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Distribution, Abundance and Socio-Economic Impacts of Parthenium (Parthenium hysterophorus) in Southern Zone of Tigray, Ethiopia

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Abstract
Parthenium hysterophorus is *spreading* at alarming rate, threatening agricultural ecosystem, biodiversity, human and animal health in the study area as well as in the country. There is a paucity of information regarding the spread and distribution of *Parthenium* in the Region in specific and the country in general. Hence, objectives of the study were: to determine the distribution and abundance level, to develop distribution and abundance map and to assess the socio-economic impacts of *Parthenium* based on communities perception. The biophysical data was recorded from abundance level observation of *Parthenium* using hand held GPS and analyzed by Arc GIS to make the distribution and abundance maps. The socio-economic survey was conducted through interview using semi-structured questionnaires and data has analyzed using SPSS software. The biophysical survey result showed that *Parthenium* was the major invasive alien plant species in the study area. *Parthenium* was found in all the Districts but abundantly found in Alamata and Raya Azebo Districts. The socio-economic impact assessment result indicated that expected to be introduced unintentionally by different agents, i.e. food aid and through livestock movement from neighboring Regions. Perception of the respondents indicated that *Parthenium* has negative impacts on biodiversity, agricultural ecosystem, human and animal health. Assessment widely in the Region is very important to collect information and status of *Parthenium*. This used to plan research priorities and facilitates sustainability and success of future control programs.
Keywords: *Parthenium hysterophorus*, distribution, abundance and socio-economic impacts.

1. Introduction

In Ethiopia, *Parthenium hysterophorus* (hereinafter referred to as Parthenium) has become noxious weed since its discovery as exotic, invasive weed in the 1980s. It was regarded to be introduced accidentally through aid shipments or from Somalia during Ethio-Somali war. It has been observed to grow on roadsides, gardens, waterways, and in grasslands and crop fields, both during the crop season and after harvest so long as enough moisture is available (Taye, 2002; Tamado and Milberg, 2000; Besufekad *et al*., 2005). Being a major and relatively new weed in Ethiopia, it is still spreading rapidly having substantial impact in arable land, pasture and grazing land of the country (Rezene *et al*., 2005). Similarly, studies conducted in other countries indicated that occurrence of the weed in grasslands reduced forage production up to 90 % besides making land less fertile; affecting grazing land, animal health and milk and meat quality (Parsons and Cuthbertson, 1992; Navie *et al*., 1996; Evans, 1997; Mahadevappa, 1997).

Parthenium hysterophorus also threatened the agricultural ecosystem as well as the biodiversity in Southern Zone of Tigray National Regional Governmental State. Productivity of the crops and livestock in the area was affected because of the impacts of *Parthenium hysterophorus*. There is a lack of information about the distribution, abundance and impacts of *P. hysterophorus* in the study Zone specifically and in the Region in general. Therefore, over view of this study was to fulfill the information gap by developing up to date maps of abundance and distribution of *Parthenium hysterophorus* in the study area. The information also helps the community, subject matter specialists and others who need this information for different purposes such as planning area wide management, biological control, identification research priorities, etc. Hence, this survey investigated the distribution and abundance level, the distribution and abundance map and the socio-economic impacts of *Parthenium hysterophorus* based on community's perception.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study area is located in the southern part of Tigray Regional State. Southern Zone is one of five Zones of Tigray. It is bordered on the south and west by Amhara Regional State, on the northwest by Maekelawi (Central), the north by Misraqawi (Eastern) and on the east by the Afar Regional Governmental State. It extends between 12°46'47"N latitude and 39°32'23"E longitude. The zone is located about 603 kms north direction of Addis Ababa and about 120 kms south of the Tigray Regional State capital, Mekelle.

2.2. Survey of the distribution and abundance of *Parthenium hysterophorus*

Survey of *P. hysterophorus* was conducted during 2009/10 cropping season in Southern Zone of Tigray Regional State at 10 km interval. Field observation was made by the road side and inside the villages preferably which are easily accessible by car (along gravel and asphalt roads).The locations' latitude and longitude coordinates were recorded using a handheld GPS and simultaneously the presence/absence (prevalence) and abundance were observed and noted on data collection sheet. From the collected field data varying abundance categories of *P. hysterophorus* based on the percentage cover estimation with modification developed by (Booth *et al.,*2003) i.e. very abundant, abundant, frequent, occasional, rare, present and absence and habitats type of the areas were recorded. (Table 1) and the Frequency was summarized using formulas developed by (Taye & Yohannes, 1998).

F= 100*X/N

Where, F= frequency; X = number of occurrences of a weed species; N= sample number

Table 1.Abundance and coverage estimation used in *Parthenium hysterophorus* assessment

Abundance Category	Description
Absent	No IAPS is found
Present	Individuals plentiful, but coverage small
Rare	Individuals very numerous at least coverage 5% of the area
Occasional	Plant Covering 6-25% of the area
Frequent	Individuals few or many collectively, covering 26-50% of the area
Abundant	Plant covering 51-75%of the area
Very Abundant	Plant covering 76-100% of the area

Source: Booth *et al.,(*2003)

2.3. Developing abundance and distribution maps of *Parthenium hysterophorus*

Two forms of distribution maps were prepared using appropriate Arc GIS analyses and mapping software. First, the distribution map of *P. hysterophorus* was developed from the data collected at point data level. The field data collected at point data was aggregated to District level and from this data mean abundance map of *P. hysterophorus* was generated at Zone level. Thus, point distribution map showing presence or absence and mean abundance map showing area coverage of *P. hysterophorus* in Zonal level were developed.

2.4. Socio-economic impact assessment of *Parthenium hysterophorus*

Both primary and secondary data were collected which is related to the present study. Group discussion was made with developmental agents and subject matter specialists to collect general information on presence, absence and infestation level of *P. hysterophorus* in the study area. Respondents were interviewed using semi-structured questionnaires. Secondary data was collected from Bureau of Agriculture and Rural Development of the study area. The primary data collected from the sampled respondents focused on invasiveness, abundance and impacts of *P. hysterophorus* in the study area.

2.5. Sample Size and Sampling Procedure

For the socio-economic impacts of *P. hysterophorus*, four Districts (Alamata, Hintalo Wejirat, Endamehoni and Raya Azebo) were purposively selected. A total of 120 respondents were randomly selected and interviewed i.e., 30 respondents from each District. A stratified sampling procedure was employed to select the Kebeles. Each District was categorized into three stratus (i.e., high infestation, medium infestation and low infestation) based on infestation level. Two kebeles were randomly selected from each stratum. Fifteen, ten and five respondents were randomly selected from high infestation, medium infestation and low infestation, respectively. Both men and women were interviewed.

2.6. Data Analytical techniques

The biophysical data was analyzed using ArcGIS version 9.1 software. The socio-economic impacts were coded, entered and analyzed using statistical package for social sciences (SPSS version 12.0).

3. RESULTS AND DISCUSSION

3.1. Distribution and Abundance of *Parthenium hysterophorus*

P. hysterophorus was distributed in the Southern zone of Tigray growing on roadsides, villages, crop lands, wasteland, rangeland and around forest. The biophysical survey showed that *P. hysterophorus*was distributed in Waja, Alamta town, Bala, kukufto, Zata, Weyra wiha, Bedenoleka, Mohoni town, Maichew town, Kisad Gudo, Adishu, Adi gura and Adigudom). Alamata District is the first infested area by *P. hysterophorus* from the region. Starting from Alamata *P. hysterophorus* was distributed to the other Districts of the Zone as well as the region. In the kebeles of Alamata and Raya Azebo Districts heavy and widespread infestation occurs mostly on crop

lands, roadsides, wastelands, towns, villages and gardens. In the highland districts *P. hysterophorus* was observed only in the town along the road and near dwellings. In Hintalo Wejirat and Enderta districts infestation of *Parthenium* was observed on roadsides and towns indicating that its introduction into these areas is very recent. Similar results were found by (Taye Tessema, 2002) in the East and West Shewa. The abundance and distribution map showed that P. hysterophorus was distributed from the lowlands to the highlands (Figure 1). It abundantly occurs in the lowlands of the Zone indicating it can adapt to various agro-ecology and different soil types. Further results (Figure 2) showed that P. hysterophorus is abundantly found in Alamata and Raya Azebo because widely distributed and first infested Districts from the study Zone, it is frequent in Enderta and rarely found in Ofla and Endamehoni and present in Hintalo Wejirat Districts because of its recent introduction to the areas.

3.2. Socio- Economic Impacts of *Parthenium hysterophorus*

3.2.1. Characteristics of sample respondents

Table 2. Demographic Characteristics of sample respondents

Variable		**Southern Tigray**
Mean Age of respondents		45.75
Sex	Male	91
	Female	29
Education	Illiterate	63
	Literate	38
	Informally Literate	19

3.2.2. Community perception on year and way of introduction of *P. hysterophorus*

The findings indicate that all the individuals in all the respondent categories replied that *P. hysterophorus* infested the area and 43% of the sample individuals perceived that *P .hysterophorus* was introduced to their area from 1971-1980 while 40.9% sample individuals perceived that it was introduced to their area from 1980-1990 the rest perceived from 1990. *P .hysterophorus* was first observed in Alamata area known as *Timuga* Kebele because it is the southern border of Tigray Regional State and easily expose for the invasion of *P. hysterophorus*. The result of the formal survey indicated that *P. hysterophorus* was introduced into their area by different ways. It was introduced into their area with food aid coming from Amhara Region (41.7%) and through livestock dung when driven to market (62%) from neighboring regions like Amhara Region (Table 3). About 42.7% of the interviewing individuals perceived that *P. hysterophorus* was introduced from neighboring areas by flood.

Table 3: Means of introduction of *P.hysterophorus* into Southern Zone of Tigray

Means of introduction	Low Infestation N=20		Medium infestation N=40		High infestation N=60		Overall sample N=120	
	n	%	n	%	n	%	n	%
With Food aid	10	10.4	14	14.6	16	16.7	40	41.7
Livestock dung	16	16.7	21	21.9	25	26	62	64.6
Flood	8	8.3	14	14.6	19	19.8	41	42.7

N= Sample number n=Respondents' number

3.2.3. Respondents' perception on the invasiveness and spread status of *P. hysterophorus*

According to the respondents, *P.hysterophorus* was disseminated in the area as well as to other area because of movement of the cattles, by flood, with seeds by the farmers during market exchange and by wind. The cattles feed on the seeds and the seeds are distributed through their dung. From all the infested area 84% of the respondents perceived livestock dung to be the agent by which *P.hysterophorus* seeds are disseminated, 32.1%, 67% and 38.7 of the sample individuals perceived that the seeds are also transported to distant places with seeds by the farmers during market exchange, by flood and wind (Table 4) respectively.

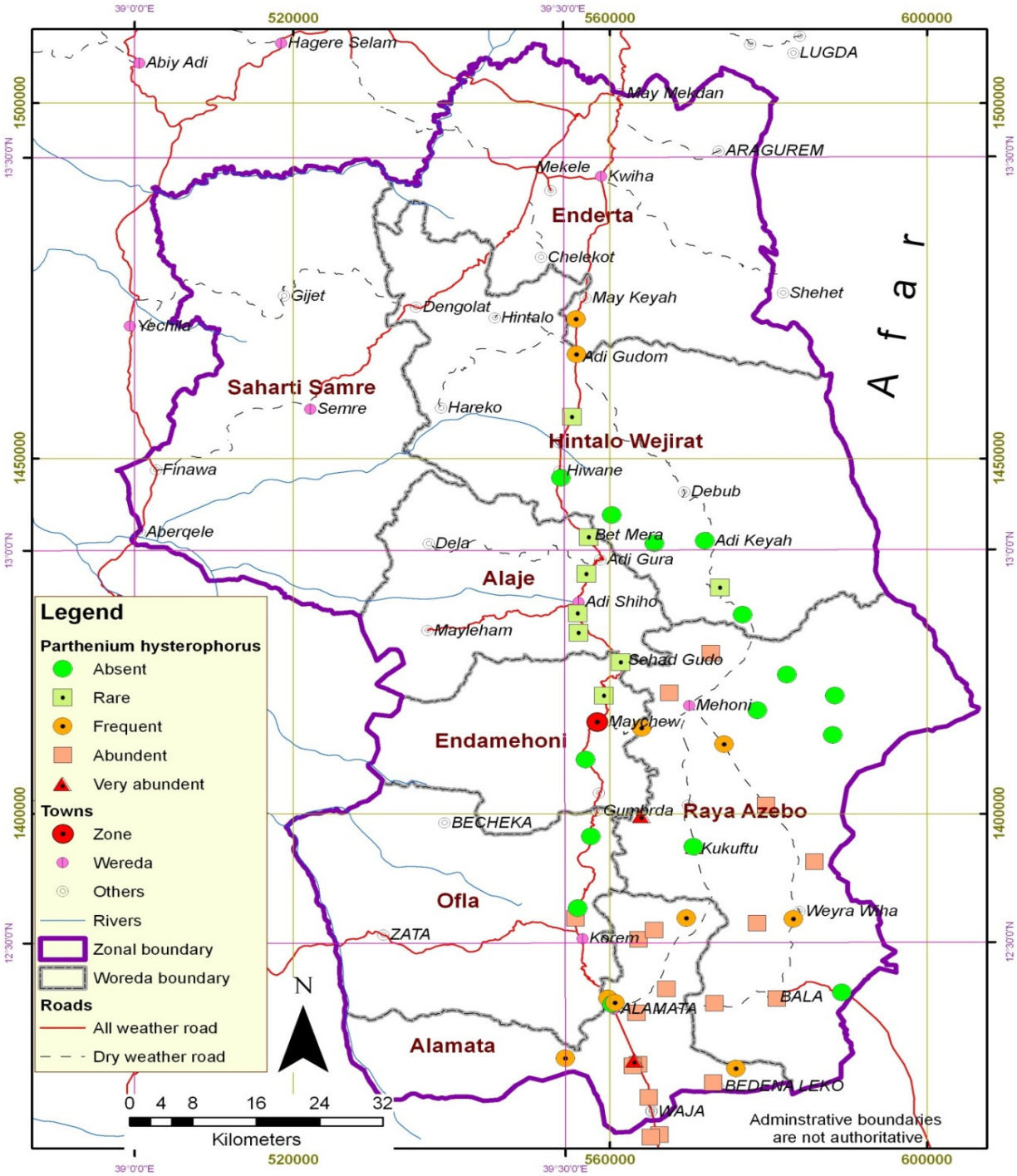

Figure 1. Abundance and distribution of *Parthenium hysterophorus* in the Southern Zone of Tigray, Ethiopia.

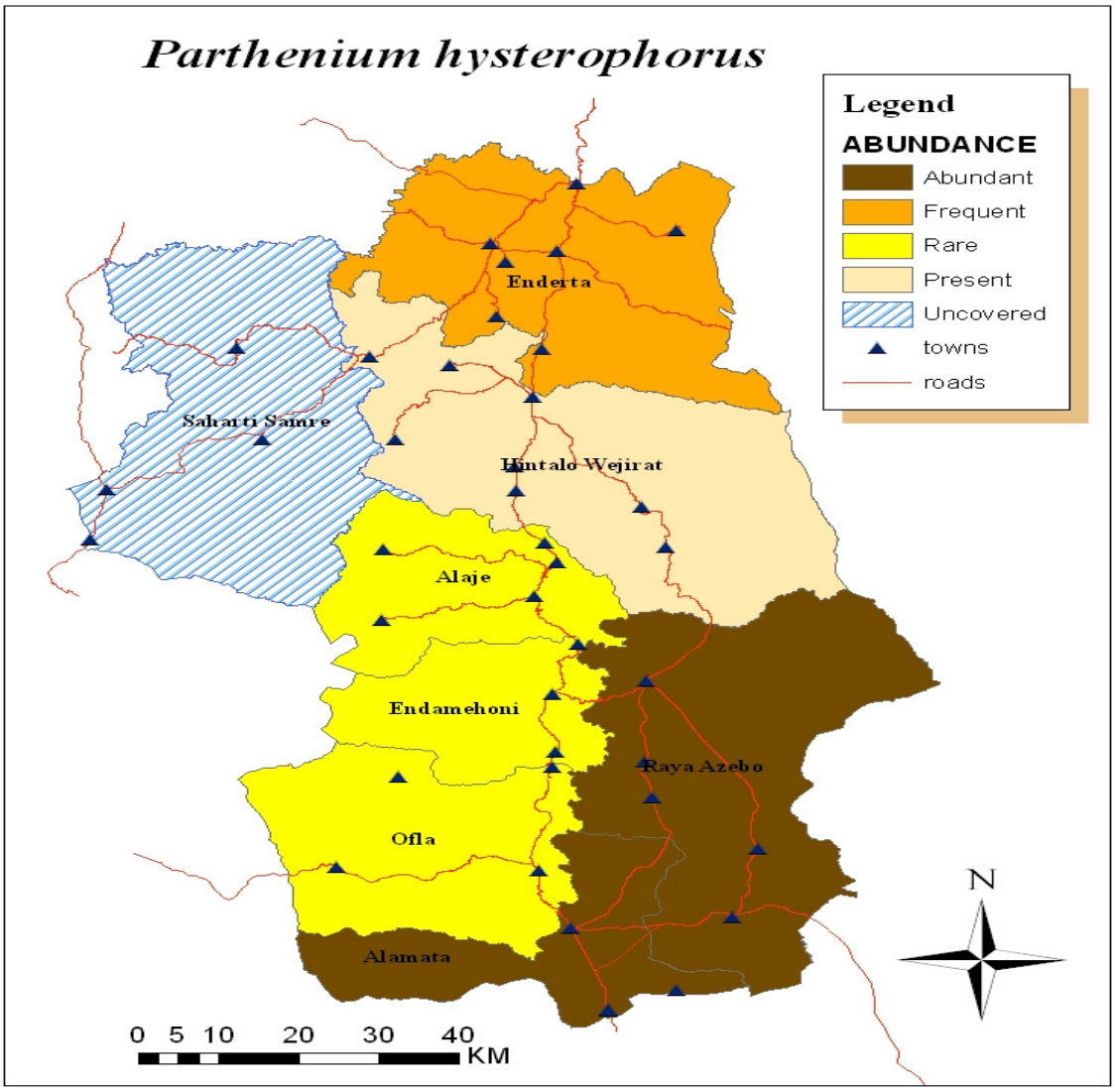

Figure 2. Mean abundance of *Parthenium hysterophorus* in the Southern Zone of Tigray, Ethiopia.

Table 4: Agents facilitating spread of *P. hysterophorus* in Southern Zone of Tigray Region

Means of spread	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall sample N=120	
	n	%	n	%	n	%	n	%
Livestock Dung	20	18.9	29	27.4	40	37.7	89	84
Flood	11	10.4	26	24.5	34	32.1	71	67
Wind	8	7.5	14	13.2	19	17.9	41	38.7
With seeds	9	8.5	14	13.2	11	10.4	34	32.1

N= Sample number n=Respondents' number

The result of the formal survey indicated that individuals perceived that *P.hysterophorus* is a highly invader plant. In this regard from the infestation level categories 94.5% of sample individual perceived that it is a highly invasive weed whereas 5.5% regarded invasiveness of *P.hysterophorus* as medium (Table 5).

Table 5: Respondents perception on invasiveness of *P. hysterophorus* in Southern Zone of Tigray Regional.

Invasiveness	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall Sample N=120	
	n	%	n	%	n	%	n	%
High	23	20.9	36	32.7	45	40.9	104	94.5
Medium	2	1.8	2	1.8	2	1.8	6	5.5
Low	-	-	-	-	-	-	-	-

N= Sample number n=Respondents' number

3.2.4. Perception of Community on impacts of *Parthenium hysterophorus*

On biodiversity

According to the result of the formal survey invasive alien plant species had impacts on the biodiversity of the study areas. About 54.5% of the sample individuals from high infestation, 4.5% from medium infestation and 40.9% from low infestation area replied that grasses species used for livestock feeding have disappeared from the area because of invasive alien plant species especially due to *P. hysterophorus* (Table 6). Similar results were found by (Tamado, 2001) in Ethiopia.

Table 6. Community perception on impacts of *P. hysterophorus* on plant species in Southern Zone of Tigray

Plant species disappeared	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall Sample N=120	
	n	%	n	%	n	%	n	%
Grass species	9	40.9	1	4.5	12	54.5	22	100

N= Sample number n=Respondents' number

On crop production

The study area is known for its high potential of cereal and vegetable production. The effect of invasive alien plant species on farmlands, field borders, and roadsides is revealed in the increased cost of production incurred for clearing the infested lands. The respondents replied that *P. hysterophorus* is threatening the agricultural production (Table 7). About 92.7% of the interviewees perceived that *P. hysterophorus* has a negative impact on crop production. Similar results were found by (Tamado *et al*, 2002) in northern Ethiopia.

Table 7: Effect of *P. hysterophorus* on crop production as perceived by the respondents in Southern Zone of Tigray Region

Effect on crop production	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall Sample N=120	
	n	%	n	%	n	%	n	%
Losses yield	5	4.5	9	8.2	11	10	25	22.7
Decreases yield	24	21.8	31	28.2	37	33.6	92	83.6
Changes taste quality	15	13.6	9	8.2	16	14.5	40	36.4

N= Sample number n=Respondents' number

On livestock production

The findings also indicate that *P. hysterophorus* has an effect on livestock production as perceived by all the respondents in all the infested areas. *P. hysterophorus* affects livestock production in different ways. According to all of the respondents in all the infestation category, *P. hysterophorus* changes tasting quality of milk producing sour taste. Similar results were found by (Taye, 2002). About 20% of the sample individuals from the total respondents replied that *P. hysterophorus* encroaches grazing land. About 5.5%of the individuals in high infestation category, 7.3% in medium infestation category and 5.5% in the low infestation category believed that *P. hysterophorus* threatens animal health (Table 8). Perception of the respondents showed chemical produced by *P. hysterophorus* is dangerous for the livestock health.

Table 8: Effect of *P. hysterophorus* on livestock production as perceived by respondents in Southern Zone of Tigray Region

Effect on livestock production	Low infestation N=20		Medium infestation N=40		High Infestation N=60		Overall sample N=120	
	n	%	n	%	n	%	n	%
Encroaches grazing land	5	4.5	4	3.6	13	11.8	22	20
Threatens animal health	6	5.5	8	7.3	6	5.5	20	18.2
Changes milk quality	24	21.8	36	32.7	47	42.7	107	97.3

N= Sample number n=Respondents' number

On human health

The findings also indicate that *P. hysterophorus* affects human health as well. The most important effect of *P. hysterophorus* on human health is the allelo chemicals which cause irritation human body (Table 9). Similar results were found by (Anonymous, 1976) in India.

Table 8: Effects of *P. hysterophorus* on human health in Southern Zone of Tigray

Effects on human health	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall sample N=120	
	n	%	n	%	n	%	n	%
The thorns cause itching	1	0.9	2	1.8	5	4.5	8	7.3
The Allelo chemical causes irritation	2	1.8	2	1.8	12	10.9	16	14.5

N= Sample number n=Respondents' number

3.2.5. Control activities undertaken by the Respondents

With regard to control techniques applied by the respondents, early weeding before flowering and mowing burning were the most commonly used techniques. About 31.8% of the individuals in the high infested area, 24.5% in the medium infestation area and 15.5%in the low infested area tried to control *P.hysterophorus* by mowing and burning it. Early weeding before flowering was practiced by 40.9% of the respondents in the high infestation area, by 30.9% in the medium infestation area and 20% of the respondents in the low infested area (Table 9). According to the information obtained from respondents and developmental agents, cooperational activities like as mowing and burning control mechanism is commonly used as control strategy for *P.hysterophorus* with community to decrease the expansion rate.

Table 9: Control techniques used by the community in Southern Zone of Tigray Region

Control techniques	Low infestation N=20		Medium infestation N=40		High Infestation N=60		Overall sample N=120	
	n	%	n	%	n	%	n	%
Early weeding	22	20	34	30.9	45	40.9	101	91.8
Cooperational activities by mowing and burning	17	15.5	27	24.5	35	31.8	79	71.8

N= Sample number n=Respondents' number

Table 10 shows the perception of respondents on the effectiveness of the measures they have taken to control *P. hysterophorus*. About 23.6% in the high infestation area, 17.3% in the medium infestation area and 14.5% in the low infestation area believed that the measurement taken were not effective, because of easily grow again and cover large area of the weed. In the other side about 16.4% in the high infestation, 11.9% and 7.2% in the low infestation area believed that the control measurement taken were effective in decreasing the abundance level.

Table 10: Effectiveness of the control measures employed by the community in Southern Zone of Tigray Region

Effectiveness	Low infestation N=20		Medium infestation N=40		High infestation N=60		Overall Sample N=120	
	n	%	n	%	n	%	n	%
Not effective	16	14.5	19	17.3	26	23.6	61	55.5
Effective	8	7.2	13	11.9	18	16.4	39	35.5

N= Sample number n=Respondents' number

Conclusion

Parthenium hysterophorus is *spreading* at alarming rate, threatening agricultural ecosystem, biodiversity, human and animal health in the study area as well as in the country Assessment widely in the Region is very important to collect information and status of *Parthenium*. This used to plan research priorities and facilitates sustainability and success of future control programs. Majority of the respondents were illiterate indicating that distribution of written materials to understand its invasiveness, facilitator agents for dissemination, its dangerous effects and to popularize management techniques cannot be a possible strategy. Other means such as radio programs, field days and training opportunities have to be made available to create awareness.

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