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Impact of Invasive Alien Plants on Biodiversity and Livelihood of Local Communities in Tigray, Ethiopia

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Abstract: An assessment was conducted to identify the type and number of invasive alien plant species found in Tigray region state and community's perception on their socioeconomic and ecological impacts. The survey area was randomly selected and the total numbers of respondents were 180. The major threat and challenge were loss of biodiversity and crop production due to high spread rate, prolific seed production and high regeneration capacity of invasive alien plants. Respondents noted that invasion of both disturbed and undisturbed areas in the study districts was adversely affected fertility status of soils, suppresses growth of grasses, other herbaceous plants, bush lands and economically important crops, human and livestock health. These species were found to increase the cost of production, decrease quantity and quality of crop production. The rapid movement of peoples and commodities across regional and international boundaries aggravates introduction of invasive alien plants. It is difficult to prevent the entry of invasive plants with phytosanitary measures in checkpoints. Utilization invasive plants as firewood, construction, fence, feed and erosion control were major tackle of their management. Adoption of an integrated management program is mandatory in instead of depending on any single option. Researchers urgently need to characterize and quantify the socioeconomic impacts and devised proper strategies for cost effective and time efficient management options of invasive alien species. Thereby, raising awareness of community and government agents on likely impacts of invasive species is urgently required.

Key words: *P. juliflora* · *P. hysterophorus* · *P. barbatus* · *A. conyzoides* and *L. camara*

INTRODUCTION

Invasive alien plant species are not native to the ecosystem and whose introduction threatened directly or indirectly to al llife forms because of their rapid spreading rate, higher competitiveness and capacity to invade larger areas within a short period of time [1]. Invasions of invasive alien plant species are serious threats to bio-resources conservation, management and sustainable utilization ofbenefits accrued from such ecosystem across all regions of the globe [2-4]. Apart from revealing impacts on ecosystem services, invasive alien plants have also drawn undesirable socio-economic and ecological challenges [5].

Intrusion and spreading of invasive alien plant species into new areas has been more likely associated with anthropogenic and natural factors. Socioeconomic development in all sectors, considerably facilitates the process of infestation and immensely accelerates the spread rate of these species [2]. It is recognized that development in the transport network, pattern of life style changes and cosmopolitan interests in the introduction and use of exotic plant species have been changing and shaping natural areas of the world.

Major factor responsible for loss of biological resources are comprised of habitat loss and degradation, invasion of invasive alien species together with overexploitation and pollution [6]. The disturbance of ecosystem with invasion invasive alien plant species have been significantly threatened agricultural areas, residence, backyards, roadsides, rangelands, rivers, lakes, power dams and national parks [7]. This was due to high population pressure, overstocking, overgrazing together with deforestation has adversely hastened and aggravates disturbance of ecosystems in Ethiopia [8]. Nationally clear policies or strategies have yet not set so far for management and control of invasive alien plant species [9]. There are about 22 identified invasive alien

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plant species in Ethiopia [10] and among them *Parthenium hysterophorus*, *Eichhornia crassipes*, *Prosopis juliflora*, *Lantana camara* and *Acacia* species, such as *Acacia drepanolobium*, *Apis melifera* are major ones [11]. The Environmental Policy of Ethiopia, the Forest Resource Strategy and the National Biodiversity Strategy and Action Plan, recognize invasive plant species to be growing threats to the biodiversity of the country and socioeconomic well-being of the people [9].

The introduced invasive alien plant species found threatened nearly all biodiversity resources and most adversely affects indigenous woody plants, herbs, agricultural crops, animals and livelihood of humans. Farmers in the region claims that invasive alien plants found in their areacaused massive yield reduction, increased cost of production, increases cost of control, reduces labor efficiency and impairs human and animal health. Some of the invasive alien plants are known to local communities for a long time and few of them were recently introduced. The major invasive alien, which have been introduce formerly were *Parthenium hysterophorus, Prosopis julifora, Ageratum conyzoides, Lantana camara, Striga hermonthica, Orobanche crenata, Orobanche ramosa, Argemone ochroleuca*, *Nicotiana glauca*, *Calotropis procera* and *Sennadide mobotrya* [12]. However, recently one unidentified invasive alien herbaceous plant was found in the region stretched from the verge of southern to the edge of northwestern Tigray.

Tigray has been invaded by more than twelve [12] invasive alien plant species, but their socioeconomic and ecological impacts were not assessed sofar. Assessing the overall impact of invasive alien plants was quite crucial to measure, communicate and made scientific decisions about the likelihood of socioeconomic and ecological damage in the region. Thus, quantification of impacts of invasive alien plant species on invading species, communities and ecosystems was important in providing cogent information and prioritizing management options to the public and policy makers. Therefore, this research was planned to attain the following specific objectives.

- To increase awareness on socioeconomic and biodiversity related problems and concerns due to introduction invasive alien plant species
- To mobilize stakeholders, local governors and communities on the control of invasive alien plant species
- To generate basic information that assists to alert decision makers, stalk holders and communities to campaign against invasive weeds

MATERIALS AND METHODS

Description of the Study Area: A survey of invasion of invasive alien plant species was conducted in southern, southeastern, central and northwestern zones of Tigray regional state, Ethiopia during 2016. Climatically, Tigray belongs to sub-tropics and monsoon weather prevails throughout the year and there are three distinct seasons. The first is the main rainy monsoon season, which lasts from June to September (locally called *Kermit*), the second is the dry winter season from October to February and the third is a pre-monsoon hot season from March to May. Rainfall is very sparse and unpredictable with annual average of 650mm or less over the past decades [13]. The regional climate is characterized by large spatial and temporal variations and frequent drought. Like the rest of Ethiopia, the economy of Tigray is mostly reliant on agriculture. The immense contribution of this sector to the regional economy can be estimated by the fact that directly supports about 80% of the population in terms of employment and livelihood [14]. Agricultural systems are rain-fed and dominated by small-scale farmers with an average land holding of near one hectare per family [15].

Major parts of northern Ethiopia experience year-round water deficit. Tigray is dry for most of the year except during the rainy season and exhibits arid and semi-arid climate. Recurrent droughts are the major threat to rural livelihoods and food security in the study area. The situation is worsened by the fact that the majority of these farmers is so poor that they have no assets at their disposal [16]. As such, agricultural shocks are an important source of vulnerability for the majority of the populations.

Data Collection: This survey was cover a total of purposefully selected nine districts (*Raya Alamata, Emba Alaje, Enderta, Kilte Awulaelo, Kola Temben, Adwa, Mereb Lekhe, Tahitay Quraro* and *Asgede Tsimbela*) to represent three dominant agro-ecological zones of (*kola, weyinadega*and *dega*) from entire zones. Based on above depicted selection criteria from nine districts, nine kebelles (the smallest administrative unit in Ethiopia) one from each were purposively selected in terms of infestation and the distribution rate of invasive alien plants with the help of respective woreda office of

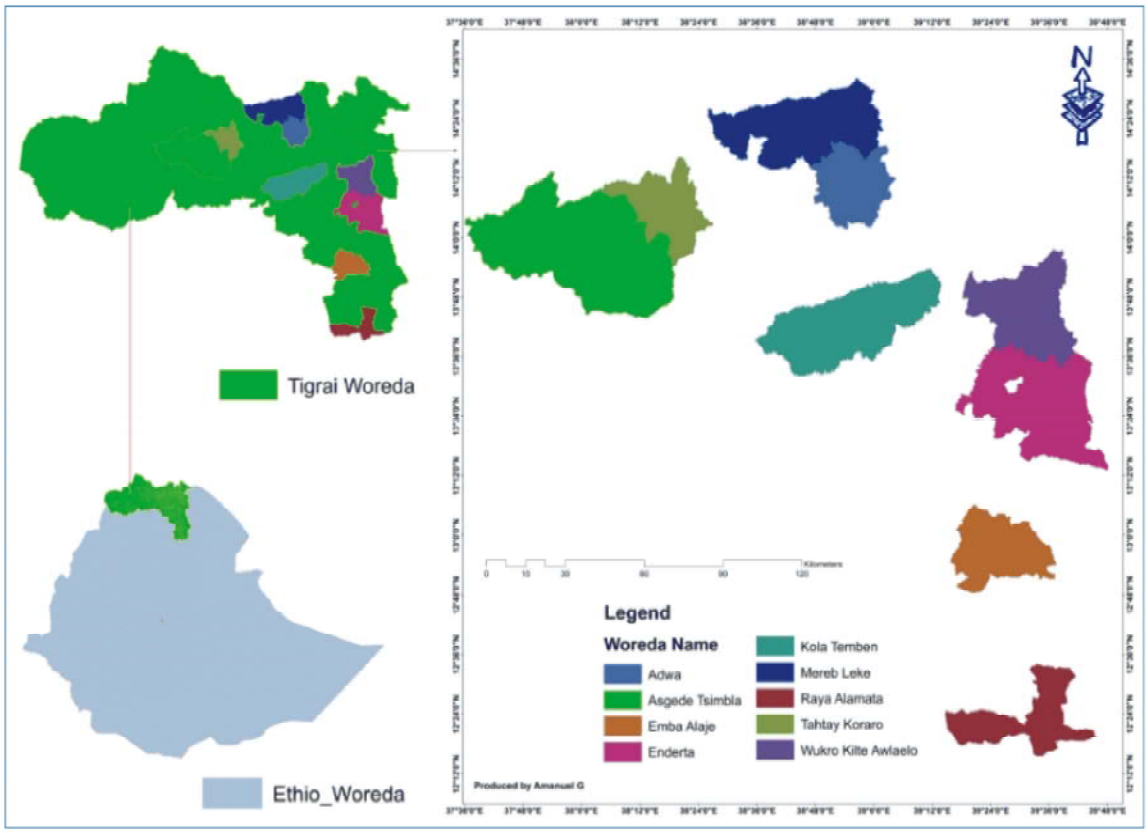

Fig. 1: Map of Study Areas

agriculture and rural development. From each kebelle, 20 households were randomly selected and brought the total number of respondents to 180. The study was mainly on primary data collection using structured and semi-structured questionnaires and field observation. The questionnaires were focused on type of invasive alien plants being grown in the districts, derived socioeconomic and ecological impacts, host range, major constraints and related features of management in study districts. Data obtained from the survey, was used foranalysis ofdescriptive statistics on qualitative and quantitative variables using Microsoft excel 2007 [17].

RESULT AND DISCUSSION

Social Characteristics of Respondents: In this survey 12 invasive alien plant species were identified and recorded and categorized into woody, noon woody/herbaceous and broad leaves. The dominant invasive alien plant species found in Tigray were *newly Plectrantus barbatus, Parthenium hysterophorus, Lantana camara, Prosopis juliflora,* and *Ageratum conyzoides* but the rest (*Striga hermonthica, Orobanche crenata, Orobanche ramosa, Argemone ochroleuca, Nicotiana glauca, Calotropis procera* and *Sennadide mobotrya*) were minorinvaders. The intrusion of invasive plant might be due to century's long overgrazing, degradation, poor management practices, expansion of free trade, poor decision making and lack of quarantine infrastructure in the country in general and in Tigray in particular. Infestation of these species was severe constraints to biodiversity, agricultural activities, livestock and human health.

Respondents were asked about their background of age, sex and educational status and the result was discussed with the perception of respondents in relation to theobservation of invasive alien plant species in their surroundings and likely socioeconomic and ecological impacts. The average age of respondents ranged from 40 to 47 years and minimum age of households was recorded at *AsgedeTsimbela* while the maximum was noted from *Emba Alaje* district (Figure 1). Respondents in this age group were believed to be experienced in recognizing thetype of plants being grown and growing now in respective districts. It has also helpful in detection of any changes happened in the ecosystem derived due to natural and or anthropogenic factors.

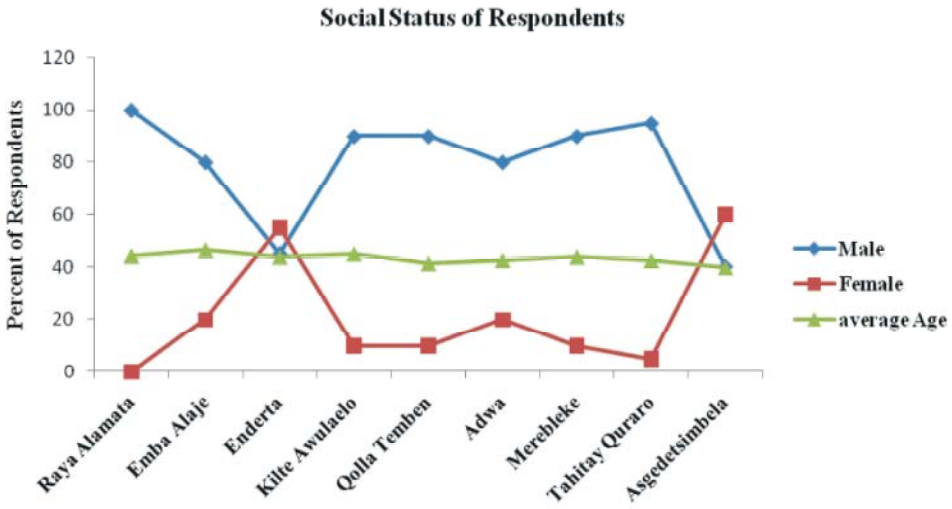

Fig. 1: Social Status of Respondents in the Study Districts
Sources; Own Survey Result, 2016

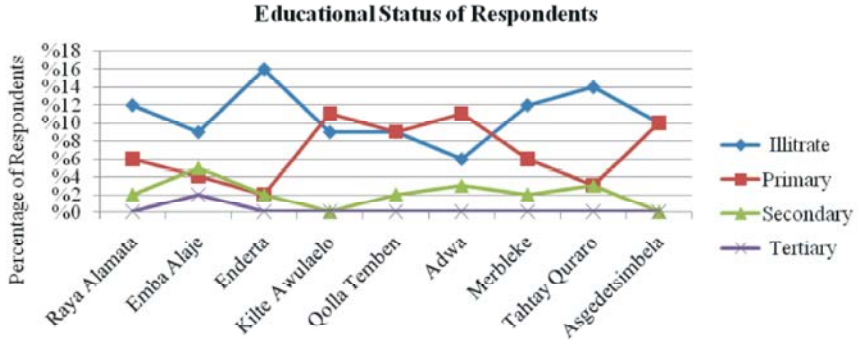

Fig. 2: Educational Status of Respondents by Districts in Study Sites of Tigray Regional State Sources; Own Survey Result, 2016

The entire number of respondents 20 (100%) was males in the Raya Alamata district, whereas 19(95%) of respondent households in *TahitayQuraro* were also males. On the other hand, 18(90%) of respondents in *KilteAwulaelo, QollaTemben* and *MerebLeke* districts were males. The maximum number of female households 11(55%) was recorded in *Enderta* while the minimum 1(5%) of females was obtained at *Tahitay Quraro* district (Fig. 1). On the other hand, the minimum 8(40%) of male households was recorded in *Asgede Tsimbela* district. The survey result indicated that most of the respondents were males with very few numbers of females.

This is because of traditionally males are considered as household heads, landowners and decision makers while females are considered housewives. Amare *et al*. [18] was reported in line with the present result. The prevailed male number of respondents was occurred by accident when households were randomly selected, but females were not systematically ignored for this research. The presence of higher number of male respondents did not affect the quality of information to be collected in regard with ecological and socioeconomic impact of invasive alien plants. In contrary, participating of higher number of males was helpful to have a comprehensive overview with invasive alien plants because traditionally most jobs carried out on the farm are the responsibility of males in Ethiopia. Thus, males were expected to have a complete perception of changes occur outside of the home as compared to female counterparts in Ethiopia.

Educational attainment of respondents was recorded and the classifications were on the bases of those who cannot read and write were grouped into illiterate, formal education up to grade eight into primary, formal education up to grade twelve into secondary and formal education above secondary levels were grouped into tertiary levels.

Of the total 180 respondents, 97 (53.89%) were illiterate, 62 (34.44%) of them had primary level, 19 (10.56) of them had secondary and remained 2 (1.11%) of respondents had attained tertiary level of education (Figure 2). The higher illiterate rates (16%) from total respondents were recorded in *Enderta*district, whereas lowest 6% was recorded in *Adwa* district. On the other hand, maximum numbers of respondents (10%) who had a primary level of education were recorded in *Asgede Tsimbela* district, whereas the lowest (2%) was recorded in *Enderta*. Likewise, maximum number (5% and 2%) of respondents who attains both secondary and tertiary levels of education was recorded at *Emba Alaje* respectively.

The educational background of respondents indicated that most of the households were with no formal and attains primary level of education. The level of education is an indicator of individuals' level of recognition of environmental, ecological and socioeconomic changes occurred within their respective areas. It was also important in determining and analyzing proper interventions in the empowerment of the community to make decisions to address problems and providing management options of invasive alien plants. But, it was believed that respondents have been developed own traditional knowledge to observe and acknowledge any changes occurred in their surroundings. Thus, educational status might not be an absolute limit to get perception about socioeconomic and ecological circumstance of invasive alien plants found in different land use systems of the districts.

Nature and Impact of Invasive Alien Plants on Agricultural Production, Ecosystem and Human Health Ecological and Socioeconomic Impact of *Plectrantus barbatus* in the Study: An assessment was conducted in Tigray, Ethiopia to identify the type and number of invasive species found in the region and respondents' perception onsocioeconomic and environmental (ecological) impacts. Respondents were asked to mention the observed adverse effect of invasive alien plants found in the study areas and their perception was summarized in (Figure 3). Respondents in the study areas don't have complete knowledge on how this *P.barbatus* was first introduced into the area except guessing of possible factors such as emergency aid, vehicles, animals and fertilizer. It was noted that, invasive alien plant has a very unpleasant odor and invaded both disturbed and undisturbed areas. Health problem was reported when peoples in infested areas were unknowingly utilized for sweeping after toilet and causing severe temporarily pains to them. Respondents also mentioned that dense growth habit of the plant enables to hold much moisture and serving as a suitable ground for mosquito reproduction. The presence of the plant across the Tigray regional state, from the lowland of *Raya Alamata* (1500masl) to the highlands of *Emba Alaje* (>3000masl) implies its wider adaptability.

Of the total respondents, 20% of them mentioned that *P. barbatus* was found widely spread across the study areas from *Raya Alamata* to *AsgedeTsimbela* districts covering larger areas with a variable rate of infestation, whereas 20% of them also stated that it had the deleterious effect of biodiversity (Figure 3). Likewise, 20% of respondents were mentioned that it had bad incidence with livestock/livelihood, whereas 19% of them were noted that this invasive plant had the most dense growth habit and forms impenetrable thickets. On the other hand, 17% of respondents were mentioned that it was aggressively/fast spreads within a short period of time and covers larger areas, but 4% of respondents did not have any information about the adverse impact of *P. barbatus* (Figure 3).

In *Lantana camara* invaded areas of *Adwa*, the survey team observed that no other herbaceous plants were found coexistent with *L.camara* except *P. barbatus*as depicted below (Picture 1). The most dense growth of *lantana camara* found in *Adwa* was seen over dominated by *P. barbatus*. Hence, growing of newly germinatedseedling of *Lcamara* was found strongly suppressed by *P. barbatus* and was anticipated that *lantana camara* would also be removed by this invasive plant in near possible future. Respondents were asked to indicate a negative effect of *P. barbatus* in the ecosystem in the study areas and their perception was summarized in Figure 4. Of the total respondents, 31% of them were mentioned that newly *P. barbatus* had negatively affected grazing lands, 27% of them said affected agricultural lands, 22% of them were mentioned affects forest areas, 13% of them stated affected other (roadsides and backyards), but 6% of respondents did not have any information on the negative effect of invasive alien plants in the ecosystem (Figure 4). Respondents noted that, *P. barbatus*was worse than *parthenium* in terms of the level of damage it caused to ecosystem and it's unpalatable.

They further mentioned that in *parthenium* invaded areas, at least grasses were grown in under shade and *parthenium* was partially palatable to livestock. However, *P. barbatus* was found to destroy *parthenium* and is not palatable to livestock. It is also an imminent threat to social, economic and environment of Tigray and requires strategies and management options in reducing

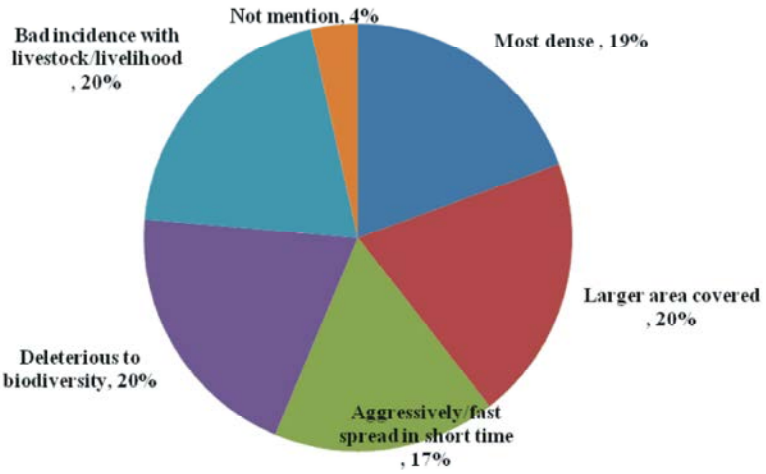

Fig. 3: Respondents Perception of Nature of *Plectrantus barbatus* in the Study Areas
Sources; Own Survey Result, 2016

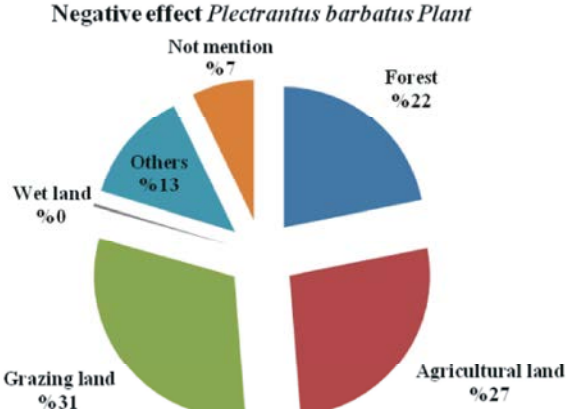

Fig. 4: Respondents Perception on Negative Effect *Plectrantus barbatus* on the Ecosystem
Sources; Own Survey Result, 2016

Picture 1: *Plectrantus barbatus* in Adwa district dominantly covering *Lantana camara*
Photo taken by Abraha Reda (EBI, MBC) on the 22th of December 2016

its possible impacts. Respondents in Raya Alamata were mentioned that their surroundings were once severely invaded with *parthenium,* but now *parthenium* infestation was eventually lost in areas where *P. barbatus* was growing densely. It was observed during the survey that *parthenium* was seen totally replaced by *P. barbatus*. Recently emerged *new invasive alien plant (P. barbatus*) was major biotic constraints to food security and agricultural production systems in Tigray.

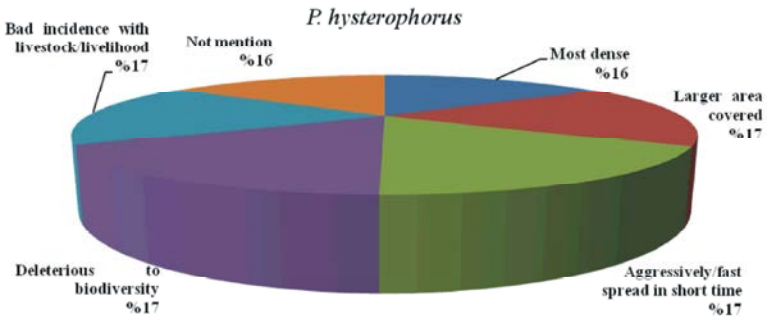

Fig. 5: Respondents Perception on Nature of *P. hysterophorus*in the Study Areas
Sources; Own Survey Result, 2016

It is very challenging to manage in farmers' fields and respondents' noted that this *P. barbatus* was resistant to eradicate due to high seed production and spread rate, adaptation to wider climatic and soil conditions, rapid regeneration capacity once mowed or uprooted and spreads probably with water, wind, animals and farm implements very rapidly than anyone imagines. The other challenge mentioned by respondents was availability of honey bees in invading areas, particularly in *Kilte Awulaelo* district that deters application of chemical control. Generally, the socioeconomic impact derived due to *P. barbatus* was destroyed herbaceous plants which were utilized for honey bees. Unless drastic measures will not put in place to manage and eradicate *P. barbatus*, bee keeping will be history soon. What makes in common for the majority of respondents of this new *invasive alien plant* (*P. barbatus*) were their perception and views in categorization of *Arekibe* into worst ever seen alien plant species in their entire life. Further studies are required to quantify derived socioeconomic impacts on the livelihood of farming households and the biodiversity of the region to inform decision makers to devise proper policies and strategies on its control and eradication.

Ecological and Socioeconomic Impact of *P. hysterophorus* in the Study Areas: Respondents were asked to indicate the adverse impact of *P. hysterophorus* found growing in their surroundings and their perception was summarized in (Figure 5). Among respondents, 17, 17, 17 and 17% of themhave mentioned that *P. hysterophorus* invasion in districts was found covered larger areas, deleterious to biodiversity, aggressively/fast spread ina short period of time and had bad incidence with livestock/livelihood respectively.In accord with this study, Lisanework *et al.* [19] and Talemos *et al*. [20] were reported that *P. hysterophorus* invasionwas significantly declines species diversity and evenness in northeastern Ethiopia. Likewise, Shashie [21] was similarly reported that invasion of *P. hysterophorus* had removed herbaceous plant species, mostly grasses and then results destocking of herds in pastoralist areas of eastern Ethiopia. On the other hand, 16% of them mentioned that *P. hysterophorus*was found most densely grownand forms thickets whereas, 16% of them did not have an idea and perception about adverse impacts of *P. hysterophorus* in their surroundings.

Respondents were also asked about the type of ecosystem negatively affected due to *P. Hysterophorus* invasion in study areas and their response was summarized in (Figure 6). Of the total respondents, 29% of them noted that *P. hysterophorus* was negatively affects agricultural lands, 16% of them was noted forest areas, 14% of them was mentioned grazing lands, whereas 13% of them were noted that negatively affected other sectors such as river banks, roadsides and backyards. On the other hand, 29% of them did not haveidea about the type of ecosystem negatively affects due to presence of *P. hysterophorus* in their surroundings. This indicated that *P. hysterophorus* was invaded every ecosystem with varied levels of infestation and caused removal of native plant species in the area. In accord with present finding, Mulugeta [22] was reported that *P. hysterophorus* infestation imposes extensive constraints on agriculture due to suppression and severe competition. Tamado and Milberg [23] reported that *P. hysterophorus* is an emerging aggressive weed because of prolific seed production and rapidly spread ability and mainly affects grazing lands, agricultural field particularly cereal crops.

It causes undesirable consequences and burden to agricultural production systems, environment and threat to biodiversity as well as main sources of nuisance and health hazards to both humans and animals. In line with this result, Mulugeta [22] reported that *P. hysterophorus* was ailing on human health caused asthma, blindness, skin irritation, diarrhea, cough, tuberculosis andaggravates malaria problem due to serving as host of a vector. Respondents were mentioned that enormous

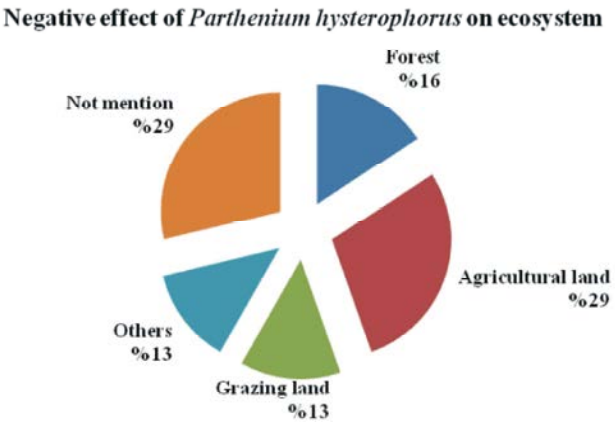

Fig. 6: Respondents Perception on Negative Effect *Parthenium hysterophorus*on the Ecosystem
Sources; Survey Result, 2016

number of livestock has been dying due to direct feeding on molded parts of *P. hysterophorus*. The formation and secretion of toxic chemicals cause animal health hazards in survey districts particularly in *Raya Alamata*. The claim of the respondents on the ailment of *parthenium* on animal health was similar to the finding of Knox *et al*. [24], Tudor *et al*. [25] and More *et al*. [26] who indicated that *parthenium* is toxic to animals and causes severe human ailments [27] and major threat to ecological functions. It is also known for its respiratory effects on animals and humans and allelopathic effects for growth of coexisting species in close proximity [23, 28].

On the other hand due to dense growth habit of *P. hysterophorus*, germination and growth of grasses for grazing were suppressed and adversely affect folder availability in communal areas (Picture 2). Dense growth habit of *P. hysterophorus* holds dew and moisture, which suited for mosquito reproduction and causes to prevail malaria prevalence in study areas. It is difficult to manage in single hand weeding and hardly requires frequency to minimize impacts on the final performance of crops. Hence, increases demand of labor and time for its management in asingle plot of land affects time and labor budget to other plots. It has suppressive effects on important economic crops in addition to competition for growth resources such as water, nutrient, radiation and space. Respondents noted impact of *P. hysterophorus* was magnificent in small grain crops such as tef compared to others and production of such crops was severely harmed.

Ecological and Socioeconomic Impact of *Prosopis juliflora* in the Study Areas: *Prosopis juliflora* is an evergreen shrub/tree throughout the year and one of most awful invasive alien plant of the world in terms its socioeconomic and environmental damage it causes in arid and semiarid regions [29]. It is also considered to bea worst invasive alien plant of agro-pastoral and pastoral areas of eastern Africa in general and Kenya and Ethiopia in particular[30]. *Prosopis juliflora* was found rapidly spread and covered larger areas in Ethiopia because of contradictions in views, perceptions, lack of clear policies and strategies both at governmental, nongovernmental and community level in the development of management options were major limitations [31]. It thrives best a range of environmental conditions mainly from 200-1500 masl and with receiving an annual rainfall of 50-1500 mm [32]. The plant didn't require favorable conditions for growth and performs best in any types of soils including saline, alkaline, sandy and rocky lands [32].

Respondents were asked toindicate the adverse effect of *P. juliflora* and their perception was summarized in (Figure 7). Of the total respondents, 28% of them were not mentioned (had no idea) about adverse effect *P. juliflora* in the study districts.Whereas, 15, 15, 15, 15% of respondents noted that *P. juliflora* had larger area coverage, aggressively/fast spreads in a short period of time, deleterious to biodiversity and had bad incidence with livestock/livelihood respectively in their respective districts. On the other hand, 11% of respondents mentioned that *P. juliflora* had most dense growth habit and suppresses growth of other vegetation and narrowing footpath access to the homes.

In accord with current result, Shetie [5] and Berhanu *et al*. [33] were reported that thicket and impenetrable growth habits of *p. juliflora* prevents movement of human, livestock, access of grasses to livestock and inhibits growth of grasses due to shading and smother effects. Similarly Essa *et al*. [34] also reported that invasion of *P. juliflora* was severely destroyed other

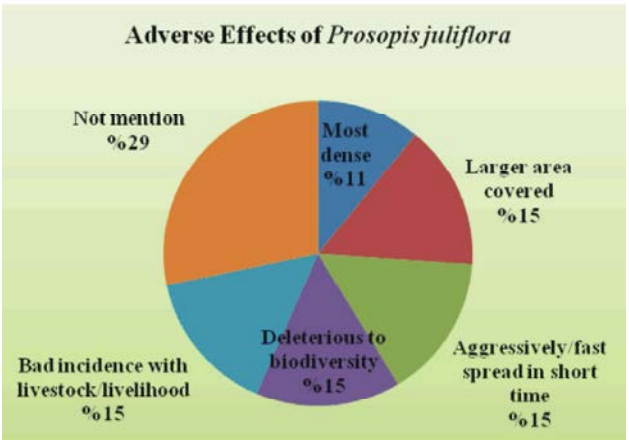

Fig. 7: Respondents Perception on Nature of *Prosopis juliflora* in the Study Areas
Sources; Survey Result, 2016

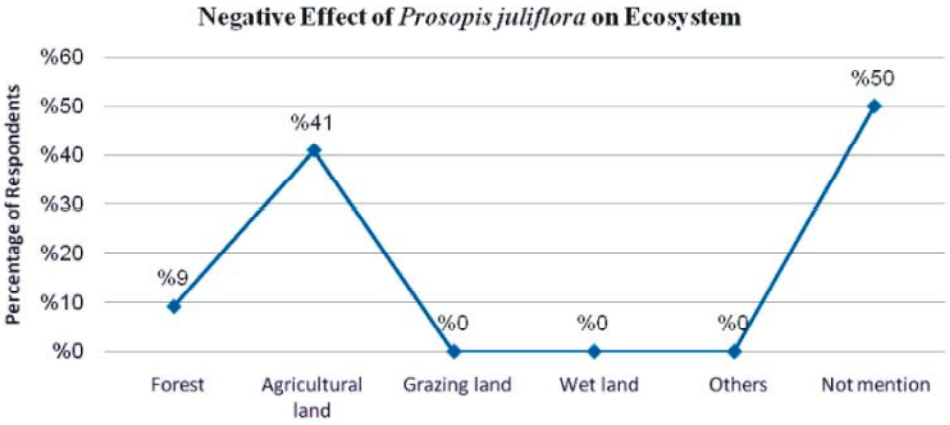

Fig. 8: Respondents Perception on Negative Effect of *Prosopis juliflora* on the Ecosystem
Sources; Survey Result, 2016

vegetation because of competition for resources, place and overcrowding. Niguse and Amare [35] also indicated that high invasion area of *p. juliflora* completely removes grasses compared to less infested areas and blocks road access to villages.

Households were asked to indicate their perception regarding the type of ecosystem negatively affected by *p. Juliflora* infestation in study areas and their response was summarized in (Figure 8). From total respondents in this survey, 50% of them were not mentioned (have no idea) on thenegative effects of *p. juliflora* invasion in each specific ecosystem found in the respective districts. On the other hand, 40% of respondent were perceived that *P. juliflora* was negatively affected agricultural ecosystems and impairs final productivity. Similarly, 9% of respondents mentioned that *P. juliflora* was negatively affected forest areas and declines diversity.

In line with this result, Shetie [5] mentioned that infestation of *P. juliflora* drastically decline size of grazing and crop lands and finally decreases both quantity and quality of production. Anderson [36] reported that the invasion of invasive alien plant species in the introduced areas usually caused environmental, economic and social damage and with other associated problems of decline in crop productivity, reduced pastureland, change water flow, injuries and poisonings in humans and animals, loss of biodiversity and the formation of impenetrable thickets. The research conducted in Afar by Herrie [37] indicated that the pointed thorn of *P. juliflora* inflicted to legs, hands and eyes with causing of additional infections like amputation and blindness and creating favorable conditions for mosquito reproduction and increases incidence of malaria in the Afar.

Respondents also reported that *P. juliflora* kills, injuries and poisons farm animals. According to respondents major symptoms seen when animals feed hard seeds of *p. juliflora* were inflammation, disfigure of livestock jaws, twisting of necks, wounds in skins, hooves and impairs movement for searching of water and grasses for grazing. The research reported by Selamnesh [38] and Abiyot and Getachew [39] was in accord with the current perception. On the other hand, Dubale [40] was also reported that exclusive subsequent feeding of livestock on Prosopis pods for an elongated period of time caused health problems to animals such as constipation, dental disfiguration and overall reduction of productivity. Likewise, Nick *et al*. [41] indicated that excessive feeding of *P. juliflora* pod to livestock causes illness and death and must not be used as sole dietary sources, but used to be as part of a balance diet. Communities in the study area were utilized *P. juliflora* as fuel wood, life and died fence, shade and construction. The view of respondents in eradication of Prosopis was strongly left aside and likely prefers to live together with fully exploiting the current potential. The research conducted by Niguse and Amare [35] indicated that economic benefit of *p.juliflora* adversely affects to provide management options to prevent further domination in west Shewa and west Arsi zones of Ethiopia.

Ecological and Socioeconomic Impact of *Ageratum conyzoides* in the Study Ares: The intrusion of invasive alien species into new geographical areas is second biggest threat to biodiversity loss and brought undesirable most important costs to the economic wellbeing of infested regions. Kohli *et al*. [42] reported that 50-60% of lost to native plant diversity and density was observed following infestation by *A. conyzoides* in northern part of India. *A. conyzoides*is an indigenous plant in Central America and Caribbean's and now found widely spread throughout the world [43]. Households were asked to indicate the adverse impact of *A. conyzoides* in their study areas and their perception was summarized in (Figure 9). Of the total respondents, 20% of them mentioned that *A. conyzoides* have larger area coverage, 20% them indicated that it has most dense growth habit, 20% of them noted that found aggressively/fast spread in a short period of time, 20% of them said that it was deleterious to biodiversity, whereas 20% of them mentioned that infestation by *A. conyzoides* was a bad incidence to livestock/livelihood in respective districts.

Respondents were asked to understand the type of ecosystem negatively affectedmost due to invasion of *A. conyzoides* in the study areas and their perception was summarized in (Figure 10). Out of total respondents, 31% of them mentioned that agricultural lands were negatively affected, 31% them said grazing lands, 25% of them indicated the others (roadsides, backyards and river banks), whereas 12% of them mentioned that forest areas were negatively affected due to invasion of *A. conyzoides* in the study areas. On the other hand, 1% of respondents did not have any information (did not have an idea) about the negative impact of *A. conyzoides* in their respective districts.

In accord with present perception, Kuldip *et al*. [44] reported that *A. conyzoides* adversely affects diversity and composition of native species in infested areas of India and further indicated that non-woody herbaceous plant was most severely impaired. Similarly, Ripu and Ram [45] identified and noted that most favorable area for *A. conyzoides* invasion was roadsides, agricultural lands, fallow lands, disturbed grasslands and marginal forest areas. It increases the cost of production for its availability of larger seed banks in soil and germination of seeds is non-stop throughout growing season and requires more frequent weeding. According Ripu and Ram [45], *A. conyzoides* completes its physiological process within less than two months (germination to fruiting) and adversely affected the ecosystem by production of the numerous numbers of propagules that can easily disperse by animals, clothes and farm equipments. It was further noted that its high competitive ability affects existing biodiversity and is poisonous.

Literatures indicate that infestation of *A. conyzoides*. affects soil chemistry, composition and ecosystem function and creates novel conditions for native species either directly or indirectly [46]. It modifies the growing environment through secretion of root exudates that impairs the soil structure and mobilizing capacity of nutrients. In contrary, with present result, Kuldip *et al*. [44] conducting a research to compare the effect of *A. conyzoides* infestation on soil fertility and the result was indicated that 37.48% increment in calcium, 31.54% in magnesium, 32.67% ofchloride content, 31.2% of ion activity, 56.85% in available nitrogen, 47.51% in available phosphorus, 37.91% in available potassium, 25.29% sodium and 49% increment in organic matter and carbon content relative to uninfected areas. Similarly, Nardi *et al*. [47] was also reported that *A. conyzoides* infestation was altered physicochemical property of soils and improves fertility status of the soil compared to uninfected areas.

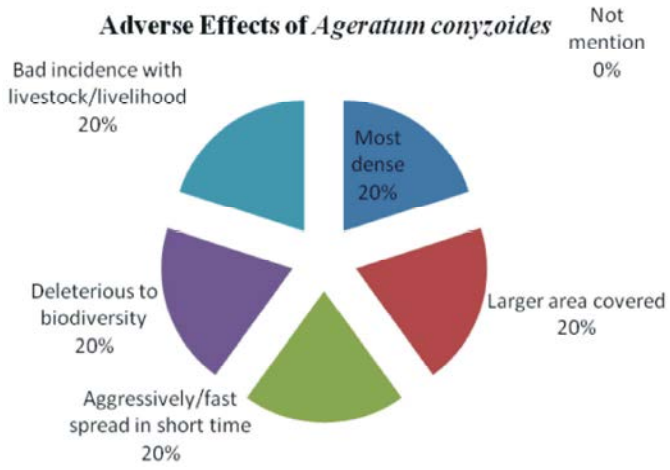

Fig. 9: Respondents Perception on Nature of *Ageratum conyzoides* in the Study Areas
Sources; Survey Result, 2016

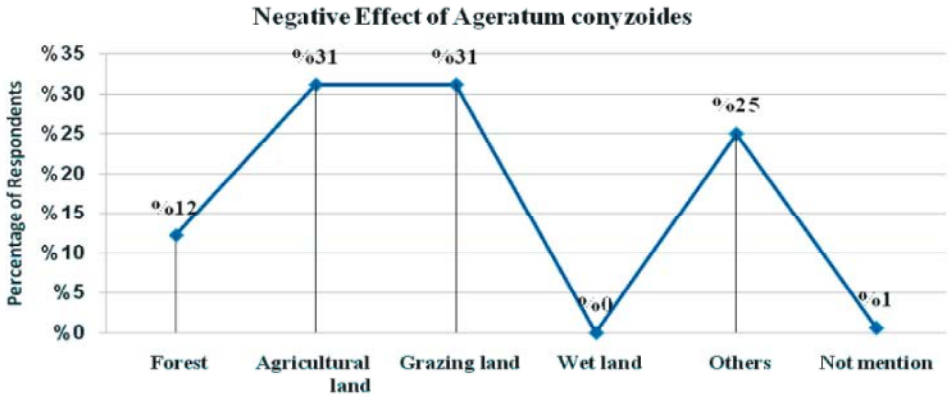

Fig. 10: Respondents Perception on Negative Effect of *Ageratum conyzoides* on the Ecosystem
Sources; Survey Result, 2016

Ecological and Socioeconomic Impact of *Lantana camara* in the Study Areas: *L. camara* was found widely spread across the globe as an ornamental plant and adapted well to extreme of tropical and subtropical conditions [48]. It was intentionally introduced into Ethiopia for serving as an ornamental plant and found affecting forest areas, national parks, roadsides, communal areas. It is considered most important invasive alien plant in Ethiopia because of the formation of impenetrable thickets, invasiveness, spread potential and likelihood of high environmental impact. Respondents were asked to indicate the adverse impact of *L. camara* and their perception were summarized in (Figure 11). Out of the total respondents, 19% of them noted that *L. camara* was found covered larger areas, 19% of them mentioned that aggressive/fast spread in short period time, 19% of them noted that deleterious to biodiversity, 19% of them noted that bad incidence to livestock/livelihood, Whereas 19% of them was mentioned that it has most dense growth habit and forms impenetrable thickets. On the other hand, 5% of respondents did not have any information about the adverse effect of *L camara* on socioeconomic and ecology of their surroundings.

Respondents indicated that presence of *L. camara* in their surroundings impacts their livelihood by affecting and threatening biodiversity, grasses for grazing, narrowing footpaths and served as a safe haven for snakes and rodents. Taye and Ashenafi [49] and Lonare *et al*. [48] were also reported in line with current respondents' perception in Tigray. Comparable with present perception, Bharath *et al*. [50] was reported that *L. camara* invasion was altered structure and composition of native species.

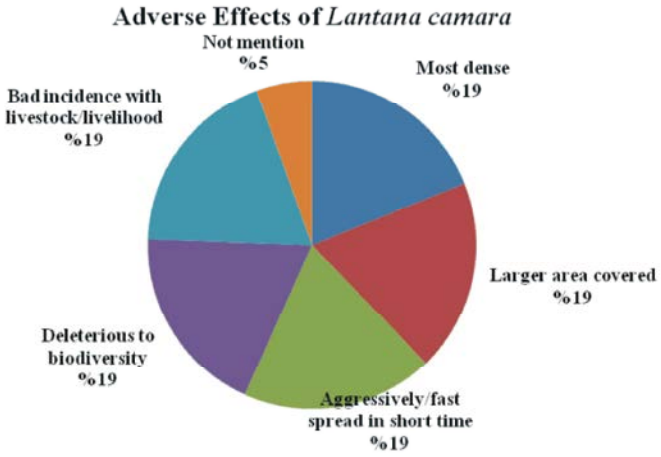

Fig. 11: Respondents Perception on Nature of *lantana camara* in the Study Areas
Sources; Own Survey Result, 2016

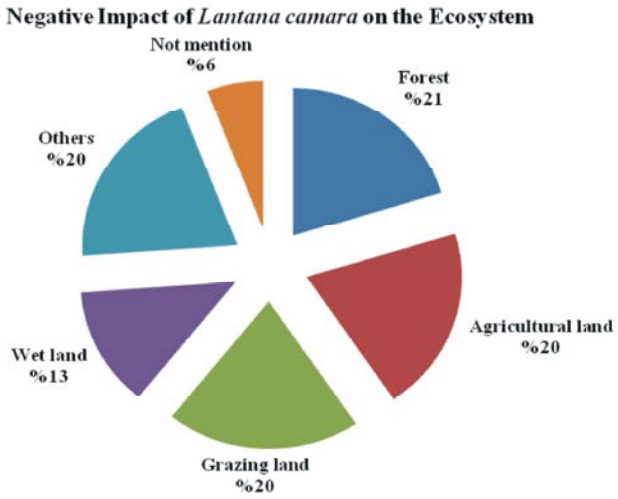

Fig. 12: Respondents Perception on Negative Effect of *Lantana camara* on the Ecosystem
Sources; Own Survey Result, 2016

L. camara was found invaded all ecosystems and 20% of respondents noted that agricultural lands were more infected and negatively impaired its productivity (Figure 12). Comparable with this perception, Lonare *et al*. [48] reported that *L. camara* was toxic to crops and significantly reduced viable yields. On the other hand, 20% them indicated grazing land, 20% of them noted that forest areas, whereas 20% of them noted that other ecosystems (roadsides, backyards) were negatively affected. Likewise, 13% of respondents perceived that wetlands were most negatively affected ecosystems due to infestation of *L. camara* in their areas. However, 6% of respondents did not have any information about the type of ecosystem, mostly a ffected due to invasion of *L. camara* in the study areas. In accord with current observation, Taye and Ashenafi [49] reported that *L. camara*was negatively affected every ecosystem with varied degrees.

Despite of respondents view of benefits, there are also respondents were noted that handful numbers of goats have been dying due to direct feeding of *L. camara* seed and perceived that *L. camara* was an imminent threat of goat production in Adwa. In accord with this perception, Lonare *et al*. [48] indicated that animals were ill ones after ingesting as a result of toxicity. On the other hand, Kumar and Maneemegalai [51] noted that *L. camara* leave and flowers were enriched with toxic chemicals, Lantadene A and B and harmful to browsers like sheep and goats.

But for further assertion of view of the respondents on the toxic nature of the seed, it requires chemical analysis to determine whether it has toxic nature or not and to have a comprehensive view on its nutritional values. The conceivable constraint in Tigray might be its utilization as fence in irrigation sites and homestead could deceive attention of communities to campaign against it. Thereby, raising awareness of communities in respective with potential socioeconomic and environmental impacts of *L. camara* is mandatory in Tigray in general and in central and northwestern zone in particular.

CONCLUSION

Deliberately or accidentally introduced invasive alien plants threatened nearly all biodiversity resources and most adversely affects indigenous plants, crops, animals. The major invasive alien plants found were *P. hysterophorus, P. julifora, A. conyzoides, L. camara, S. hermonthica, O. crenata, O. ramosa, A. ochroleuca*, *N. glauca*, *C. procera, Plectrantus barbatus* and *S. didemobotrya P. barbatus, P. juliflora, Parthenium* and *L. camara* have a dense growth habit and prevent movement of human, livestock, access of grasses to livestock and inhibit growth of grasses due to shading and smother effects.

An organized plan of action is required in respective districts to enlighten hazardous effects of invasive alien species. Adoption of an integrated weed management program is mandatory in place of depending on any single management option. There is an urgent need for researchers to identify, characterized, quantify the socioeconomic impacts and devised proper strategies for cost effective and time efficient management of invasive alien species. Thereby, raising awareness to the general public and government agents on likely impacts of invasion of invasive species on the socioeconomic conditions of farming households and biodiversity is urgently required.

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