduate Studies and Scientific Research*, *6*, 94-987.

Talaat, A., & Abdurahman, G. (2014). The Potential of Acacia seyal as a Resourceful Tree for Gum Arabic in Sudan.

Tegenu, M., & Simon, S. (2018).Structure and Regeneration Status of Nagasa Sacred Forest in Chencha, Gamo Gofa Zone, Ethiopia. *Journal of Cell and Molecular Biology, 7(1)*, 1- 13.

Yemenzwork, E., Abayneh, D., Mekuria, A., & Catherine, M. (2017) Farmland tree species diversity and spatial distribution pattern in semi-arid East Shewa, Ethiopia. *Journal of Forests, Trees and Livelihoods*, *26(3)*, 199-214.

Zemede, A. (2001). Origin and evolution of rural home gardens in Ethiopia. BiologiskeSkrifter (Biodiversity research in the Horn of Africa region): *Danske Videnskabers Selskab, 54*, 273–286.

Zomer,R, J., Trabucco. A., Coe. R., Place, F., van Noordwijk, M., & Xu J, C. (2014). Trees on farms: an update and reanalysis of agroforestry's global extent and socio-ecological characteristics. Working Paper 179. Bogor, Indonesia. *World Agroforestry Centre* (ICRAF) Southeast Asia Regional Program. DOI: 10.5716/WP14064.