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Impacts of Invasive Plant, *Cryptostegia grandiflora*,on Species Diversity and Composition of Invaded areas in East Shewa Zone, Ethiopia

Tesfaye Bekele*, Amare Seifu and Ashenafi Ayenew
Genetic Resources Access and Benefit Sharing Directorate, Ethiopian Biodiversity Institute (EBI), Addis Ababa, Ethiopia.
*Corresponding author email id: tesfayebekele44@gmail.com

Abstract **– Invasive alien species have been affected every ecosystem types on the planet and considered as the second greatest global threat to biodiversity, following habitat destruction. *Cryptostegia grandiflora* (Rubber vine) is one of the invasive alien species which pose negative impacts on country's biodiversity. This species has negative impact on native plant species by growing up into their canopy, blocking their access to the sun and "choking them. However, its impact on biodiversity has not been determined. Therefore, the objective of this study was to assess the impact of *Cryptostegia grandiflora*, on the species diversity and composition of invaded communities in East Shewa Zone. Accordingly, Systematic random sampling design was employed for data collection from 60 quadrants, each with 20 m x 20 m area at 50m intervals. Out of 60, 40 plots were laid in Ledota natural forest and the remaining 20 quadrants were laid at the roadside. From the three sites, 37 plant species representing 19 families were recorded. Species diversity indexes (H') were 1.88, 1.67, and 0.79 in un-invaded forest site, invaded forest and roadside respectively. Similarly, cover percentage of un-invaded forest site were exceeded invaded forest by 10.5% due to infestation of the invasive alien plants, *Cryptostegia grandifilora*, which has turned into a major driver of biodiversity loss in the invaded regions and adversely affecting agro-economy of the pastoralist and the country. Therefore, it needs the effort of all concerned bodies to control the impacts and its spread.**

Keywords **–** ***Cryptostegia grandifilora,*** **Invasive, Invaded, Un-Invaded.**

I. INTRODUCTION

According to Convention on Biological Diversity [2], invasive alien species are introduced deliberately or unintentionally outside their natural habitat, where they have the ability to establish themselves, invade, out-compete natives and take over the new environment. Beside this, invasive species have now affected every ecosystem types on the planet and considered as the second greatest global threat to biodiversity, following habitat destruction [18], [23]. Similarly, invasion by alien species cause extensive damage on the habitats they invade, which include impact on indigenous species diversity, soil nutrient composition, altering forest fire cycles and loss of productivity of invading ecosystems. It also becomes a threat to endangered or threatened plant species around the world [22]. Invasive species are responsible for the homogenization of floras that causes a substantial threat to biodiversity and ecological integrity of native habitats and ecosystems [8]. Invasive species may cause changes in environmental services, such as flood control and water supply, water assimilation, nutrient recycling, conservation and regeneration of soils [15].

Biological invasions are attracting far-reaching attention from ecologists because of their significant ecological impacts and economic costs. Particularly, biological inva-sions are increasingly recognized as a significant problem for the conservation of biological diversity. Invasive Aliens Species (IASs) are of a great concern in Ethiopia, posing particular problems on biodiversity of the country with great economic and ecological consequences. The extraordinary rise in the movement of wild species that goes parallel to the globalization of the economy has produced an acceleration of the rate of introduction of new alien species everywhere, with its harmful consequences on native biological diversity [21], [26].

In Ethiopia, several invasive alien plant species are posing negative impacts on native biodiversity, agricultural lands, rangelands, national parks, waterways, lakes, rivers, etc. [10]. *Cryptostegia grandiflora* (Rubber vine) is one of the invasive alien plant species which pose negative impacts on country's biodiversity. *Cryptostegia grandiflora* is one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts and also negative impact on the pasture, toxic to livestock and dense infestations replace productive species, rendering grazing country less productive or even unusable, which has led to its declara-tion throughout Australia (www.biosecurity.qld.gov.au) [4]. Likewise, in Mexico, rubber vine is outcompete native vegetation, altering important habitat for an array of vertebrate and invertebrate species [24]. *Cryptostegia grandiflora* is an aggressive woody climbing shrub, which is capable of growing over trees up to 30m high. Plants are common in disturbed situations where there is temporary or permanent water, such as along gullies, rivers, creeks, and waterholes areas [6], [20].

The impact of invasive weeds on environment, Article 8(h) of the Convention on Biological Diversity (CBD) signed by 161 countries at the Earth Summit in 1992 urges the parties to prevent the introduction of, control, or eradicate those alien species, which threaten ecosystem, habitat or species. Hence, *Cryptostegia grandiflora* has natural dispersal mechanism and can be introduced to an area by animals or humans. Livestock can carry seeds long distances through agricultural fields. Likewise, contamina-ted vehicles and machinery transport seeds from one worksite to another. Cultivation of *Cryptostegia grandiflora* as an ornamental plant makes the problem much worse, especially since a plant may live for up to 80

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years [11]. In addition to this, about 95% of seed produced by *Cryptostegia grandiflora* is viable. It is scattered short distances from the parent plant by wind that catches the tufts on the seed ends, or longer distances by floating on floodwaters. Most seed remains viable even after the pods have floated on fresh or salt water for over a month, potentially leading to spread between catchments. Seeds can also be potentially spread by birds, or in mud attached to vehicles, machinery and animals. The seedpods are rigid and grow in pairs at the end of a short stalk. The pods are 10-12 cm long, 3-4 cm wide and each can contain up to 450 brown seeds. Each seed has a tuft of long, white, silky hairs, which enable easy dispersal by wind and water, a hectare of *Cryptostegia grandiflora* can produce millions of seeds every year [30], it colonize flood plain, pasture land, hill, etc. [9], [19].

Cryptostegia grandiflora is also regarded as one of the worst invasive alien plant in Ethiopia. It is widely distributed in East Shewa and Afar regions, Ethiopia. However, little attention is given to this invasive plant species [16]. Moreover, no adequate recent information exists about the impact of *Cryptostegia grandiflora*, on the species diversity (richness and evenness) and composition of invaded communities. Therefore, this study aimed at assessing the impacts of invasive plant, *Cryptostegia grandiflora*, on species diversity and composition of invaded areas in East Shewa Zone, Ethiopia.

II. Materials and Methods

2.1. *Description of the study area*

East Shewa (Amharic: Misraq Shewa; Afaan Oromo: Shawaa Bahaa) is one of the Zones of the Ethiopian Regi--on of Oromia. East Shewa is located in the middle of Oromia, connecting the western regions to the eastern ones. This zone is bordered on the south by the West Arsi Zone, on the west by South west Shewa and Oromia Special Zone, on the northwest by North Shewa, on the north by the Amhara Region, on the northeast by the Afar Region, and on the southeast by Arsis. Its westernmost reach is defined by the course of the Bilate River. Towns and cities in East Shewa include Bishoftu, Metehara, and Ziway. Currently, East Shewa Zone undertakes its administrative duties and responsibility in 10 districts (Fantale, Boset, Adama, Lume, Bora, Dugda, Adami Tullu Jido Kombol--cha, Ade'a, Liben and Gimbichu) and three urban centers under reform namely, Matehara, Mojo and Batu (Ziway). Our study areas focused on Fantale and Boset (Fig. 1).

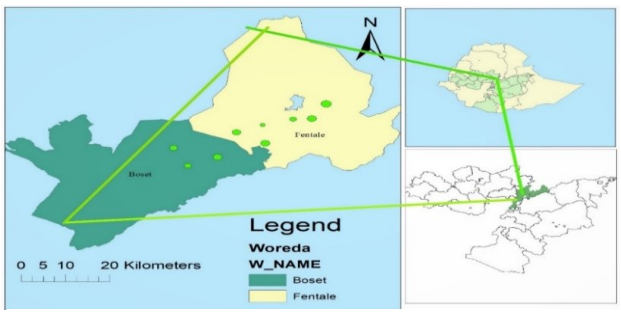

Fig. 1. Map of the study area and distribution of invasive species.

2.2. *Data Collection*

The study was conducted on Ledota forest (invaded by *Cryptostegia grandiflora* and un-invaded site) and the main road (from Adam to Djibouti) side. Systematic sampling design was employed for data collection by laying 60 quadrants, each with 20 m x 20 m area. Two consecutive plots were separated from each other by 50 m. Out of 60, 40 plots were laid in Ledota natural forest (20 invaded and 20 un-invaded sites), following [5], [7], which could have been assumed with reasonable certainty due to the un-invaded plot being located in close proximity to the invaded plot. The remaining 20 quadrants were laid at the roadside. These plots were laid out along line transects with 50 m distance between adjacent plots. Data regarding herbaceous species under the canopy were collected from five 2 m x 2 m subplots systematically laid within each main quadrant (four at the four corner of the main plot and one at the center). All of the vascular plant species present in each plot was recorded, and the coverage of each species in the sampled plots was estimated [14].

2.3 *Method of Data Analysis*

The collected data were analyzed by using SPSS (statistical package for social sciences version 23). Vegetation data analysis involved both descriptive and statistical analysis stage. The PAST software, were used to calculate total number of each species, densities (number of individuals per unit area), community diversity and F test was used to check for species diversity differences between invaded and un-invaded areas in each stratum. On the other hand, species abundance, richness and similarity index were analyzed by Shannon-H diversity and Evenness index. In addition, the species richness S was taken as a measure of diversity at the plot scale and the impact of invasion on diversity at the study site [13]. The formula for Shannon-Wiener diversity index is as follows:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where: H'-Shannon diversity index.
S - The number of species in the sample.
Pi - The proportion of the individual species to the total or kinds measures.
Ln - Natural logarithm or log to base n.
N - Total number of individuals of all kinds.
ni - Number of individuals of i^{th} species.
Equitability (Evenness) index is calculated using the formula:

$$J = \frac{H'}{H'max} \text{ or } J = \frac{H'}{\ln(S)},$$

Where:
J = Evenness.
H` = Shannon-Diversity Index.
S = Total number of species in the sample.
ln = natural logarithm
S= number of species
H'max' = lns [25], [27].

Percentage cover and number of individuals of each species were determined using Braun Blanquet and count techniques respectively. Braun-Blanquet method is often

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used for identifying all species in that area, and then assigning a code to each species based on its percent cover. An example of Braun-Blanquet codes is:

0: Species not present.
1: Species <5% of total.
2: Species 5-10% of total.
3: Species 10-25% of total.
4: Species 25-50% of total.
5: Species 50-90% of total.
6: Species >90% of total.

III. Results and Discussion

3.1 *Impact of Cryptostegia grandiflora Invasion on the Floristic Composition of the Study Areas*

Cryptostegia grandiflora is a highly invasive weed in semi-arid natural ecosystems. It has the potential to spread much further and resulting in a loss of trees and native vegetables, which in turn leads to a loss of biodiversity and habitat. This species has a much wider distribution in forest, roadside, flooding areas, pasture land of Fentale than Bosat district. In this study, 25 plant species representing 13 families were recorded in the invaded forest site including trees, shrubs and herbaceous plants. Whereas, 16 plant species representing 10 families were recorded in the invaded roadside. Regarding to un-invaded forest site, 31 plant species representing 16 families were recorded. Generally, from the three sites 37 plant species representing 19 families were recorded (Fig. 2).

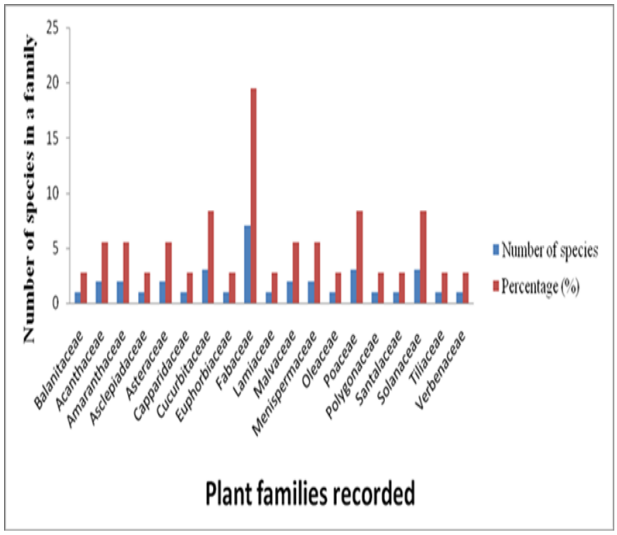

Fig. 2. Families all plant species recorded from the three sites.

Among these families, Fabaceae was found to be represented by the highest number of species 7(18.9%), followed by Solanaceae 4(10.8%) and (Acanthaceae & Cucurbitaceae) each 3 (8.1%), within a total families recorded from the study area.

Shannon - Wiener diversity index was used to assess the species diversity of invaded Ledota forest which computed as H' = 1.67. Whereas, in un-invaded areas with similar site condition of this forest was computed H' = 1.88. The result indicated that the species diversity for un-invaded forest site (H' = 1.88) was found to be greater than the invaded forest site (H' = 1.67). This means the un-invaded forest site had slightly higher species diversity than invaded one. This has been also demonstrated by both species richness and evenness indices computed for both invaded and un-invaded Ledota forest sites (Table 1).

On the other hand, species similarity index is generally used to characterize the degree of spatial heterogeneity in diversity at the landscape scale, or to measure the change in diversity along transects or environmental gradients. Jaccard's similarity index was used to determine the pattern of species turnover between two sites (invaded and un-invaded). Its coefficient value ranges from 0 (complete dissimilarity) to 1 (total similarity). Accordingly, the level of overlap in species composition between these sites was found to be 2.23 % (J = 0.22).

Table 1. Shannon-Wiener and Simpson's index in the invaded and un-invaded forest strata.

Ledota Forest	Shannon- Weiner diversity index (H')	Simpson's index (1-*D*)	Dominance (D)	Evenness (E)
Invaded site	1.67	0.68	0.32	0.2
Un-invaded site	1.88	0.80	0.20	0.3

The assessment of invaded roadside was also determi--ned and showed lest Shannon-Wiener diversity index, species richness and evenness among them (invaded and un-invaded forest site) (Table 2).

Table 2. Shannon-Wiener indices and Simpson's index in the invaded roadside.

Invaded site	Shannon- Weiner diversity index (H')	Simpson's index (1-*D*)	Dominance (D)	Evenness (E)
Roadside	0.79	0.30	0.69	0.13

In addition, 8102 individual plant species were recorded from un-invaded followed by 5259 and 3175 individuals were from invaded forest site and roadside respectively. This indicates individual plant species were more recorded in un-invaded site than the invaded one. The area was dominated by invasive aliens species, even out of the target species (*Cryptostegia grandiflora*).]. Regarding this, many invasive species grow faster than native plants and reproduce quickly, and thus replace indigenous plants and completely alter the composition of the area they have colonized. They may alter the environment in directions that are more favorable for them but un-favorable to native species. This could include altering geomorphic processes (soil erosion rates, or sediment accretion), biogeochemical cycling, hydrological cycles, or fire or light regimes [1]. For instance, *Parthenium hysterophorus, Xanthium strumarium* and *Prosopis juliflora* were invaded most of the study areas (Figure 3). These are the worst invasive alien species in Ethiopia [10], [29], and there were highly invasive and invaded around the Fentale and Bosat district. The study was revealed that this invasive plant species to

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have acute negative impacts on a number of native trees around the Awash River that are important to pastoral livelihoods [17]. The main factors that recorded for the occurrence of invasive plant species in the study area were human interference, grazing and contaminated soil by the seeds of those invasive species moved from the sources to un-invaded areas by different mechanisms. The least diversity was recorded in the invaded roadside and the invasion by different invasive aliens plants were showed in the affected areas.

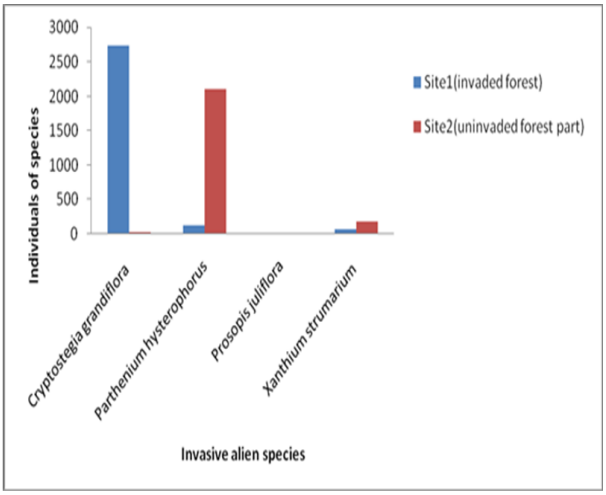

Fig. 3. Invasive plant species invaded the study areas.

Moreover, assessment of plants species diversity (richness and evenness) and family, among the invaded and un-invaded forest sites and invaded roadside revealed that the plant species diversity were decreased in both invaded forest site and roadside. For alpha diversity, measures from sampling simulations of different species richness and sampling intensity were showed in (Figure. 4).

Alpha-parameter has a low sensitivity to sample size [12], [28], and is more robust to changes in abundance of the commonest species. The high decline of species diversity is an indication of impact of invasive alien's species on the native species.

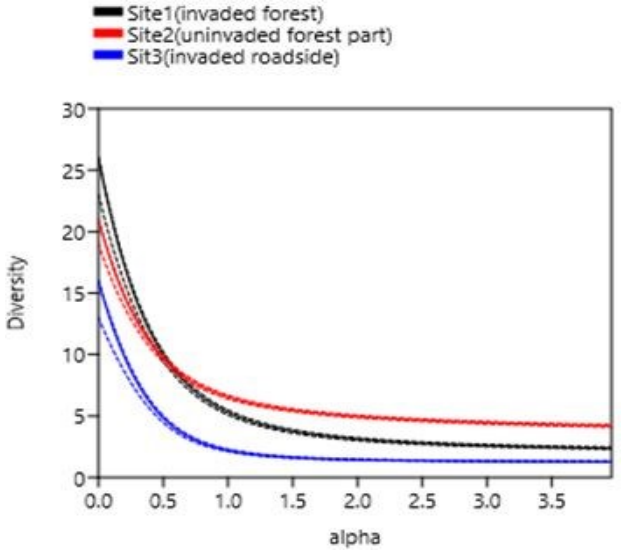

Fig. 4. Alpha diversity of species richness between the three study sites and their relationship.

The plant invades waterways forming dense, impenetrable thickets that smother riparian vegetation and decrease biodiversity. Rubber vine can also affect ranching operations by restricting livestock access and lowering pasture productivity. Furthermore, the invasive often compete with other species directly, alter ecosystem processes and may hybridize with natives thereby degrading the native gene pools [3]. This invasive plant is extremely poisonous; it contains cardiac glycosides, chemicals that interfere with heart function in humans and animals when the plant is ingested. Contact with the plant's milky sap can cause burning rashes and blisters. When the vine is dry, a powdery dust emerges that can cause violent coughing, swelling of the nose, and painful blistering of the eyelids [11].

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Photo taken by Tesfaye, 2017 infestation of *C. grandiflora*at from different sites of study areas.

The statistical analysis of invaded and un-invaded forest site were showed that there was significant difference in species diversity, F-test = 241.981, P-value <0.001 and relationships between invasive and native plants. The quadratic correlation and cover analysis indicated that the cover of invasive alien plant, *Cryptostegia grandifilora* (F = 909.843, p-value <0.0001) and Correlation is significant at the 0.01 level (2-tailed) (Table 3). Besides, the cover of un-invaded forest site was showed that an individual plant species their cover percentage greater than 90 was counted 42.1% of the total. Whereas, an individual plant species their cover percentage greater than 90 of invaded forest site were counted 31.6%. This indicated that un-invaded forest site were exceeded invaded forest by 10.5% due to infestation of the invasive plant. Similarly, the relationship between coverage of native plants and invaders were indicated negative relationships. This implies as log abundance decreased the rank of invader species increased (Figure 5).

Table 3. The table of correlation between un-invaded and invaded forest site.

ANOVA

Cover of invaded

Category	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2315.438	16	144.715	241.981	.000
Within Groups	8.971	15	.598		
Total	2324.409	31			

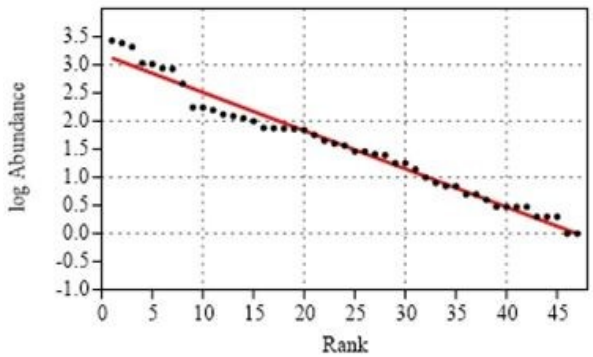

Fig. 5. The log abundance of coverage between un-invaded and invaded forest site.

The relationship of invaded roadside and invaded forest site were indicated an increasing positive relationship (Figure 6). This means as invasive aliens plant species increased native plant species of both sites decreased.

IV. Conclusions

Information on the spatial distribution of any species is very important for its management. Similarly, recording invasive species, distributions and how they affects the inherent diversity of native plants species in the study areas are important, in developing strategies for manage--ment. Ecosystems of Fenatale and Bosat Woredas' (Ledota forest, forests along Awash River and native plants of roadside) threatened by *Cryptostegia grandiflora* which is widespread. This invasive species has already caused negative impacts on the diversity and richness of native species and its effects are increasing from time to time. As a result, *Cryptostegia grandifilora* was out of control in the study area and they recommended further investigation by concerned body to control the spread and need integrity of concerning Institutions.

Recommendation

During the study, several factors were documented as related to the dispersal of invasive species in the study area. Such as listed as spreading mechanisms like flood, bird, animal, wind and contaminated soil transported from place to place by construction vehicles and also concerned bodies was not given attention. Likewise, lack of effective physical (manual and mechanical) eradication methods, this means local communities try to eradicate by different mechanical methods but the rubber vine's regenerate in excessive seedling from one individual at once. In this regard, the following recommendations could minimize the spread of invasive: awareness rising among the members of local communities about impacts and manage--ment of invasive alien species and train communities in order to preventing invasive species from introducing and eradicating potential invaders soon after invasion.

Moreover, the invasion has turned into a major driver of biodiversity loss in the invaded regions. Many important plant species have declined after the invasion and habitat destruction enforced.

Therefore, invasive alien species need attention to eradicate or minimize its spreading. For high value of labor intensive and expensive control methods could not implemented by local communities, as a result eradication still be economically sound. This calls for integrated of community, concerning government bodies and NGO's to eradicating *Cryptostegia grandifilora* invasion under different cost effective methods and determining the optimal strategies under different circumstances. To this effect, Ethiopia needs to design clear policy, laws and regulations to control and detailed strategies in controlling invasive alien species. Institutional mandate in managing invasive species should also be well specified and give priority for eradication.

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AUTHORS PROFILE'

MR. TESFAYE BEKELE
Date of birth and place: 07-02-1982, Asella, Ethiopia.
Associate Researcher at Ethiopian Biodiversity Institute, Access and Benefit sharing Directorate, Ethiopia.
email id: tesfayebekele44@gmail.com or tesfaye.bekele@ebi.gov.et

EDUCATIONAL QUALIFICATION:

DEGREE	FIELD	PASSING YEAR	UNIVERSITY
MSC	BOTANY	2012	DILLA
BED	BIOLOGY	2007	DILLA

LIST OF RESEARCH PUBLICATIONS:

1. Tesfaye Bekele and Wendawek Abebe (2018). Indigenous Woody Species Regeneration under the Canopies of Exotic Tree Plantations at Tore Forest, Gelana District, Southern Oromia, Ethiopia. Biodiversity International Journal, 2(1): 00034.
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MR. AMARE SEIFU ASSEFA
Date of birth and place: OCT, 1978, Asella, Ethiopia.
Associate Researcher at Ethiopian Biodiversity Institute, Access and Benefit sharing Directorate, Ethiopia.
email id: ameseifu21@gmail.com or Amare.seifu@ebi.gov.et

EDUCATIONAL QUALIFICATION:

Degree	Field	Passing year	University
BED	Biology	2004	Dilla
MSc.	Botany	2012	Dilla

LIST OF RESEARCH PUBLICATIONS

1. Diversity of Enset Landraces (*Enset eventricosum* (Welw) Cheesman) in Aleta Chuko District, Sidama Zone, SNNPR, Ethiopia.
2. The ethno botanical study and distribution patterns of enset landraces *(Ensete ventricosum* (welw) cheesman) in Aleta chuko district, Sidama Zone, SNNPR, Ethiopia.
3. Bio-prospecting Potential of *Ocimum basilicum* for Access and Benefit Sharing Around Bahir Dar City Administration, West Gojam and Northwest Gondar, Amhara Region, Ethiopia
4. Assessment of the Invasive Alien Plant Species, *Mimosa diplotricha*, in Shebe-Sombo, Kersa and Seka-Chekorsa Districts, Jimma Zone, Southwest Ethiopia.
5. Assessment of the Invasive Alien Plant Species, *Argemone ochroleuca,* in North Gondar and West Gojam Zones, Amhara Region, Ethiopia.
6. Impact of Invasive Alien Plant, *Xanthium strumarium*, On Species Diversity and Composition of Invaded Plant Communities in Borena Zone, Ethiopia.
7. Assessment of the Invasive Alien Plant Species, *Cryptostegia grandiflora*, in East Shewa Zone of Oromia Region, Ethiopia,
8. Bio-prospecting potential of *Colocasia esculenta* for Access and Benefit Sharing in Sidama and Gedio Zones, SNNPR, Ethiopia.
9. Bio-prospecting potential of *Dioscorea* Spp. for Access and Benefit Sharing in Sidama and Gedio Zones, SNNPR, Ethiopia.
10. Abundance and Socio economic uses of *Osyris quadripartita* in South Omo and Gamogofa Zones of SNNPR, Ethiopia.

MR. ASHENAFI AYENEW
Place of birth Tigray, Ethiopia. MSc. Degree in Ethno botany, ABS National Focal Point, ABS Director at Ethiopian Biodiversity Institute.
email id: ayenewashenfi2007@gmail.com
Phone No.: +251916458972