

## Full Length Research Paper

# Socio-economic and environmental impacts of invasive plant species in selected districts of Bale Zone, Southeast Ethiopia

Mohammed Mussa<sup>1\*</sup>, Habtamu Teka<sup>1</sup> and Ahimed Aliye<sup>2</sup>

<sup>1</sup>Department of Animal and Range Science, Madda Walabu University, Bale-Robe, Ethiopia.

<sup>2</sup>Department of Rural Development and Agricultural Extension, Madda Walabu University, Bale-Robe, Ethiopia.

Received 10 January, 2018; Accepted 7 March, 2018

Understanding the socioeconomic and environmental impacts of invasive plant species from the affected communities' perspectives is essential to design and plan sustainable control and prevention strategies. Hence, understanding the socio-economic and environmental impacts in the infested and susceptible areas such as Bale zone is very crucial. Therefore, the objective of this study was to assess socio-economic impacts of in lowlands of Bale zone, Southeastern Ethiopia. House hold survey, focus group discussion and key informant interview to understand socio-economic and environmental impacts invasive plant species were used. Statistical package for social sciences (SPSS) (v. 20) was used for data collection. The results showed that a total of 12 invasive plant species were recorded, and of which *Parthenium hysterophorus*, *Xanthium strumarium*, *Argemone ochroleuca*, *Ceasalpinia spp*, *Acacia bussie*, *Acacia mellifera*, *Acacia seyal* and *Acacia tortolis* were highly distributed in the study areas. Respondents reported that heavy infestation of invasive plant species were found on the roadsides followed by arable land. The invasive plant species has also certain economic and ecological benefits. The local communities blame the invasive plant species for their negative impacts on biodiversity, degrading ecosystems, livestock and livestock products, crops, animal and human health. The study result showed that the local community utilizes chemical, mechanical and biological methods to reduce and control the impacts even though the percent of households that were trying to control is very low. Community perception showed the invasive plants species infesting grazing lands, crop lands, road sides, frosts and settlement areas. However, much has not been done to alert the local people on the danger of environmental impacts on biodiversity, agriculture and health. The menace of the species is increasing at an alarming rate, thus control methods have to be designed to stop further spreading into Bale Mountain National Parks.

**Key words:** Environmental impacts, invasive alien species, socio-economic impacts, Southeast Ethiopia.

## INTRODUCTION

Globalization has brought social and economic benefits to many people, but it has also presented new challenges of which invasive alien species (IAS) are among the most significant. At no time in history has the rate of biological

invasion (Mack et al., 2000) or the diversity and volume of these invaders been so high and the consequences so great (Reaser et al., 2007).

Ethiopia has a long history in the introduction of alien

plant species, especially those which were found to be productive elsewhere and offered potential economic benefits to the country. In many other countries in the tropics, hundreds of alien plant species have entered Ethiopia intentionally and unintentionally (Abdulahi et al., 2017). In the country, there are many invasive plant species that are posing negative impacts on native biodiversity, agricultural lands, range lands, national parks, water ways, lakes, rivers, power dams, road sides and urban green spaces with great economy and social consequences being reported (Reaser et al., 2007; Abdulahi et al., 2017).

Invasive plant species reduces the effectiveness of development investments by choking irrigation canals, fouling industrial pipelines and threatening hydroelectric schemes thus, contributing to social instability and economic hardship, placing constraints on sustainable development, economic growth, poverty alleviation and food security (Habtamu, 2015; Abdulahi et al., 2017).

Previous works conducted in Southeastern Ethiopia indicated presence of the invasive plants for a long period of time (Takele, 2006; Teshome, 2006). Invasions of invasive plants hinder crop production through claiming agricultural lands and serving as a hiding place for crop pests and wild animals. The livestock feed shortage is also further complicated by the introduction and expansion of unwanted bushes and invasive weeds (Abate et al., 2010). The existing biodiversity and peoples livelihood is a threat because of invasive plant species (Mohammed et al., 2016). Therefore, there is a need to take a concerted look at the likely effects of invasive alien weed species on socio-economics of the community, and devise appropriate measures to mitigate the effects of these invasive plant species (Habtamu, 2015).

Community based knowledge plays a significant role in management and preventions of invasive plant species (Mulugeta, 2006; Herrie, 2014; John et al., 2014). People influence plant distribution and need management of invasions to reduce impacts and enhance benefit thus an understanding of social perspectives is important (Mulugeta, 2006). In recent years, growing bodies of literatures (Oba, 1998; Angassa et al., 2012; Tilahun et al., 2016) have tried to inform policy makers and development practitioners to recognize community's knowledge for sustainable management of their environment. Previous studies (Feye, 2007; Angassa et al., 2012; Tilahun et al., 2016) have also shown that communities' knowledge has a role to play in the advancement of scientific research and attainment of sustainable development goals.

Although knowledge of the communities has provided basis to design and plan sustainable control and

prevention strategies, such knowledge has been overlooked in different areas of southeast Ethiopia. Studying the socioeconomic and environmental impacts of invasive plant species from the affected communities' perspectives is essential to design and plan sustainable control and prevention strategies. It would enable one to identify the communities' perception regarding the plant, determine the negative and positive impacts as perceived by the community and understanding the solutions in the context of the local social, cultural and environmental conditions.

Therefore, the objective of this study was to assess socio-economic and environmental impacts of invasive plant species in lowlands of Bale zone, Southeastern Ethiopia.

## MATERIAL AND METHODS

### Description of the study areas

The study was conducted in the selected districts of Bale zone, Oromia National Resional State, Southeast Ethiopia (Figure 1). The selected districts were Raitu, Dalomana, Ginir and Maddawalabu of Bale zone, Southeast Ethiopia. Rayitu district covers an area of about 6139 km<sup>2</sup> of land. Its climate varies from hot to warm sub-moist plains (Sm1-1) sub-agro ecological zone. The rainfall pattern is bimodal (March - June and September - October) with mean annual rainfall about 450 mm. The production system in the district is pastoral. Dallomana district covers about 9,543 km<sup>2</sup>. The rainfall pattern is bimodal (March - June and September - October) with mean annual rainfall about 600 mm and mean annual temperature ranges between 26-42°C. Madawalabu district covers about 9,543 km<sup>2</sup>. The rainfall pattern is bimodal (March - June and September - October) with mean annual rainfall about 600 mm and mean annual temperature ranges between 26-42°C. Ginir district is located 07°08'357" north and 040°43'178" East. Also boulder is in the Eastern part of Bale zone. The rainfall pattern is bimodal (March - April and September - October) with mean annual average rainfall is 700mm whereas the minimum and maximum rainfall is 200 and 1200mm respectively.

### Study design

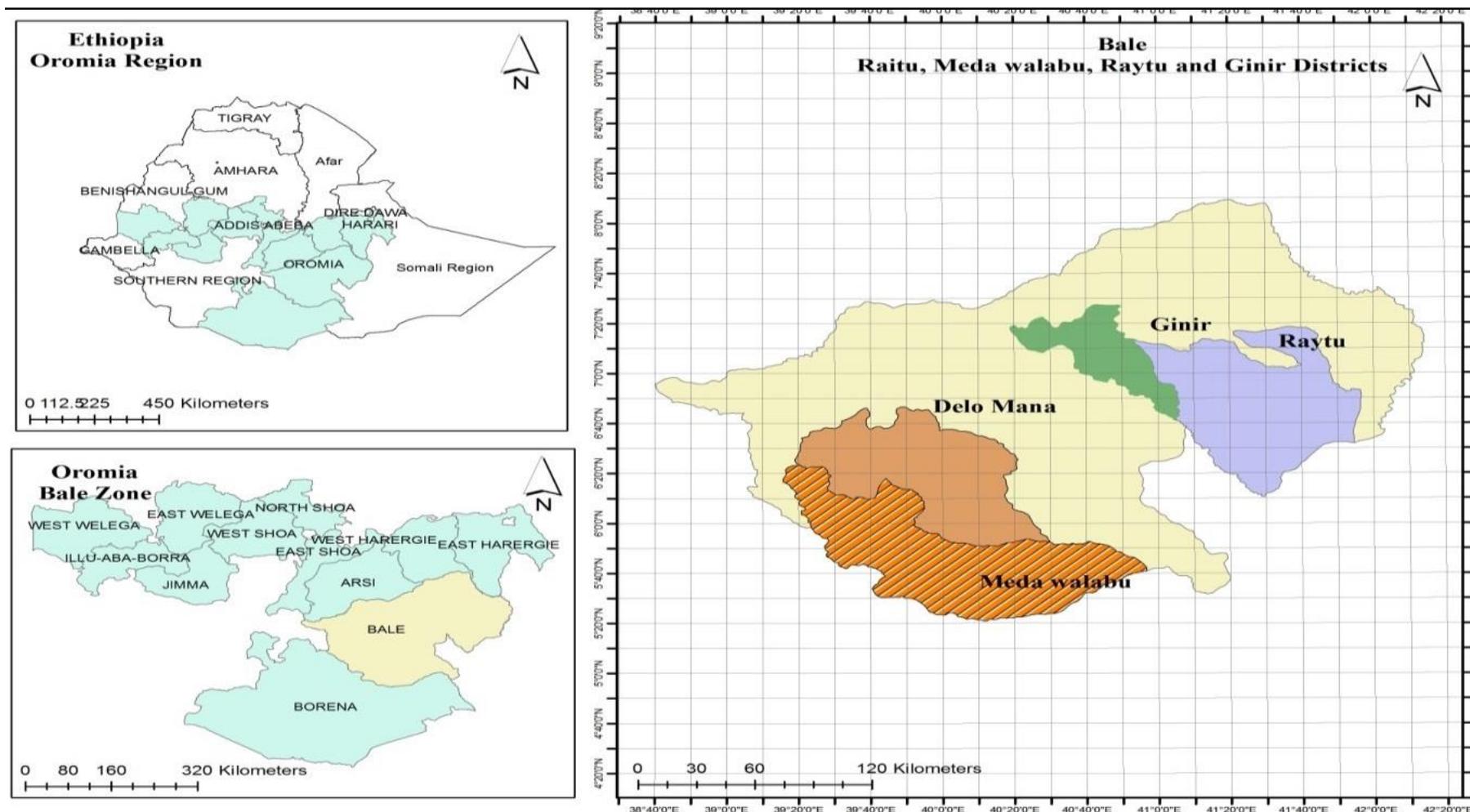
Four selected districts of Bale zone, namely Raitu, Dalomana, Ginir and Maddawalabu, of Bale zone, Southeast Ethiopia, where infestation is high using purposive random sampling technique. For this study, cross-sectional type of study was employed.

### Sampling technique and sample size determination

The study was conducted in selected kebeles of Raitu, Dalomana, Ginir and Maddawalabu districts of Bale zone, Southeast Ethiopia. In order to achieve the objective of the study, five (5) of 19 Kebeles of Rayitu, five (5) of 20 Kebeles of Madda wallabu, five (5) of 20 Kebeles of Ginir and 7 (seven) of 28 Kebeles of Dallomana district

\*Corresponding author. E-mail: mussamahammed@gmail.com

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**Figure 1.** Map of study areas in selected districts of Bale zone, southeast Ethiopia.

were selected purposefully based on their importance to livestock as a major grazing areas due to problems of invasive plant species and representativeness of rangelands. The sample size of households was determined by using the formula recommended by Arsham

(2007) for survey studies. Finally, a total of 286 households were selected by using proportional to population size technique from each study of kebeles. The number of households selected per Kebele was fixed based on the proportion of households in each kebele.

**Data collection methods**

The primary data were collected through household survey, key informant interview, and field observations. Household survey is one method of gathering primary data

from horse mouth. By this particular method, 286 households were considered and interviewed as research subject from December 2016 to May 20, 2017.

A semi-structured questionnaire that includes both close and open-ended were designed and employed to generate quantitative data from respondents. The questionnaire was prepared in English language and translated to local language (Afaan Oromo). Three local enumerators who can understand both English and Afan Oromo languages were hired and trained on how to administer questionnaire.

Pretesting of questionnaire was conducted to see about inclusiveness, its validity, relevance and comprehensiveness. Based on the pre-testing feedback, final questionnaire was prepared and administered accordingly (Mussa et al., 2017).

During key informant interviews, key informants having long standing knowledge regarding invasive plant species were purposefully selected with the help of development agent and Kebele administrators. These informants are mainly elders, clan leaders of local communities, administrators and development workers (Tsegaye et al., 2010). Key informant interviews were conducted with these knowledgeable community representatives. For the key informants' interview, a total of 4 individuals were included in the study from each selected kebele.

The other method employed to collect firsthand information from the respondents were focus group discussion. It is one of the most important research methods to get varieties of information from different segments of the community for qualitative data which was conducted to get general information about the impacts of invasive plant species on pastoralist livelihood. In this particular research, focus group discussion with key informants containing 12 individuals were conducted in each Kebeles selected from each districts. A check-list prepared for and key informants interview, and an open kind of discussion were held. The information obtained from focus group discussions were analyzed and checked with those obtained by other methods for triangulation.

Field observation method was used during the whole period of field work activities by informally discussing with the people; observed by different activities carried out by the community to control the impacts of invasive plant species. During observation, field note was taken and issues were raised during focus group discussions and key informants interview to get insight about the issue under investigation. The secondary data sources that were used in this research were both hard copies and online materials such as published articles, unpublished documents, proceedings and project reports available at kebele, district, and zonal, regional, national and international levels.

### Data analysis

The socio-economic data were coded, entered and analyzed using Statistical Package for Social Sciences (SPSS v.20). For data that does not require analysis, simple descriptive statistics were employed. Descriptive statistics such as mean, percentage and standard deviation were used to present the results.

## RESULTS AND DISCUSSIONS

### Demographic characteristics

Two hundred and eighty six households were successfully interviewed about their knowledge of the invasive plant species in south east Ethiopia. Of the total 286 respondents involved in this study, 252 (88%) were male households and 34 (12%) were female households.

Among the households interviewed, 51 households were from Rayitu, 72 from Delomana, 72 from Ginir and 85 from Maddawalabu. The result of household survey showed an average family size of  $9.43 \pm 1.38$  ( $\pm$  SD) (Table 2). This result is comparable with that reported for Rayitu district (9.45) by Mussa et al. (2017) but less than that reported for the Borana pastoralists (13) (Alemayehu, 1998).

In contrast to that of Borana pastoralists, the average family size in the study areas was higher than the ones reported for Afar (7.87) (Mohammed and Abule, 2015), of Borana (7.32) (Elias et al., 2015) and for South Omo zone (6.83) (Worku and Lisanework, 2016). The high family size might be associated with the cultural practice of polygamy for most of the pastoralists of the study area (Tables 1 and 2).

The age range was 31 to 89 years (mean  $48 \pm 9.44$ ) (Table 1). The level of education attained by the respondents was low, about 72.7% of the respondents had never been to formal school, only a few (26%) had attained primary education and even fewer (1.3%) had attained a secondary education (Table 4). Out of the interviewed households, 8% were uneducated and 64% of households had not attained formal education which indicated a low level of education which might be the case in many pastoral areas of Ethiopia (Admasu, 2006; Abule et al., 2007). This might suggest that such phenomena encountered in the study areas might impede technology transfer, intervention to be made and the need for introduction of pastoralists based education. During group discussions, pastoralists in the study areas indicated that due to shortage of trained staff, low motivation of teachers, mobility and cultural taboo towards sending girls to school the level of education is very low; this situation is in line with the report of Beruk (2003). Pastoralists do not allow their children especially girls to attend school mainly due to their cultural conviction; that if they send their children to school, they will be overwhelmed by their own livestock.

Table 4 presents the main occupation of the local community in Raitu, Ginir, Delomana and Maddawalabu districts of Bale zone, Southeast Ethiopia. The result of this study indicated that, about 80% of the households were agro-pastoralist (mixed farming system), 12% were pastoralist, while about 5.6% were pure agriculturalist and the rest 2.1% were involved in petty trade (Table 4). This is well documented in the earlier reports of Mussa et al. (2017) for these study areas. The majority of the people are engaged in both animal production and crop cultivations. The result of this survey revealed that livestock were used mainly for both traction and income generation from the sale of live animals.

Human population pressure, decrease in livestock feed, commercialization and settlement were the main reasons for increasing dependency on crop cultivation and decreasing dependence on animal rearing. According to the reaction of the respondents, the government was

**Table 1.** Sex, educational backgrounds and main occupation of sample respondents.

Variable		Number	Percentage (%)
Sex	Male	252	88
	Female	34	12
Main occupation	Pastoralism	34	12
	Agro-pastoralism	229	80
	Pure agriculturalist	17	5.9
	Petty trade	6	2.1
Education	Illiterate	23	8
	Elementary	74	26
	High school	4	1
	Diploma and above	0	0.0
	Some mosque education	185	65

**Table 2.** House hold size and age of sample respondents.

Variable		Mean $\pm$ SD
House hold size		
	Male	10.22 $\pm$ 1.39
Sex	Female	8.24 $\pm$ 1.29
	Total	9.43 $\pm$ 2.38
Age of the respondents		48 $\pm$ 9.44

inducing people from other Woredas to come and settle on the vast rangeland to expand commercial crop farming, especially sesame.

### Introduction and dispersal mechanisms of invasive plant species

Invasions of invasive plant species are perceived to be widespread and increasing in many different environments in the study areas. All respondents (100%) mentioned that invasive plant species was present on their grazing lands, road sides, settlements and croplands. The majority of the local community indicated that invasive plant species had been in the area for long period of time. The result of this study is in line with the reports from highlands and lowlands of Ethiopia (Lemma et al., 2015; Tola and Tessema, 2015; Belayneh et al., 2016).

According Table 3, most of the respondents (26.5%) reported that, the plant is dispersed by wind, 20% by flood, 29% by animals, while 13.3% by vehicle and 11.2% by others (donkey). In line with the study, local community in Borana and Guji zone agreed that animals are major dispersal agents of invasive plant species (Lemma et al., 2015). Moreover, invasion of invasive

plant species is aggravated by the aid of different dispersal agents, such as donkey, harvesting vehicles and road construction (Abiyot and Getachew, 2010). *Parthenium* is widely used as a shade during the transportation of *Opuntia* (Shooka) from Sawena (*Parthenium* infested) district to Ginir. Invasive plant species is also distributed with sands used for road construction and vehicle during harvesting. Some of the respondents also said that the increased importance of browsers such as camels and goats in the pastoral production system also resulted in the expansion of unwanted *Acacia* species. They also said that because the camels are highly browsers on *Acacia* species, their seeds are not digested but released through faeces and then regenerate again in masses.

Hence, *Acacia* species were believed to be widely distributed to districts of the study area with the introduction of camels in to the area which was totally absent in previous time. This result supports the report of Lemma et al. (2015).

### Impacts of invasive plant species

According to the informants, invasive plant species has several harmful effects on the inhabitants of the study area (Table 4). Around 45.1% of the respondents replied that, the plant is threatening the local plants (biodiversity) whereas 23.4% of the informants perceived that the plant destroys the ecosystem. The rest of the respondents (17.8%), mentioned the plant has problematic thorns that cause problems to both humans and animals, about 5.7% respondents replied that the plants decreasing the productivity of crops, and other 8% agreed that the species negatively affects the animal products. Invasive plant species is one of the major threat to Ethiopian rangeland ecosystems and it diminish the biodiversity (Mussa et al., 2016). Furthermore, the study reported by



**Figure 2.** Invasive plant species invaded different environments in selected districts of Bale zone, southeast Ethiopia.

**Table 3.** Dispersal mechanisms of invasive plant species in the locality.

Dispersal mechanism	No. of respondents	Percentage (%)
Animals	83	29
Vehicle	38	13.3
Wind	76	26.5
Flood	57	20
Others	32	11.2

**Table 4.** Harmful effects of invasive plant species in the locality.

Harmful aspects	No. of respondents	Percentage (%)
Threatening local plants (Biodiversity)	129	45.1
Degrade ecosystem	67	23.4
Decrease crop productivity	51	17.8
Problematic thorn (towards human and animal)	16	5.7
Decreasing the quality of animal products	23	8

Lemma et al. (2015) and Belayneh et al. (2016) has also reported similar harmful impacts of invasive plant species on pastoralists and agro-pastoralists. The thorns of the plant are inflicting wounds on legs, hands and eyes causing blindness, lameness and even amputation of legs and hands due to infection of wounds. In the study areas, the local community expressed their views about the effect of parthenium on quality of animal products. They reported that the milk had bitter taste. This result

confirms the reports of Lemma et al. (2015) and Archer (1997a). However, the pastoralists and agro-pastoralists said that the cattle feed on parthenium only during shortage of pasture (Figure 2).

#### **Benefits of invasive plant species**

As mentioned by most of the respondents in the Table 5,

**Table 5.** Economic and ecological use values of invasive plant species.

Economic benefits	Respondents		Ecological benefits	Respondents	
	N	Percentage (%)		N	Percentage (%)
Source of fodder and nectar	95	33	Combat desertification	73	26
Hedge (live and dead)	51	18	Decrease soil erosion	121	49
Fire wood	40	14	Reduce wind speed	41	14
Medicinal value	29	10	Shelter for wild life	13	5
Food	18	6	Shade tree	38	13
Construction	31	11	-	-	-
Charcoal	22	8	-	-	-

**Table 6.** Perceptions of local community on invasive plant species.

Perceptions on invasive plant species	No. of respondents	Percentage (%)
Disadvantage	246	86.2
Advantage	40	13.8
Should be completely removed (agreed)	265	92.7
Should proper management adopted (disagreed)	21	7.3
Attempted to remove or control (yes)	72	25
Attempted to remove or control (No)	214	75

invasive plant species has certain economic and ecological benefits. The results of this study showed that, invasive plant species is used as a source of fodder and nectar (33%), hedges (18%), fire wood (14%), medicine (10%), as food (6%), construction (11%) and used for charcoal (11%). The result of this study also showed that, invasive plant species has ecological functions such as combat of desertification (26%), soil erosion control (49%), reduce of wind speed (14%), shelter for wildlife (5%) and shade tree (13%) (Table 5). Invasive plant species such as acacia species are widely used by pastorals as a fodder for browser, nectar for bees, charcoal, medicine against different disease, fuel wood and construction material (Shackleton et al., 2017).

#### Perception of local community on invasive plant species

Table 6 presents the perceptions of local community on invasive plant species. The result of this study showed that most of respondents (86.2%) blame invasive plant species for the socio-economic problem facing them, and most of the respondents (93%) need complete removal of invasive plant species. The rest of the respondents (13.8%) mentioned the plant has important socio-economic importance as discussed earlier, and around 7% of respondents want proper management of invasive plant species. The local community specifically the pastorals in dry land of the study areas used woody plant

species for charcoal, medicine, fuel wood, and fodder for browsing animals (Table 5). Despite the fact that residents recognized the negative impacts caused by invasive plant species, only 25% of respondents mentioned that they had attempted to remove or control the spread of invasive plant species from their cropping lands. This shows the lack of awareness of the local communities regarding the invasive plant species. Table 7 presents control methods of invasive plant species in the in Raitu, Delomana, Madda Walabu and Ginir districts of Bale zone. Most of the respondents (56%) agreed that, chemical control is a controlling mechanism for invasive plant species. On the other hand, 43% of the informants perceived that, mechanical methods such as burning is the best mechanism to eradicate invasive plant species. Whereas 2% of the informants reported that, biological methods should also be used to minimize invasive plant species (Table 7). Consistent with this study, pastoralists and agro-pastoralists and farmers in Borana and Afar uses the aforementioned controlling mechanisms (Shetie, 2008; Lemma et al., 2015). Similar studies has also reported burning (Archer, 1995) and having population of large browsers in invaded areas (Archer, 1995) which can be used to reduce bush encroachment. The local communities use chemicals (herbicide) and mechanical methods such as weeding and cutting in combination with burning to control the weed from their croplands. The use of chemical to control weed from rangelands is uncommon, and they use the mechanical ones to control the invasive plant species

**Table 7.** Controlling mechanisms of invasive plant species in the locality.

Controlling mechanism	No. of respondents	Percentage (%)
Chemical method	160	56
Mechanical	120	43
Biological	6	2

from their lands.

## CONCLUSIONS

The spread of invasive plant species is now recognized as one of the greatest threat to the ecological and wellbeing of the planet. Pastoralists and agro-pastoralists and farmers in the study areas are affected by invasive plant species differently in different habitats. From composite data, a total of twelve invasive plant species were recorded.

Heavy infestation of invasive alien plant species was recorded on the roadsides followed by arable land. On the other hand, natural forest is the least infested habitat in the study area. Generally, disturbed habitats are more infested by invasive alien plant species than natural habitats. Acacia species have taken over vast grazing, crop land areas, blocks movement routes and access to available pasture and water points. They are seen to be very difficult to control and almost impossible to remove as they are easily spread and re-invade a cleared land unless a strict measure was taken.

Invasive plant species are dispersed by wind, flood, animals, vehicle and other types of transporting mechanism. Invasive plant species has also certain economic and ecological benefits. It is used as a source of food and fodder, nectar, hedges, fire wood, medicine, construction and charcoal. Combating desertification, soil erosion control, reduce of wind speed, shelter for wildlife and shade tree for human and animal are the ecological benefits of the species. The local communities blame the invasive plant species for their negative impacts on biodiversity, degrading ecosystems, livestock and livestock products, crops, animal and human health. The local community utilizes chemical, mechanical and biological methods to reduce and control the impacts of invasive plant species even though the percent of households that were trying to control is very low.

Hence, it was concluded that much has not been done to enlighten the local people on the danger of invasive plant species causing impacts on biodiversity, agriculture and health. Based on the results obtained, the following recommendations were drawn: Findings of this study can be used as part of the baseline information in managing the threat of invasive plant species; impacts of invasive plant species on human beings should be investigated in the study area; very little is known about

the impacts of invasive plant species on the biodiversity in the study area and this should be given urgent attention to create awareness and research should be conducted in the area of invasive plant species in order to develop appropriate management systems.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGMENTS

We are grateful to the Madda Walabu University for funding the research. We also acknowledge the kind Bale pastoralists for devoting their time and willingness to share their accumulated knowledge and experiences.

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