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Research Article

Status and Impact of Newly Invading Alien Plant Species in Metekel Zone, Benishangul Gumuz Regional State Northwest of Ethiopia

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Abstract

Over the last decade non-native plants have been observed expanding their ranges in Ethiopia and a number of new non-native plants have been discovered. There is concern that with climate change invasive plants could cause ecological and economic damage like that seen in other parts of the world. In order to develop a strategy for combating invasive plants, a baseline inventory of Invasive Alien Plant Species (IAPS) in the study was required. Of all woredas five Woredas in Metekel Zone was selected based on pre-informed level of IAPS infestation, the assessment identified both infestation status and impact of IAPS. Four IAPS namely *Parthenium hysterophorus, Lantana camara, Senna obtusifolia* and *Hyptis suaveolens* that threatens native habitats along roadsides, rangelands, rivers and free areas in towns of BGRS. All respondents (100%) agreed about the invasiveness of these four species. Majority of the respondents (96.6%) agreed that the level of its invasion has been increasing from time to time. Majority of the respondents (61.7%) reported that *Hyptis suaveolens* and *Senna obtusifolia* has been causing different damage to the community such as minimize the growth of other plants, expand and compete to agricultural, grazing land and communal land, toxicity and health of livestock and also human. The patterns of distribution of these IAPS show that invasion is most pronounced in areas that have received recent road way construction and maintenance of all woredas in metekel zone. Furthermore, populations around bridges and culverts pose a risk to river ecosystems. We also recorded the presence and abundance of IAPS at rest stops, campgrounds, gravel pits and other disturbed areas along major roadsides of Metekel zone. As observed during the assessment frequently cultivated areas, highly grazed lands, frequently maintained roadways, market areas and roads which receive the most vehicle traffic had showed the highest infestation by invasive alien plants species.

INTRODUCTION

Background of the study

Invasive plants are defined in this report as plants that are not native and have negative effects on our biodiversity, environment, health and economy by expanding their ranges and substituting native ones. Around the globe "there is an increasing realization of the ecological costs of biological invasion in terms of irreversible loss of native biodiversity". Invasive plants can displace native plants, destroy wildlife habitat and modify ecosystems. They facilitate introduction of insect pests, invasive animals and diseases. Furthermore, invasive plants can affect our health and economy. They reduce agricultural production.

Invasive Alien Plant Species (IAPS) are of a great concern in Ethiopia, posing particular problems on biodiversity of the country, agricultural lands, range lands, national parks, water ways, lakes, rivers, power dams, roadsides and urban green spaces with great economic and ecological consequences [1]. Foremost among these are parthenium weed (*Parthenium hysterophorus*), prosopis (*Prosopis juliflora),* water hyacinth (*Eichhornia crassipes*), cactus (*Euphorbia stricta*), lantana weed (*Lantana camara), Acacia saligna, Ageratum conyzoides Argemone ochroleuca, Ccaesalpiniadecapetala, Cirsium vulgare, Cryptostegia grandiflora, Eichhornia crassipes, Mimosa pigra, Mimosa diplotricha , Nicotiana glauca ,Opuntiaficusindica, Opuntia stricta, Piistia stratiotes, Opuntia stricta, Senna occidentalis, Xanthium spinosum* and *Xathium strumarium*. They have been identified by the Environmental Policy and the National Biodiversity Strategy and Action Plan as a major threat to biodiversity of the country and economic wellbeing of its people [2]. However, little attempt has been made in terms of research and management of IAPS in the country as the whole and in BGRS in particular. Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia. Manual control of *Parthenium hysterophorus* and *Hyptis suaveolens* by farmers resulted in some of them developing skin allergies, itching, fever, & asthma and somehow attracting tsetse fly. Prosopis prohibits free movement of people and animals and its thorns damage eyes and hooves of animals. The social cost of parthenium in Ethiopia was measured by Disability Adjusted Life Years and its equivalence in terms of monetary value was estimated at 2,535,887 - 4,365,057 USD [3].

More resources have to be invested to tackle the IAPS problem as the estimated loss is disproportionate to the cost of investment on IAPS research and development activities. This assessment attempted to document the available information on IAPS, i.e, distribution, abundance and spread, impacts, control measures and suggest the future prospects on research and management [2].

Invasive species have been receiving more attention north of 09º17` - 12º06` latitude and East of 34º10` - 37º4` longitude in recent years. Ethiopia has experienced an exponential increase in invasive plants in the last 40 years Carlson and Shephard and has a sizable budget earmarked for research and management. In Benishangul Gumuz Regional State (BGRS) we are observing the spread of IAPS with their significant effects on native ecosystems. The Invasive Alien Species Strategy for Ethiopia ENBSAP stresses that prevention is the key: the best way to avoid the high costs of control is to develop an Early Detection and Rapid Response strategy (EDRR). Early detection and rapid response (EDRR) are practices that enable land managers to identify new and spreading invasive species quickly, and to enact control quickly, before the species population grows to the point where it cannot be locally eradicated [4].

Up until recently it was believed that introduced plants that have major impacts in other parts of the country the region have little or no impact on the northwest regions' landscapes particularly Benishangul Gumuz Regional State (BGRS) simply because of less degree of disturbance experienced by the natural environment so far. However, since climate change and the increasing human population with its unlimited need is now improving some of these conditions in the way that favors the invasion speedy and worst. Therefore, it is important to study all invading non-native species and particularly IAPS to manage their long-term impacts in the territory/region [2].

Based on personal observations made in the region over the last decade, it appears that nonnative plants that have existed in small populations for long years have started expanding their ranges now a day. Furthermore, it has been reported that newly discovered plant species that are considered invasive in other areas of the country have been surviving the impacts of climate change and anthropogenic disturbances and becoming established. It is believed that with a warmer and wetter climate in the region, more invasive plants will establish, over-winter and spread across our landscape [5].

In order to develop a strategy for combating invasive alien plant species, we required a baseline inventory. Since roadways are thought be the most important vector for dispersing invasive plants in any parts of the world we surveyed disturbed areas, road sides, grazing areas, market areas, urban and rural villages. Prior to this survey, no inventories specific to invasive plant species had been conducted in BGRS.

MATERIALS AND METHODS

Description of the study area

Metekel is one of the three zones in Benishangul Gumuz Region. It is bordered on the south and southwest by Kamashi zone, on the west by Sudan, and on the north and east by the Amhara Region. The Abay River defines the Zone's boundaries with Kamashi, while the Dinder River defines part of its boundary with the Amhara Region. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA 2007), this Zone has a total population of 276,367, of whom 139,119 are men and 137,248 women. 37,615 or 13.61% of population are urban inhabitants. A total of 58,515 households were counted in this Zone, which results in an average of 4.72 persons to a household, and 56,734 housing units. The five largest ethnic groups reported in the Metekel Zone were the Gumuz (36.78%), the Shinasha (21.6%), the Amhara (17.39%), the Awi (11.33%), a subgroup of the Agew, and the Oromo (11.09%); all other ethnic groups made up 1.81% of

the population. Main languages are the Gumuz (36.31%), Oromo (19.89%), Amharic (18.21%), Shinasha (12.81%) and Awngi (10.91%). The study was conducted in selected woredas of metekel zonesuch asPawe, Mandura, Dibatie and Dangur that administratively belongs to the Metekel Zone of the Benishangul-Gumuz Regional State (Figure 2). The study districts were selected purposively on the basis of the level of invasive alien plant species infestation with the help of information obtained from Agricultural office of the region.

Method of data collection

Survey on the distribution and spread of IAPS: Surveys

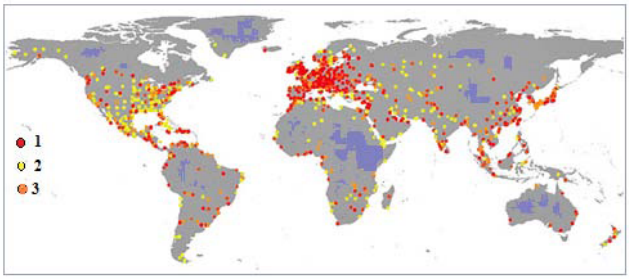

Figure 1 Native range of some invasive alien plant species
1 - Lantana camara; 2- Partinium hysterophorus; 3 - Eichhornia crassipes

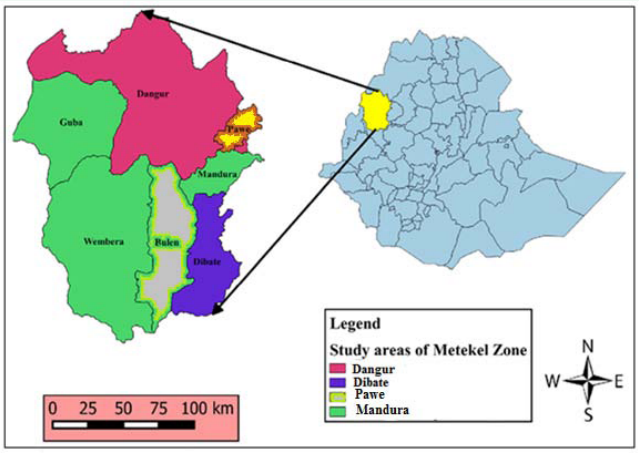

Figure 2 Map of the study area.

of invasive alien plant species were conducted in Metekel Zone of Benishangul Gumuz Region, Ethiopia from September to December 2010. Visual observation on distribution and spread of IAPS was recorded at different Districts of the Zones at regular intervals of 10Km. Distribution and abundance of the IAPS was recorded based on the level of infestation at different infested habitats (natural/semi-natural, and disturbed/manmade habitats). Due to immensity of the study area it is difficult to count each species. Thus abundance of each species was determined by using abundance scale (Table 1) after the modification of the methods used by Martin and Foxcroft and estimation scale [6].

Assessment of socio-economic impacts of invasive alien plant species: To congregate information about socio-economic impacts towards the IAPS in the study area, data were collected through semi-structured questionnaires. The questionnaires were provided to farmers who were live for about 40 year and above, woreda biodiversity experts in the different levels of Agriculture Offices who were involved in addressing the impact of IAPS. A total of 80 key respondents among households, woreda biodiversity experts were selected using purposive sampling technique.

Method of data analysis: The collected data was analyzed by using SPSS (statistical package for social sciences). A descriptive statistical method was employed to analyze and summarize the data and to calculate percentages, frequency and mean.

RESULTS AND DISCUSSION

A total of 3800 hectares of land was surveyed during the assessment. Of these hectares surveyed 3610hactars of land was infested with five IAPS (Table 2) of which more than 75% of the area was mainly dominated by *Senna obtusifolia/Senna occidentalia and hyptis suavealens.*

Many species of IAPS were assumed to invade most areas of Metekel Zone. However, only five invasive alien plant species were recorded in all sites surveyed existing as one IAPS replacing the absence of the other IAPS. This discrepancy may reflect the fact that other IAPS may be restricted to agricultural and horticultural areas, not covered by the researchers. Others may be concentrated within communities and have not yet spread beyond them. The number of IAPS per site surveyed ranged from 0-5.

Table 2 summarizes the presence and degree of distribution of invasive alien plant species namely *Senna obtusifolia/Senna occidentalia, Senna didymobtrya*, *Hyptis suaveolens, Parthenium hysterophorus, Lanta acamar, Parthenium hysterophorus and Sida* sp at surveyed sites along five woredas of Metekel zone. The greatest infestation of *Senna obtusifolia, Lantana camara* and *Hyptis suaveolens* of invasive plants were recorded in all surveyed woredas along mostly traveled roadsides, grazing areas and free uncultivated home gardens. Furthermore, these three species not only had the greatest infestation, but in general they also had the highest proportion of sites containing any other particular IAPS identified.

One IAPS that has been spreading rapidly along roadsides, riversides & grazing areas and has captured the attention of many farmers in Mandura and paweworedas is *Hyptis suaveolens*. The plant is perennial, herb, which have violet or White flowers. As

Table 1: A quantitative estimation used to determine the abundance IAPS.

S/N	Abundance	Description	Cover percentage
1	Very abundant	If the area is covered by extensive stands	> 75
2	Abundant	If there are many clumps or stands	50 – 75
3	Frequent	If there are many sightings of single plants or small groups	30 – 50
4	Occasional	If there are a few sightings of one or a few plants	15 – 30
5	Rare	If there are one sighting of one or a few plants	5 – 15
6	Present	Abundance uncertain	1 – 5
7	Absent	If there is no IAPS	0

Table 2: The Distribution of IAPS in Metekel zone.

No	IAPS observed	Common name	Infested area/ site	Degree of infestation	Infested Woreda
1	Senna obtusifolia/Senna occidentalia	Atermesay (Am)	2,3,4,5	Very abundant	Db,Mn,Pw,Dg,Gb& Sk
2	Senna didymobtrya		2,5,6	Frequent	Db,Mn,Pw,Dg,Gb& Sk
3	Hyptis suavealens	Aseded (Am)	2,3,5,6,7,	Abundant	Db,Mn,Pw,Dg,Gb& Sk
4	Lantana camara	Yewofkolo (Am)	2,4,5,6	Frequent	Db,Mn,Pw,Dg,Gb& Sk
5	Parthenium hysterophorus	Qinchearem (Am)	2,5,6	Occasional	Db,Mn,Pw,Dg,Gb
6	Wire weed (Sidasp)	*Amera	1	Occasional	Gb , Dg

Abbreviations: 1 : Cultivated Land; 2 : Road Side; 3 : Grazing Areas; 4 : Non-Cultivated Land; 5 : Rural Villages; 6 : Urban Areas; 7 : Riverside; 8 : Forest Areas; Db : Dibatie; Mn : Manbuk; Pw : Pawe; Dg : Dangur; Gb : Guba; Sk : Sherkole; Am : Amharic; Gm : Gumuzigna; *Unkown Naming

informed by the villagers the plants do have a special smell that can attract insects specially tsetse fly and can cause asthma and skin allergies to human. *Hyptis suaveolens* has become a problem for farmer of the region, as it threatens native ecosystem and poses risk to grazing areas.

Along the road sides, with in urban/rural villages, grazing areas of all the surveyed woredas were intensively invaded by two species namely *Senna obtusifolia* and *Solenostemon* spp (Figure 3). The assessed region/areas would normally contain sparse native vegetation and open plane, suitable for some dwarf grasses important for grazing of livestock in the areas (Figure 4).

River corridors and wetlands in Gubaworeda have also become overgrown with *Solenostemon* sp and significant management efforts should be underway. Because both invasive species can grow over a meter in height, they can obstruct the growth of understory and generally reduce grazing stock and replace endemic species of the area (Figure 3). It can also reduce food source for wildlife and thus increase the risk of migration. The purpose of this portion of the survey was to digitally record and map the distribution of *Senna obtusifolia/Senna occidentalia, Senna didymobtrya*, *Solenostemon* spp, *Parthenium hysterophorus, Lantaacamar, Parthenium hysterophorus* and *Sida* sp. over areas of metekel zone.

Based on surveyors' observations, a number of potential sources for spread of new weed called *Sida* sp*/wire weed/* dispersal on wide investement land in Gubaand Dangurworeda were noted (Figure 5). First, intensive agricaltural work disturb soils, and making perfect habitat for *Sida* sp. Frequent soil disturbance eliminates competition from other plants and prepares the soil for rapidly growing *Sida* sp. Larger infestations of *Sida* sp along the agricultural investment areas appeared to correspond with recent need of technologically improved seeds of sesame it was also expected to present in very small amounts where there is use of such seeds in all over the region.

These all information will prioritize areas upon which all stalk holders engaged in managing the spread of IAPS can focus their management efforts. It will also highlight native ecosystems that are vulnerable or sensitive to invasion, such as road-accessible areas, watersheds with gravel bars and wetlands.

Figure 6 is a map of areas where there is high infestation of *Senna obtusifolia/ Senna occidentalia, Senna didymobtrya, Solenostemon* sp, *Parthenium hysterophorus, Lantaacamar,*

Figure 3 The infestation of Senna obtusifolia (left) and Hyptiis suaveolens (right) on roadsides and grazing areas of Mandura Woreda (Photo by Dereje M).

Figure 4 Grazing area free and/or infested by Senna obtusifolia (Photo by Dereje M).

Figure 5 A farmer complaining about the infestation of Sidasp on sesame tilled field (Photo by Dereje M).

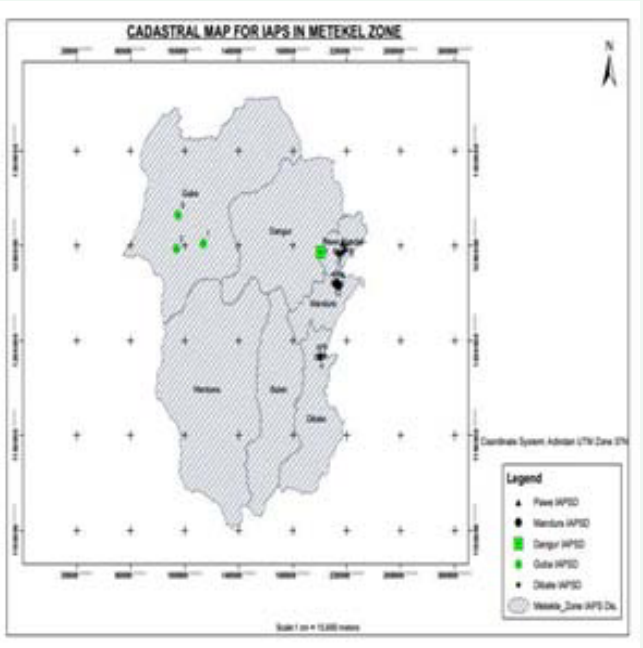

Figure 6 Map showing high infestation areas of four IAPS in Metekel Zone.

Parthenium hysterophorus and Sida sp. on five woredas' of Metekel zone, based on the recorded abundance classes: continuous, sporadic or absent/ rare. Note that for presentation purposes the data were simplified for ease of interpretation. Digital data are accurate to +/- 3 m and are available upon request at Ethiopian Biodiversity Institute Assosa Biodiversity Center. Patches

of continuous IAPS were predominantly recorded along the roadsides, grazing areas and villages near the major communities of: Dibatie, Mandura, Pawe, Dangur, Sherkole and Guba.

The most extensive 'continuous' patches were recorded east and north of these Woredas' (Figure 6). Sporadic/irregular distribution of *Senna didymobtrya*, *Parthenium hysterophorus* and *Lantaacamar* was observed along much of the areas of the market, non caltivated homedarden and as the scale of the infestation/abundance/ of *Senna obtusifolia, Senna didymobtrya, Solenostemon sp. and Lantana camara* were very abundant at sample location Mandura with longitude and latitude coordinates 212278, 1236470 and 212473, 1229887 respectively. They were also recorded to be very abundant at other sample location of the PaweWoreda with longitude and latitude coordinates 216917, 1251195 and 214437, 1246733 respectively and abundant at sample location of Gubaworeda with longitude and latitude coordinates 749165, 1246945 and 749816, 1264480 respectively. The results of the study indicated that the rest sample locations for the remaining IAPS identified of Metekel Zone are absent, present and frequent (Table 2).

Parthenium hysterophorus and Sida sp are recently became a major crop weed in the surveyed areas. Heavy infestation of *Parthenium hysterophorus* was observed in Dibatie and Pawe districts Moreover; *Parthenium hysterophorus* entered urban/ rural villages having an abundant scale of infestation especially in Dibate town and in Berber kebele with longitude and latitude coordinates of 190965 and 1170792 respectively.

The results of the assessment indicated that the invasion of *Lantana camara and Senna didymobtrya* entered free home gardens and free pass ways particularly in the Districts such as Pawe, Gilge Beles town and Bashatakebele (Guba). The scale of the infestation of these IAPS is frequent in all Woredas surveyed. Complains by the people in Dangur Woreda was also observed for frequently invasion of grazing areas by acacia sp which should requires further investigation about the species.

SOCIO-ECONOMIC IMPACTS OF IAPS IN METEKEL ZONES

General characteristics of respondents

A total of 80 respondents, 64 (80%) males and 16 (20%) females, were interviewed from September to November 2018. The age of respondents varied from 19 to 85 years old with mean age of 48.23 ± 14.89 years. Majority of the respondents (88.3%) were married, 8.3% of them were divorced and insignificant number of the respondents were unmarried (3.3%). As to number of years the respondents lived in the study areas, majority of the respondents (95%) lived between 19 and 74years, while the minimum and the maximum years the respondents lived in the study areas were 2 and 75 years respectively with mean 46.9 ± 15.54. Regarding to their education status, 19(31.7%) were uneducated, while 11(18.3%) had informal education, 29(48.3%) had attended either primary or secondary school education or insignificant number of the respondents 1(1.7%) had attended higher education.

Respondents' perception about major invasive alien plant species (IAPS)

Eighty-six percent of respondents in the study area knew the impacts, source of introduction and means of dispersal of the major IAPS. However in high infestation category all respondents became aware. All respondents in high infestation category and 86% from all respondents had awareness about *P. hysterophorus* however 45% of respondents in no infestation category were aware. Forty three percent of respondents in all infestation category and 63%respondents in high infestation category were aware about *S. obtusifolia* (Table 3).

Large number of respondents were aware about major IAPS however rate of infestation increasing from time to time because most probably much effort was not done by different stake holders (Table 4).

Route of introduction and spread of IAPS

Regarding to the main route of introduction of IAPS in the study districts, respondents argued that it was introduced either by animals (16.6%) or it instantly occurred (15%); besides, 16.7% of the respondents claimed that it was introduced either deliberately for medicinal use or with agricultural tools or with dumping soil during road construction. Despite these, (51.7%) of the respondents in the study districts had no information about how IAPS was introduced in their local area. Majority of the respondents reported that IAPS can easily spread within short period of time and resists to drought.

As reported by Mhinana Z [7] the structural characteristics of most IAPS were thickness of the cell wall, the greater density of both the vascular system and stomata, and the increased development of the palisade tissue at the expense of the spongy tissue which is assumed to be associated with arid habitats. It is also believed that the arrangement of these tissues within the leaf is responsible for maximum utilization of light. The other important factor which is assumed to enhance the photosynthetic

Table 3: Respondents statement about the level of IAPS in their locality.

	Frequency	Percent	Cumulative percent
Low	5	1.7	1.7
Medium	18	21.7	23.3
High	50	63.3	86.7
Very high	7	13.3	100
Total	80	100	

Table 4: Respondents statement about the level of IAPS in their locality.

	Frequency	Percent	Cumulative percent
Decreases	7	8.75	1.7
Increases	39	48.75	60
Highly increases	26	32.5	98.3
Remain constant	8	10	100
Total	80	100	

efficiency was the presence of well-developed systems of intercellular spaces which might be involved in facilitating rapid gas exchange [7]. Although few respondents (6.7%) claimed that IAPS were introduced either from Sudan (5%) or from where road construction materials come from (1.7%), majority of them (93.3%) had no information from where IAPS were introduced to their local area.

Concerning to the mechanisms of spread, majority of the respondents (91.7%) informed IAPS easily dispersed by floods, animals, wind and vehicles in view of the fact that they have many and light seeds. The remaining (8.3%) related the mechanism of spread to the presence of long dormancy period of the seeds, its resistances to drought and lack of awareness to control its spread [8]. It was also reported that the partial tolerance to drought and salinity in most IAPS resides in its ability to achieve water conservation through stomatal closure and osmotic adjustment and reduce absorption of excess radiation through the presence of leaf wax. Moreover, the study conducted by Brandes D indicated that *Nicotiana glauca* and *senna obtusifolia* are a quickly growing shrub and herbs which are able to produce about 10,000 to 1000,000 very small seeds. Almost all of the respondents (98.3%) informed that road side, near compounds, backyards, grazing areas and agricultural fields are the main habitats which are mostly invaded by those five IAPS recorded in the study area. Insignificant number of the respondents (1.7%) did not know the areas that were invaded by IAPS [9-15].

Impact of IAPS

Majority of the respondents (61.7%) reported that IAPS have been causing different damage to the community such as poison and weakens livestock and human, minimize the growth of other plants, expand and complete agricultural and communal land. In contrast to this, 35% of the respondents reported that the recorded IAPS had no effect and insignificant number of the respondents (3.3%) did not know the negative impact of IAPS in the study area. The study done by Tabana YM indicated that congenital defects may also be seen with anabasine toxicosis. Cleft palate and multiple congenital contractures, such as torticollis, scoliosis, lordosis, and arthrogryposis, have been observed in cows, goats, cattle, pigs, and sheep after the dams ingested plants containing anabasine. Concerning to the negative impact of IAPS on biodiversity, 43.3 % of the respondents reported that its impact will be mild and 31.7% of them reported as high impact, whereas there maining 16.7% and 8.3% of the respondents reported that its impact will be `moderate and very high respectively (Table 5).

Management practices

Based on the information obtained from the respondents and field observation, IAPS covers most of communal lands, grazing fields and road side of the study areas. Farmers only worried on control them from their own farmlands. As to the technique or practice that the local community used to control the spread of IAPS, majority of the respondents (90%) used mechanical methods such as digging out and cutting at younger stage and burn it to clear from their farm lands. The remaining respondents (10%) had no information about the technique or practice that the local community used to control the spread of IAPS. As to the possible best practice that will be applied by the local people to control the spread of IAPS in the future, half of the respondents (50%) believed that to control the spread of the species in the future, it needs further investigations and awareness creation program by concerned body, 20% of the respondents reported that dig out and burn it is appropriate to control the spread of most IAPS in the future while 30% of them reported that awareness creation program by concerned body is needed to control the spread of all recorded IAPS in the future.

Table 5: The negative impact of IAPS on biodiversity in the future.

	Frequency	Percent	Cumulative percent
Mild	31	43.3	43.3
Moderate	15	16.7	60
High	24	31.7	91.7
Very high	10	8.3	100
Total	80	100	

Regarding to the organization that has been working in the control of IAPS, all of the respondents (100%) informed that there was no organization that has been working in the control of IAPS except some trials by Agricultural office. On the other hand, the organization that will be involved in the control of IAPS, almost all of the respondents (98.3%) believed that in the control process, the societies, the government and non-governmental organization should be better to work together [16-19].

CONCLUSIONS AND RECOMMENDATIONS

Many Invasive Alien Plant Species (IAPS) are introduced intentionally or unintentionally for various purposes. *Senna obtusifolia/Senna occidentalia, Senna didymobtrya*, *Hyptis suaveolens, Parthenium hysterophorus, Lantaacamar, Parthenium hysterophorus* and *Sida* sp are one of Invasive Alien Plant Species that invaded many ecosystems and communities in the study area. Currently, it is invading the main agricultural fields, disturbed land, grazing land, home gardens and road side of all wored as in Benishangul Gumuz Region, Ethiopia. This assessment study indicates the severity of the invasion in these areas. Therefore, the Governmental and Nongovernmental organizations should find a mechanism to eliminate these invasive plants and save the farm and grazing lands before becoming uncontrolled.

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