Status, distribution and impacts of invasive species in Sebeta Hawas district, Oromia region, Ethiopia

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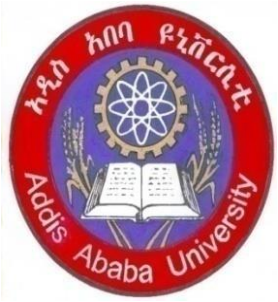
August, 2021



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By: Cheru Geremew

Msc Thesis Submitted to the department of Zoological Sciences Addis Ababa University in partial Fulfillment of the Requirement of Degree of Master of Science in Biology

Addis Ababa University

Addis Ababa, Ethiopia

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ADDIS ABABA UNIVERSITY

GRADUATE PROGRAMS

This is to certify that the thesis prepared by Cheru Geremew, entitled: *Status, distribution and impacts of invasive species in Sebeta Hawas District, Oromia Region, Ethiopia* and Submitted to the department of Zoological Sciences

Addis Ababa University in partial Fulfillment of the Requirement of Degree of Master of Science in Biology compiles with the regulations of the university and meets the accepted standards with to originally and quality.

Signed by Examining Board:

Name	**Signature**	**Date**
1.----------(Examiner)----------		**----------**
2.----------(Examiner)----------		**----------**
3. Ermias Lulekal (PhD) (Advisor)----------		**----------**
4.----------(Chairman)----------		**----------**

ABSTRACT

Status, distribution and impacts of invasive species in Sebeta Hawas district, Oromia region, Ethiopia

Cheru Geremew

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This research was done in Sebeta Hawas district Oromia region, Ethiopia. A total of nine representative kebeles were selected purposely with the help of information acquired from the office of Agriculture and conservation of natural resource department of the district. Ten(10) household informants were selected randomly from each 9 representative kebeles (90) and all the Development Agents (10) were included as informants. In addition to the primary data sources obtained by close observation and interviews made with each informant (100 informants) secondary data sources were also obtained from written documents. Data obtained were entered into SPSS 2020 version and processed. Apart from this, data were analyzed using preference ranking and direct ranking matrix to identify the main invasive weeds and their impact on cultivated crops respectively. *Cirsium vulgare, Setaria pumila, Phalaris paradoxa, Xanthium spinosum, Rumex crispus,* and *Argemone ochroleuca* were identified as the prominent invader in the Sebeta Hawas district. These species were found spread and introduced to many ecosystems by wind(31%) that followed by animals(22%). Majority of them were observed growing in roadsides(17.8%) and non cultivated lands(17.8%). *S.pumila* that followed by *P.paradoxa* pose more impact on agricultural crops in varied degrees. Making awareness creation by Development Agents and district administrator for the community regarding the nature of each species, their spreading means and their preventive techniques are recommended. Further research at regional and national level on invasive plants is recommended so as to minimize further spread and complete removal of invasive species of the district

Key words: Ecological distribution, Impacts, Invasive Species, Sebeta Hawas district.

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Table of Contents

List of Figures

List of Tables

List of Appendices

ACRONYMS

CABI Center for Agriculture and Bioscience International

CBD Conservation of biological diversity

DA Development Agent

DAISIE Delivering Alien Invasive Species Inventories in Europe

EARO Ethiopian Agricultural Research organization

SHDAO Sebeta Hawas District Agriculture Office

SHDPEDO Sebeta Hawas District Planning and Economic Development Office

SPSS Statistical Package for Social Science

UCS Union of Concerned Scientists

USDA United States Department of Agriculture

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Invasive species are either indigenous or non-indigenous species that can heavily colonize a particular habitat (Booth *et al.*, 2010). McNeeley *et al*., (2001) and DAISIE (2008) explained alien species as non-native or exotic organisms that occur outside their adaptive and dispersal ranges.

Around the world for hundreds of years, humans have been transporting species, both intentionally and unintentionally (Monaco *et al*., 2012). Many noxious weeds and some agricultural species which themselves became invasive were the results of inadvertent introductions by colonists through the transport of livestock, crop plants and goods (UCS, 2001).

Introduction of invasive species to an ecosystem has threatened biodiversity, food security, health or economic development of the society (Monaco *et al*., 2012). Invasion of invasive plants hinder crop production through claiming agricultural lands and serving as a hiding place for crop pests and wild animals(Tu, *et al*., 2001).The shortage of livestock feed is also further complicated by the introduction and expansion of unwanted bushes and invasive weeds(Abebe Gizachewu *et al*., 2010)

There are mechanical, cultural, biological, and chemical methods to control invasive plants so as to foster beneficial vegetation and to suppress undesirable plants (Radosevich *et al*.,2007; DiTomas, 2003). Engaging key stakeholders, communities and neighbors' knowledge plays a significant role in management and preventions of invasive plant species (McNeeley *et al*., 2001).

Though Ethiopia is rich in biodiversity and a center of origin of crops (Husen Azamal *et al*.,2012), there are many invasive species that threat this biodiversity of the country (CBD, 2009). These invasive species pose a serious threat to agriculture, livelihoods and human health by competing with crops, injuring (livestock, wildlife, people) and reduce forage of animals (wildlife livestock) (White, 2008).

Since there is no adequate recent information about invasive species in the selected study area, the aim of this study relies on assessing the status, distribution pattern, impacts, trend, controlling mechanisms and the future prospects of invasive species in Sebeta Hawas districts of Oromia region, Ethiopia.

1.2 Statement of the Problems

Invasive plants pose a menacing threat to livelihoods and economic progress, especially in the developing world, where most people are dependent on natural resources for their survival (Witt and Luke, 2017).Whether introduced intentionally or unintentionally invasive species need more attention because of their capability of spreading fast, their high competitiveness and ability to colonize new areas within short periods(UCS, 2001). Unlike agricultural weeds Invasive plants are non native or exotic species that can successfully establish, become naturalized, and spread to new natural habitats apparently without further assistance from humans (Radosevich *et al*.,2007). As human beings plays role both in invasive plant distribution and management, they need to control their invasions to reduce their impacts and enhance benefit (Monaco *et al*., 2012).The present research aims to identify the invasive species, their impacts and proposes preventive and controlling techniques which has never been.

1.3 Research Questions

The present research intends to answer the following questions

1. What are the highly and widely infesting invasive species in Sebeta Hawas District?
2. What are responsible agents for distribution to new areas?
3. What impacts do the identified invasive plants pose on agriculture and socio-economic aspects of the sampled area? and
4. How invasion of invasive species decimate and controlled in the study areas

1.4 Objective

1.4.1 General objectives

The general objectives of this research is to investigate the status, ecological distribution and impacts of the most common invasive species in Sebeta Hawas district

1.4.2 Specific objectives:

1. To identify the current status of the most common invasive species in Sebeta Hawas District
2. To explore the impacts of the most common invasive weeds on agriculture and socio-economic aspects in the study area
3. To determine the ecological distribution of major invasive species in Sebeta Hawas District
4. To suggest possible mechanism of reducing invasion of invasive plants in Sebeta Hawas District

1.5 Significance of the Study

The main purpose of this research relies on.

- Identification of main invasive species in Sebeta Hawas district
- Assessing the impacts of the most common invasive weeds on agriculture and socio-economic aspects
- Identification of the ecological distribution of major invasive species
- Differentiating possible mechanism of reducing invasion of invasive plants
- Delivery of information to decision makers on the main invasive species of the area so as to provide a baseline information which serves to take appropriate measures

1.6 The Scope of the Study

The scope of the study was limited in Sebeta Hawas district, Oromia region to assess status, distribution and impact of prominent invasive species. Nine kebeles were included purposefully in this study with the help of surveyed wereda Agriculture and Biodiversity Conservation Officer. The data were gathered from 90 randomly selected households and all 10 developmental agents using semi interviews which was lasted for a maximum of four month(the end of December 2020)

CHAPTER TWO

2. REVIEW LITERATURE

2.1 Invasive Species

Invasive species is non-indigenous species (e.g., plants or animals) that adversely affect the habitats they invade economically, environmentally or ecologically (Inderjit, 2005; Wilcox and Turpin, 2009).There are different types of invasive plants based on their various growth forms, shapes and sizes. These can be grouped into aquatics, palms, climbers, herbs, shrubs, succulents, and trees (Witt and Luke, 2017).

2.2 Distribution of Invasive Species

In the past century following more interaction among people and countries than ever, human activities have extensively changed our world. One of the prominent outcomes is the introduction of large numbers of species unintentionally or intentionally to regions beyond their natural distributions (Wan *et al*.,2017).

Invasive species have been introduced to new ecological areas from its native areas through different means and routes named invasion pathways. This can be either intentional or accidental introductions. When exotic plants (crops) are introduced for a great variety of purposes such as food use, forestry use, soil improvements, ornamental plants, cover crops and other uses it is termed as intentional introduction. The second method is through accidental introductions in which many alien agricultural weed species introduced as contaminants of crop seeds, shipping soil or soil attached to plant material. These are often shipped from place to place by military equipment, machinery and vehicles without cleaning (Inderji, 2005). Most weeds are accidentally introduced with crop seeds, from ship-ballast, soil, or from various imported plant

materials. Introduced weeds pose greater problem than native weeds and this is one reason why they dominate the weed species in crops (UCS, 2001).

The lives of people everywhere have been greatly enriched by their access to a greater share of the world's biological diversity. Expanding global trade is providing additional opportunities for societal enrichment. But these movements of species by humans are also having, in some cases, negative impacts on local ecosystems and the species of which they are composed. Local and national economies are also being affected. A new challenge is to identify when these alien or non indigenous species are bringing about changes that are harmful to ecosystems, biodiversity, health, economics or other aspects of human welfare (McNeeley *et al*., 2001).

The ability to disperse long distances, establish readily in modified areas, outcompete native species and its difficulty tendency to be eradicated once established are their contributors for their successful invasion (Kohli *et al*.,2009). In addition the environmental climate change could potentially favor for spreading of invasive non native species by either creating more favorable environmental conditions for them (UCS, 2001).

2.3 Invasive Species Dispersing Agents

Seeds are dispersed away from parents for several reasons like to avoid seedlings competition with their parents (or siblings) and decrease the likelihood of mating with a sibling (depress inbreeding). It also increases chance of colonizing new habitats apart from reducing chance seeds being eaten by others (herbivores). Seeds can be dispersed over long distances by agents via several types of vectors, including humans ,wind, water, birds, vehicles and animals that are often associated with specific dispersal structures (McNeeley *et al*., 2001).

Humans are an important dispersal agents because of their technology and mobility. Seeds of invasive plant disperses via many routes either direct movement through *planting* for

ornamental, soil erosion, shading, forage, crop use, or indirect movement as contaminants of soil, vehicles, equipment, or clothing (Hester and Harrison 2007). Animals disperse fruits or seeds by two mechanisms. The first one is through attaching to animals with awns, hooks, barbs, or sticky secretions and the other is following ingestion as a food source into both disturbed and undisturbed habitats. Birds are the most important animals responsible for long-distance dispersal of invasive species. In contrast, invasive species typically attract more generalist vertebrate dispersers. Among the animal seed vectors, birds are the most important vertebrate responsible for long-distance dispersal of invasive species. Water and wind dispersal can greatly impact the speed and opportunity for invasion of non-native species. Seeds particularly those with winged appendages moved long distances by water. Similarly seed or fruit that have pappi, or plumed or winged move in the atmosphere by wind (Monaco *et al*., 2012; Kohli *et al*.,2009).

2.4 Impact of Invasive Species

The global movements of species and their impacts have been recognized for decades. The development of invasion biology as a separate field is more recent. The movements of invasive species to new areas by dispersing agents including humans have enormous impacts on our society including economic, social, and ecological aspects(UCS,2001).

2.4.1 Ecological impact of invasive species

Since the last decade of the twentieth century, biological invasions happened intensively in agricultural lands, grasslands, islands, fishery, wetlands, rivers, marine and natural reserves invasions (Wan *et al*.,2017).Whether introduced intentionally or unintentionally invasive species prey on, parasitize, outcompete, or hybridize with native species to the point of extinction. They can also disrupt the function of native communities and ecosystems (UCS, 2001). The

availability of fragmented or disturbed habitats are one of the major causes that provide favorable sites for invasion by the invasive plants. This will reduce the competitive ability of the native species and allows invasive species to spread (Kohli *et al*.,2009).

2.4.2 Biological impacts of invasive species (ecosystems)

Introduction and transfer of alien invasive species among continents, regions and nations has significant impacts on the recipient ecosystems(Hester, and Harrison, 2007). An ecosystem refers an abiotic variables and the biotic elements that interact at a given place and time. Any dramatic change in the species composition, anywhere will likely affect the composition and function of the whole. Invasion by exotic plants represents a fundamental change in a system and need a unique management that challenge human society (Monaco *et al*., 2012).Invasive plants may have impacts on endangered species in relation to their own habitats, competitive ability, and environmental stress factors. It also damages soil and water resources which in turn reduce available winter forage for wildlife (Inderjit, 2005)

After the introduction to a new areas invasive species have decimated individual populations, caused multiple extinctions, and altered the functioning of ecosystems (UCS, 2001). Though all ecosystems can be invaded potentially, some areas like isolated ecosystems, water bodies, urban-industrial areas, disturbed areas, natural and anthropogenic disturbance are appear more vulnerable to invasion. Aired ecosystems, are thought by some to be more susceptible to invasion than species-rich systems with well-established species interactions (McNeeley *et al*., 2001).

2.4.3 Socio economic impact of invasive species

Invasive species pose highly diverse negative impacts on economic, that was difficult to quantify and compare either damaging to agricultural crops by a vast range of exotic pest species or directly affect ecosystems severely reducing habitat structure and diversity (UCS, 2001). Invasive plant species can have a dramatic impact on crop-yield losses, livestock production, water resources, biodiversity, human and animal health(Witt and Luke, 2017). Well known consequences of direct economic losses of certain invasive species are on agriculture, livestock production, forestry, and recreation (Monaco *et al*., 2012).

2.5 Invasive Species Control Method

As the rate of change continues to accelerate with global trade, climate change, tourism, and habitat modifications in the name of development, the dynamism of invasion system will grow. This requires a growing capacity to manage the impacts of changes created due to the invasive species (McNeeley *et al*., 2001). Though invasive non native species are a serious threat to native species, in many areas around the world by taking action to control and manage many plant invasions can be reversed, halted or slowed. Even badly infested areas can be restored to healthy systems dominated by native species. Manual, chemical, cultural, chemical and biological, are the most commonly controlling techniques (Tu, *et al*., 2001).

2.5.1 Manual and mechanical control techniques

If the population of invasive species are relatively small manual and mechanical controlling technique such as pulling, cutting, or damaging plants, may be used. Eventough this techniques are labor and time intensive, it can be extremely specific, minimize damage to desirable plants and animals (DiTomaso and Kyser, *et al*., 2013).

As shrubs are pulled and cut, re-sprouts and seedlings are treated in combination with other techniques such as with herbicides or fire. In using this method, it is important to thoroughly clean and inspect all equipment and clothing before moving it off-site so as to lessen the probability of spreading the weed/s. Hand weeding, mowing, brush-cutting, weed eating, mulching and flooding are widely applicable ones (Tu, *et al*., 2001).

2.5.2 Cultural methods of invasive species control

Cultural methods of invasive species suppression were utilized during normal process of crop production. As species are most tenacious and difficult to control after they become established prevention of a weed problem is usually easier and less costly than control or eradication attempts. Weed prevention, crop rotation, competition, smother crops, living mulches and cover crops, grazing, flooding, and fire are culturally preventive methods(Radosevich *et al*.,2007).

Grazing can either promote or reduce weed abundance at a particular site. Increased disturbance as a result of the presence of livestock facilitate spread of some invasive plant species. However, if grazing can be combined with other control techniques, severe infestations can be reduced. It is very difficult to implement in natural environments and rarely used though flooding can be effective in controlling invasive species. In the natural environment fire can be a very cheap and effective way of controlling specific invasive plant though its efficacy largely depends on the target species, the ecosystem, the intensity of the fire and the frequency it can be applied (Witt and Luke, 2017).

2.5.3 Chemical methods of invasive species control

Herbicides are organic, synthetic chemicals used to kill or suppress unwanted vegetation. Herbicides have become a major technological tool responsible, at least in part, for increase in

crop production during the last quarter to half century. It is only one of the many types of pesticides that are used to suppress or kill unwanted vegetation. Herbicides are used to reduce weeds in cropland, forest plantations, rangeland, and many other situations such as roadsides(Tu, *et al*.,2001). They are also increasingly used to assist in management and restoration of areas previously invaded by invasive plants. Attitudes among growers, land managers, and their advisors to expect that any vegetation management problem can be controlled effectively by chemical decimating other opportunity usage. It poses injury to non target vegetation and crops, toxicity to non target organisms and human health as well as residues in soil or water (Radosevich *et al*.,2007).

This type of controlling techniques is applied after the user ensured that he/she carefully consider the overall impacts of herbicide. Its usage depends on the conservation targets, other native species, and the ecological system. In addition to this the usage of herbicide need to be considered instead of other methods on the conservation targets and management goals for the site. This mean that one should be confident the proposed herbicide will do more conservation good than harm and not endanger the health of the applicators or others in the area (Tu, *et al*.,2001).

2.5.4 Biological control of invasive species

Biological control (biocontrol for short) is the use of animals, fungi, or other microbes to feed upon, parasitize or otherwise interfere with a targeted pest species. Both mechanical and chemical control methods are expensive and require frequent applications. Biological control offers a biological control programs usually significantly reduce the abundance of the pest (Radosevich, *et al*., 2007) In some cases, they simply prevent the damage caused by the pest. As it viewed as long lasting, effective and economical solution to pest, it has been explored and

implemented in several countries. Because it leaves behind no chemical residues and, provide essentially permanent, widespread control with a very favorable cost-benefit ratio (Inderjit, 2005).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Geographical location of the study areas

Sebata Hawas is one of the districts in the Oromia Region of Ethiopia. It is part of the Oromia Special Zone Surrounding Finfinne, bordered on the southwest by Debub Mirab Shewa Zone, on the northwest by Walmara, on the north by Burayu, on the northeast by the city of Addis Ababa, and on the east by the Akaki (Figure 1). The Awash River defines this woreda's boundary with Debub Mirab Shewa Zone. The towns in Sebeta Hawas include Lakole geja, Kalacha, Awash Melka, and Tefki. The town of Sebeta was separated from this district and has its own administrative though the administrative office of Sebeta Hawas district is still now found in Sebeta town. The altitude of the district ranges from 1800 to 3385 meters above sea level. The district harbors the Sebeta river (SHDPEDO, 2007)

3.1.2 Soil and drainage

There are three main dominant soil texture in sebeta Hawas district namely clay soil, sand soil and silt soil which contains 18%, 21% and 61% respectively(SHDAO, 2007). The Awash river pass within this district, providing different purposes mainly for irrigation purposes throughout the year.

3.1.3 Climate and ecology

Sebeta Hawas district Characterized by two major agro-climatic zone, dega (21%), Woina dega(88%). The mean of daily maximum and minimum temperature are $24c^{o}$ and $15c^{o}$ respectively. The district is characterized by unimodal rainfall where the total annual rainfall is

received in the end of April to September. The annual mean rainfall with maximum, medium and minimum rain having 1800mm,1033mm and 866mm respectively (SHDAO,2007).

3.1.4 Materials needed for the research

Materials which were utilized in doing this research especially filed materials include note book, ink pen, collecting bugs, hand gloves, hoes and scissors. In addition to this plant press including old newspaper, cardboard, threads were used

3.1.5 Land use and agricultural systems

According to the information obtained from Sebeta Hawas district agriculture and rural development office and district planning and economic development(2006), the district covers a total area of 84,566 hectares of the largest 72,542 ha (85.78%) is agricultural land followed by urban construction purpose 5907 (6.98%).

Table 1. Land use pattern of Sebeta Hawas District

Land use	**Area(ha)**	**% age**
Agricultural land	72,542	85.78
Urban construction purpose	5907	6.98
Grazing land	2254	2.67
Water coverage	1390	1.64
Plantation forest areas	2148	2.54
Reserved for industrial investment	124	0.15
for other food purpose	201	0.24
Total	84,566	100

Source: SHDAO, 2007

3.1.6 Population structure

According to the 2006 national census the total population for Sebeta Hawas district was 132,294, of whom 68,133 were men and 64,161 were women; 7,359 or 5.56% of its population were urban dwellers. The majority of the inhabitants (87.44%) practice the Ethiopian Orthodox Tewahdo Christianity, while 5.37% of the population were Muslims, 4.57% observed traditional beliefs, and 2.44% were Protestants (Population and Housing Census of Ethiopia, 2007)

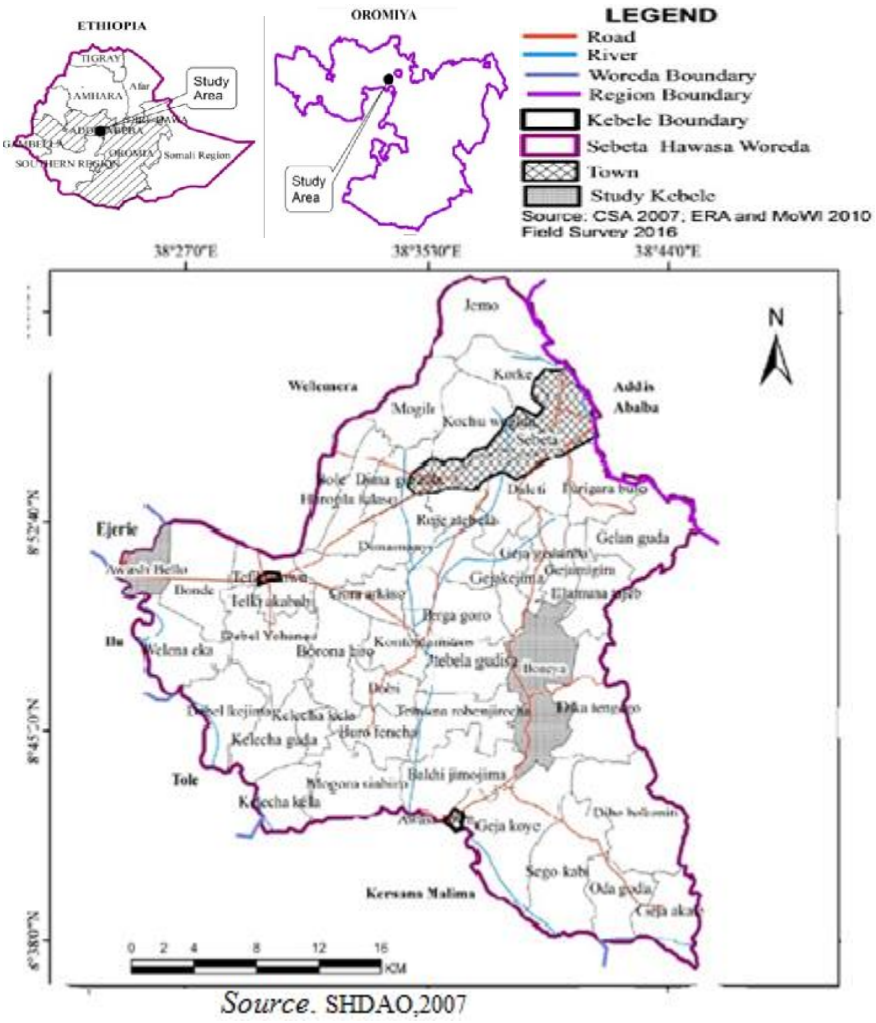

Figure 1. Map of Ethiopia showing Oromia Region and the study district

3.2 Data Sources and Materials

3.2.1 Source of data

Both primary and secondary source of data were used. Primary data were generated from reconnaissance survey, field work and the responses of the household(informants) and agricultural experts who involved directly or indirectly with the effect of invasive species that were seen in the selected area. Secondary source of data was obtained from Agriculture and conservation of natural resource officer of the district (SHDAO)

3.2.2 Research instruments

Semi-structured interviews and field observation during the survey were used as the primary data collection instruments. Interviewees were made with local people and Developmental Agents to collect appropriate data that were analyzed. Apart from collecting more accurate data, this instrument allowed informants to express their own terms freely, provide reliable and comparable qualitative data. Similarly, it enabled the researcher to discuss on sensitive issue with its reasons beyond simply listening the informants answer. Field observation was carried out in order to identify the types, morphological variation and habitat of invasive species and the degree of invasions of the area by different invasive species.

3.2.3 Reconnaissance survey

Reconnaissance survey of the study area was conducted from Sebtmber to December 2020 to collect baseline information, distribution and the management practice of invasive species throughout the selected kebele(smallest administrative unit in Ethiopia) in Sebeta Hawas district. During the survey, 9 representative kebeles were selected from 40 kebeles

3.2.4 Selection of study site and informants

This district has a total of 40 kebeles (36 countryside kebele and 4-town kebele). Out of this, 9 representative kebeles (Elamuna Tajeb, Bonde, Wale Eka, Tafki, Qoye, Balchi Jimjima, Jawe, Gora Harkiso and Haro Jila) were selected purposely with the help of information acquired from Agriculture and conservation of natural resource administration agency of the district based upon on the availability of various types of invasive plants and extensive negative impact they pose. .

From each 9 representative kebeles,10 representative informants were selected randomly adding a total of 90 general informants selected from the study area. In addition to this all Developmental Agent (DA) staffs found within the 9 representative kebeles were included in the sample (10 DA) considering that they knew more about invasive species of the area. Thus, a total of 100 informants with age above 15 years(>15) were selected from the district as source of data. Nine(out of 100) key informants (7 males and 2 females) (one from each kebeles) were selected purposely to participate in ranking (prioritize) of identified invasive plants in the study area based on the their educational status, age and knowledge they have to give detailed information about the study area. Furthermore 5 male (out of 100) key informants were selected purposely based on their explanation ability to rank the impact of prominent invasive plants on commonly cultivated crops in Sebeta Hawas district. The number of males(77 males) are greater than the number of females(23 Femals) because more males are working (outside moving) outside the house in comparing with that of women.

3.2.5 Collection of specimen

Before visiting the specimen location fields, all necessary specimen collecting materials including scissors, hoe, collecting bags, hand gloves, note book, pen and old newspapers, hard cardboards and thread were prepared.

Invasive species found distributing widely and with important body parts were chosen in the sampled areas for collection purpose. Then after the selected species were carefully pulled out by digging the ground, rearranged (their body parts cut if necessary) and adhered on newspaper. Afterwards specimens were numbered and labeled with necessary information (scientific name, common name, family name, author name, identification number, and identifier name). Finally they were put in between two cardboard and tied together tightly that will further be checked.

Identification of the well-known dominant invasive species made after collecting appropriate specimens from the selected area by comparing with the published volumes of Flora of Ethiopia and Eritrea. Identified specimens were confirmed at the National Herbarium by Dr. Ermias Lulekal and finally the confirmed specimens were finally deposited at the National Herbarium, Addis Ababa University.

3.3 Data Collection Procedure

Semi-structured interviews:- were prepared and interviewed with local people and Developmental Agents (Appendix-I). Data collection was made on the basis of checklist items of questions prepared in English and later transfer into Afan Oromo. The items include information on the informant's personal identity, types, local names, negative impact, distribution status, function, spreading method, and controlling techniques of invasive plants(Appendix-i, ii, iii). The entire interview with informants were done through the direct contact between the researcher and informants. The willingness of informant was first being confirmed before

starting data collection. This was done through awareness creation for informants by describing the future-significance of the research for the study area and for the country.

Figure 2. During interview in Sebeta Hawas District, Oromia Regional State**.**

Field observation:-field observation was done with interviewed informants**.** Type, habitat (ecosystem), growth form, distribution status, morphological variations (body parts), abundance, uses, the degree of invasions and impact of invasive plants were observed and recorded on field by direct observation and field walk. Apart from this some informants were visited again to confirm the consistence of the information collected from them.

The data gathered and observed was entered into SPSS 2020 version and rearranged, grouped, added and finally summarized in the form of percentages, frequency, tables, graphs and pie chart, with their own explanation.

Figure 3. During field observation in Sebeta Hawas District, Oromia Regional State.

3.4 Data Analysis Techniques

3.4.1 Data organization (descriptive statistics)

The data collected based on the composition of invasive plants being grown in the districts, geographical distribution, and level of infestation/spread rate/ were entered into SPSS 20 version and processed to determine proportion, draw bar graphs, and pie chart. Descriptive statistical methods such as frequency, percentage, tables and graphs were employed to analyze and summarize the data. The most useful information gathered on invasive species reported by local people include identification of prominent invasive plants, distribution status, impacts of weeds

on crops, distribution methods, intrusion(spreading) controlling method of invasive plants through software and descriptive were analyzed.

3.4.2 Preference ranking

Preference ranking for most prominent invasive plants were performed using selected key informants. Accordingly invasive plants were ranked based on their abundance and widely distribution by giving value of 0 to 4 were used in this ranking(4- for very high distribution for,3- for high distribution plants, 2-for medium distribution,1 and 0 for less and no distribution of invasive plants respectively in the study area) as compared to the other plants

3.4.3 Direct matrix ranking

Direct matrix ranking was used to identify the multiple impact of each prominent invasive plants on commonly cultivated crops. A five key informants were chosen to assign impact value to each attributes (4-highly affect, 3-more affect, 2-medium affect, 1-less affect, 0-no affect). Based on the information gathered from informants, average value of the negative impacts each prominent invasive plants pose upon commonly cultivated crops in the study areas were sum up and ranked.

CHAPTER FOUR

4. RESULTS

4.1 Background of the Respondents

Respondents are important source of data to carried out research. Well standard maintained research finding was determined by the type of respondents being included in data gathering. After an appropriate number of respondents were selected, data were gathered using semi structured interviews. Along with gathering data about status, distribution and impacts of commonly available invasive species in Sebeta Hawas district detailed background of respondents were discussed. Educational status, age, gender and marital status of respondents were discussed and written that have their own role on research outcome result

4.1.1 Educational status of respondents

Among the 100 respondents 15% of men and 5% of women were illiterate. However 4% and 13% of female and male respondents respectively were found with a background of informal education. The third categories 7% and 34% of female and male respondents respectively had a primary level of education. Similarly, 6% and 3% of male and female respondents had secondary level of education respectively. On the other hand, 4% and 9% of female and male respondents had a post-secondary education level.

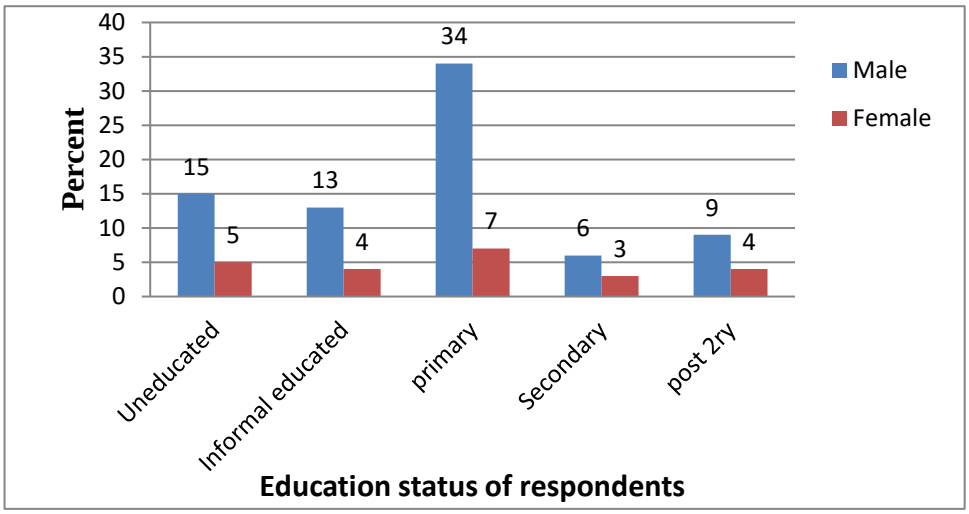

Figure 4. Social and educational status of respondents in Sebeta Hawas District, Oromia Regional State.

4.1.2 Sex of respondents

On the overall respondents, 77 (77%) of them included in survey were males and 23 (23%) were females.

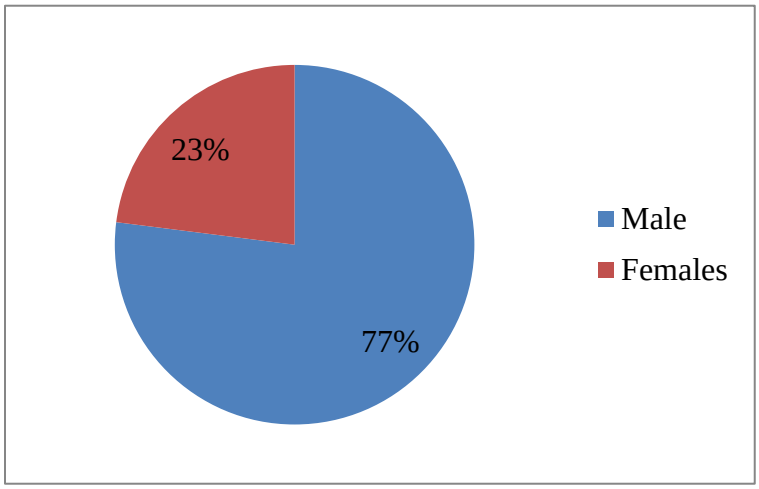

Figure 5. Sex of respondents in study sites of Sebeta Hawas District, Oromia Regional State.

4.1.3 Age of respondents

As indicated in figure 6 from the total respondents, most of the respondents (39%) had age between 38 and 49 years old, while only a few (17%) had age range between 14 and 25 years old, 35% of the respondents had age between 26 and 37 years old. Similarly 9% of the respondents were found older than 50 years old

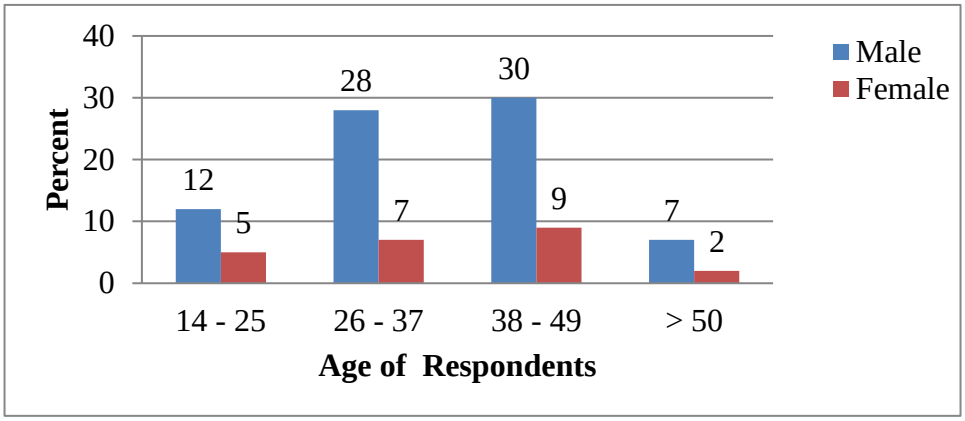

Figure 6. Age of respondents in study sites of Sebeta Hawas District, Oromia Regional State.

4.1.4 Marital status of the respondents

Regarding to the marital status of the respondents, 70% of them were married, 25% of them was unmarried and 5% of them were divorced

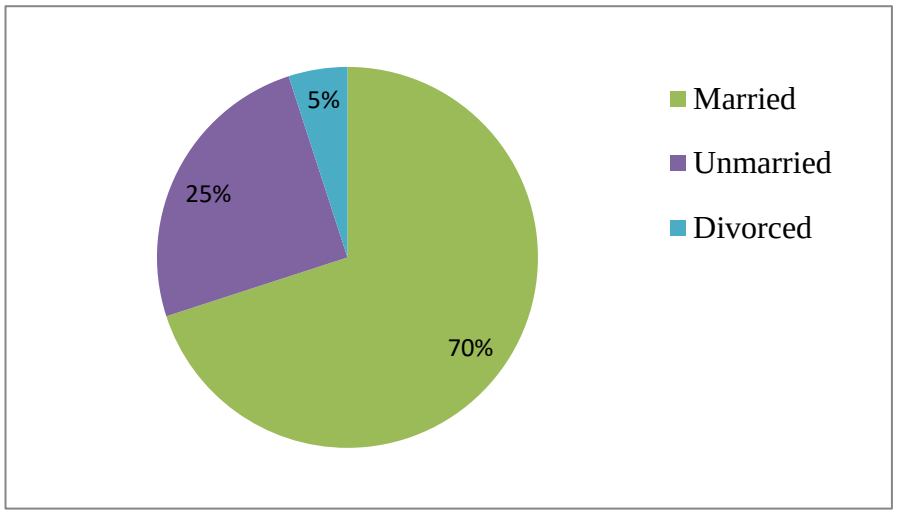

Figure 7. Marital status of respondents in study sites of Sebeta Hawas District,Oromia Regional State

4.2 Invasive Species Identified by Respondents

The major invasive species identified in Sebeta Hawas district were *Cirsium vulgare*, *Setaria pumila*, *Phalaris paradoxa*, *Xanthium spinosum*, *Rumex crispus*, *Carthamus lantus*, *Argemone ochroleuca*, *Guizotia scabra*, *Monarda citrodora*, and *Xanthium strumarium* (Table 2). On the other hand species such as *Amaranthus hybridus*, *Datura stramanium*, *Bromus pectinantus*, *Cynodon dactylon*, *Echinops spinosissmus*, *Carthamus lanatus*, *Solanum indicum*, *Avena fatua* and *parthenium hystrophorus* were identified as less invaders in the study area. Some representative invasive species of Sebeta Hawas district identified during the present research are displayed in Figure 8-19.

Table 2. Type of invasive plants identified by respondents in Sebeta Hawas District

Invasive Species	Frequency	Percent
Cirsium vulgare (Savi)Ten.	48	10.6
Setaria pumila (Poir) Roam.	46	10.2
Phalaris paradoxa Thunb.	45	10.0
Xanthium spinosum L.	38	8.4
Argemone ochroleuca weet.	33	7.3
Rumex crispus L.	33	7.3
Carthamus lantus L.	30	6.6
Guizotia scabra Vis.) Chiov.	28	6.2
Monarda citrodora L.	28	6.2
Xanthium strumarium L.	24	5.3
Echinops spinosissmu Turra.	18	4.0
Amaranthus hybridus L.	16	3.5
Avena fatua L.	14	3.1
Solanum indicum Cav.	13	2.9
Datura stramonium L.	10	2.2
Cynodon dactylon L.	9	2.0
Bromus pectinatus Thunb.	7	1.5
parthenium hystrophorus L.	6	1.3
Scorpiurus muricatus L.	6	1.3
Total	452	100.0

Figure 8. *Cirsium vulgare* (Savi)Ten.(Photographed by Cheru Geremew,2020 Suxo Sefer, Qoye kebele)

Figure 9. *Phalaris paradoxa* Thunb.(photographed by Cheru Geremew,2020 Gora harkiso

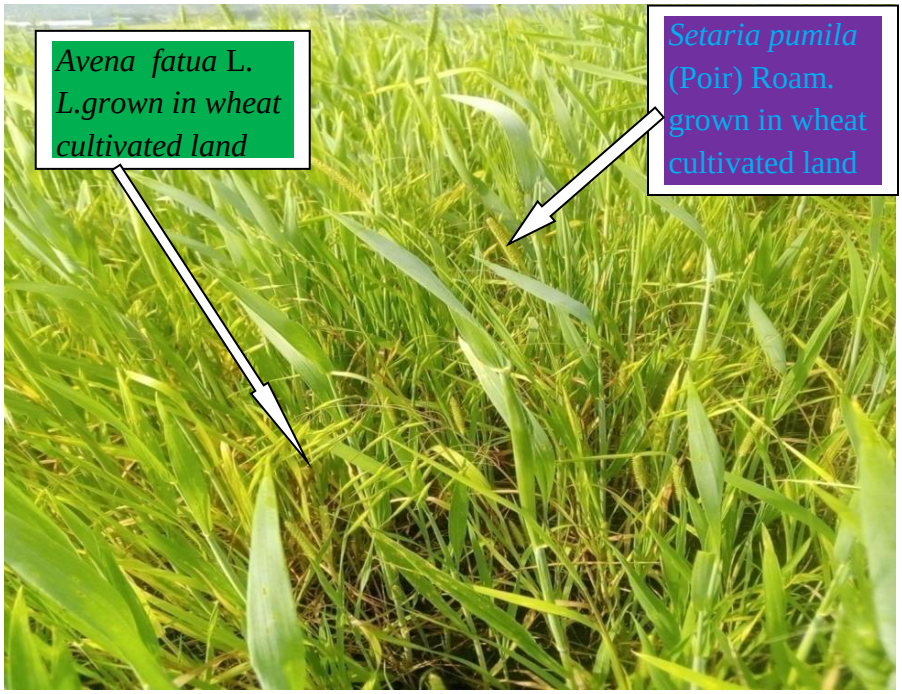

Figure 10. *Setaria pumila* (Poir) Roam. (photographed by Cheru Geremew, 2020 Suxo Sefer(Qoye kebele)

Figure 11. *Xanthium strumarium* L.(photographed by Cheru Geremew, 2020 Dilu(Tafki kebele)

Figure 12. *Xanthium spinosum* L. (photographed by Cheru Geremew, 2020 Tafki Kebele)

Figure 13. *Rumex crispus* L.(photographed by Cheru Geremew,2020 Bonde kebele)

Figure 14. *Echinops spinosissmus* Turra (photographed by Cheru Geremew, 2020 Enlamuna Tajab kebele)

Figure 15. *Monarda citrodora* L (photographed by Cheru Geremew, 2020 Gara maniso, Haro Jila kebele)

Figure 16. *Carthamus lanatus* L.(photographed by Cheru Geremew,2020 Ababule, Jawe kebele)

Figure 17. *Solanum indicum* Cav. (photographed by Cheru Geremew,2020 Gombobdu sefer, Jawe kebele)

Figure 18. *Guizotia scabra* (Vis.)Chiov.(photograph by Cheru Geremew, 2020 Yuyu ,Inlamuna Tajab kebele)

Figure 19. *Datura stramonium* L. (photographed by Cheru Geremew, 2020 Haro Jila Kebele)

4.3 Preference Ranking of Invasive Species

Regarding the distribution of nineteen commonly available invasive species, nine respondents (one from each kebele) asked to rank from highly distributed(4) to none (0) as indicated (Table 3). Accordingly, *C. vulgare* holds the first rank showing that it was highly distributed than the rest. Following this, *S. pumila, P. paradoxa, X. spinosum, A. ochroleuca, R. crispus* were grouped in decreasing order.

Table 3. Distribution of invasive plants ranked by nine respondents in Sebeta Hawas District

(4= Very high distribution, 3= High distribution, 2= Medium distribution, 1= Low distribution, 0= Not present)

No	Invasive Species	List of Invasive Plants									Total	Rank
		A	B	C	D	E	F	G	H	I		
1	*Cirsium vulgare* (Savi)Ten.	4	4	4	4	4	4	4	4	4	36	1st
2	*Setaria pumila* (Poir) Roam.	4	3	4	3	4	4	3	4	4	33	2nd
3	*Phalaris paradoxa* Thunb.	4	1	4	4	4	3	4	4	4	32	3rd
4	*Xanthium spinosum* L.	4	4	2	3	4	2	3	4	3	29	4th
5	*Argemone ochroleuca* weet.	3	4	3	4	2	3	1	4	4	28	5th
6	*Rumex crispus* L.	4	3	3	3	2	3	3	2	3	26	6th
7	*Carthamus lantus* L.	4	3	3	0	4	3	3	3	2	25	7th
8	*Guizotia scabra* Vis. Chiov.	4	3	2	3	3	3	0	2	4	24	8th
9	*Monarda citrodora* L.	3	4	0	3	3	2	3	2	2	22	9th
10	*Xanthium strumarium* L.	3	2	3	0	1	3	3	3	3	21	10th
11	*Echinops spinosissmu*Turra.	3	4	2	2	3	2	0	1	3	20	11th
12	*Amaranthus hybridus* L.	3	2	3	2	2	2	1	2	2	19	12th
13	*Avena fatua* L.	2	3	2	3	1	2	0	3	2	18	13th
14	*Solanum indicum* Cav.	2	3	2	2	1	0	2	0	3	15	15th
15	*Datura stramonium* L.	2	2	0	1	2	2	0	3	2	14	18th
16	*Cynodon dactylon* L.	2	2	2	2	2	1	2	2	2	17	14th
17	*Bromus pectinatus* Thunb.	2	0	2	2	2	1	3	2	2	16	16th
18	*parthenium hystrophorus* L.	2	0	2	0	2	2	2	0	1	11	19th
19	*Scorpiurus muricatus* L.	2	2	2	2	0	1	3	2	1	15	17th

4.4 Distribution of Invasive Plants

During this assessment, nineteen invasive plants have been identified and recorded (Table 4). The area perceived to be affected by invasive plant species were in all kebeles but with different degree of invasion. Similarly these species impairs negatively function and composition of biodiversity; threatened rare plant species and agricultural crops in varied degrees.

Table 4. Distribution status of invasive plants and ecosystem highly affected by invasive species in Sebeta Hawas District

Species	Ecosystem highly affected	Distribution status	Survey Districts infested
Cirsium vulgare (Savi)Ten.	1,2,3,4,5, 7, 8	High	All surveyed kebeles
Setaria pumila(Poir) Roam.	1,2,3,4,5, 7, 8	High	Jimjima ,Qoyye, Tafkii, Gora harkiso, Haro jjila, Enlamuf tajab
Phalaris paradoxa L.	1,2,3,4,5, 7, 8	High	Jimjima, Tafki, Jawe, Awash balo, Gora harkiso, Haro jjila, Enlamuf tajab
Xanthium spinosum L.	1,2,3,4,5, 6,7, 8	High	Jimjima, Qoyye, Tafki, Bonde, Awash balo, Gora harkiso
Rumex crispus L.	1,2,3,4,5, 7, 8	High	Jimjima, Tafki, Gora harkiso, Haro jjila
Argemone ochroleuca Sweet.	1,2,3,4,5, 7,8	High	Jimjima, Qoyye, Tafki, Jawe, Awash balo, Enlamuf tajab
Carthamus lanatus L.	1, 2,3,5,4, 8	Low	Jimjima, Tafkii, Jawe, Qoyye, Bonde ,Gora harkiso, Haro jila
Monarda citrodora L.	1,2,3,4,5,7	Medium	Tafki,Bonde, Awash balo, H/jila, Enlamuf tajab
Echinops spinosissmus Turra.	2,3,4,5, 8	Medium	Tafki, Jawe, Enlamuf tajab
Xanthium strumarium L.	1,2,4,5,7	Medium	Tafki, Bonde, Awash balo
Guizotia scabra (Vis.)Chiov.	1,2,3,4,5,7	Medium	Tafki, Gora harkiso, Haro jjila, Enlamuf tajab
Amaranthus hybridus L.	1,2,4	Low	Haro jjila, Awash Balo, Tafki
Solanum indicum Cav.	2,3,8	Low	Tafki, Bonde, , Jimjima
Avena fatua L.	1	Low	Haro jjila, Tafki, Enlamuf Tajab, Gora Harkiso
Datura stramonium L.	2,3	Low	Jimjima, Awash Balo, Jimjima
Cynodon dactylon L.	1,2,3,4,5,7	Medium	Bonde, Gora harkiso, Jimjima, Enlamuf tajab, Qoyye,
Bromus pectinatus Thund.	1, 3,5, 7	Medium	Gora Harkiso, *Jimjima*, Enlamuf Tajab, Qoyye,
Scorpiurus muricatus L.	1,3	Medium	Gora harkiso, Qoyye,
parthenium hystrophorus L.	2,3,5	Low	Jawe , Qoyye

key: 1= Cultivated 2= Non-cultivated land 3= Roadsides 4= Grazing areas

5= Rural villages 6= Urban areas 7= River banks 8= Forest areas

4.5 Type of Invasive Species Collected from Affected Ecosystems

Regarding the ecosystems affected by invasive plants, many types of invasive plants were identified from roadsides and non cultivated lands each having (16.7%) that followed by cultivated lands (15.6%), rural areas (14.6%), grazing areas (13.5%), river banks (10.4%) and forest area(9.4%). However, only few types of invasive plants (3.1%) were found in urban areas (Table.5).

Table 5. Type of invasive plants collected from affected ecosystem of Sebeta Hawas District

Ecosystems affected	Type of Invasive Species	Number	Percentage (%)
Cultivated lands	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, A. hybridus, C. lantus, A. ochroleuca, G. scabra, X. strumarium, A. fatua, C. dactylon, R.crispus B.pectinatus, S. muricatus* and *M. citrodora*	15	15.6%
Non cultivated lands	*C. vulgare, S. pumila, P. paradoxa, X. spinosum, A. hybridus, C. lantus, A. ochroleuca, G. scabra, M. citrodora, X. strumarium, E. spinosissmus, S. indicum, D. stramonium, C. dactylon, p. hystrophorus* and *Rumex crispus*	16	16.7%
Roadsides	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, A. hybridus, C. lantus, A. ochroleuca, G. scabra, M. citrodora, E. spinosissmus, S. indicum, D. tramonium, C. dactylon, B. pectinatus, p. hystrophorus* and *S. muricatus*	16	16.7%
Grazing areas	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, A. hybridus, C. lantus, A. ochroleuca, G. scabra, M. citrodora, X. strumarium, E. spinosissmus, C. dactylon* and *R. crispus*	13	13.5%
Rural areas	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, C. lantus, A. ochroleuca, G. scabra, M. citrodora, X. strumarium, E. spinosissmus, C. dactylon, B. pectinatus, S. muricatus and R. crispus*	14	14.6%
Urban areas	*X.spinosum, A. hybridus, and C. dactylon,*	3	3.1%
River banks	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, A. hybridus, A. ochroleuca, G. scabra, M. citrodora, X. strumarium,* and *C. dactylon*	10	10.4%
Forest areas	*C. vulgare, S. pumila, P. paradoxa, X.spinosum, A. hybridus, C. lantus, A. ochroleuca, G. scabra,* and *S. indicum*	9	9.4%
	Total	96	100

4.6 Respondents Perception on Impact of Invasion Species in Sebeta Hawas District

Respondents reflected on the degree of impact of invasive species introduced into their respective localities and majority (97%) of them perceived that existed invasive plants were most problematic to their livelihood and environment. However 2% and 1% of respondents described that the invasive plants were less problematic and do not have idea about the impact of these species respectively (Figure 9).

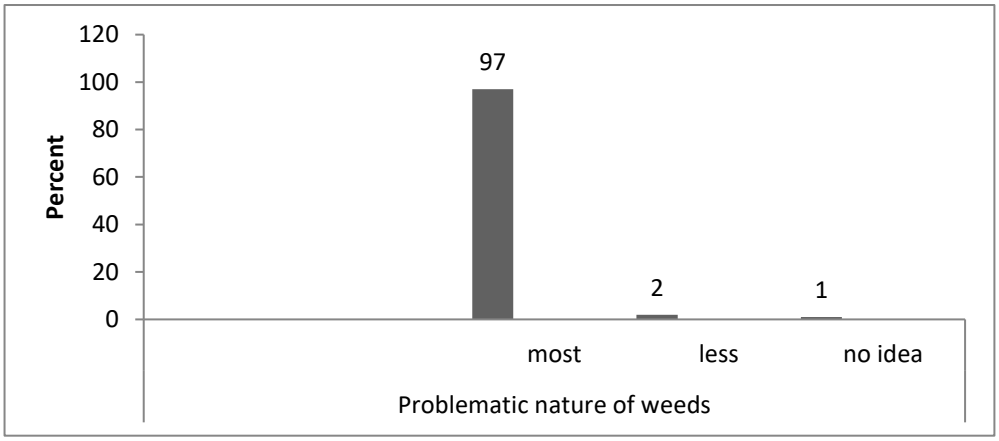

Figure 20. Perception of respondents regarding the impact of invasive species

4.7 Impact of Invasive Plants on Commonly Cultivated Crops

The most dominant invasive weed species found spread in *Eragrostis teff* cultivated fields were *P. paradoxa, S. pumila* and *R.crispus* (Table 6). Similarly the most frequent weed species in the Wheat cultivated fields were *S. pumila, P. paradoxa, A. fatu*. These invasive grass weeds especially *S.pumila* reduce yield of wheat crops, deteriorate the quality of farm produce, and trim dawn the market value of wheat. *Cicer arietinum, Lens culinaris and Vicia sativum* were the

other crops listed by respondents next to Teff and Wheat in the surveyed areas as mainly invaded by *X. strumarum, C. dactylon, R.crispus, G. scabra, A. ochroleuca, X. spinosum,* and *C. vulgare.*

Table 6. The invasive species of Sebeta Hawas identified within the commonly cultivated crops.

List of Crops	List of Common invasive species
Eragrostis teff (zucc.)	*P. paradoxa, S. pumila, R.crispus, G.scabra, S.muricatus* and *M. citrodora*
Triticum aestivum L.	*S. pumila, A. fatua, and B. pectinatus,*
Cicer arietinum L.	*X. strumarium, C.dactylon, R.crispus, G.scabra, A.ochroleuca, X.spinosum, C .vulgare and P. paradoxa*
Lens culinaris L.	*X. strumarium, C. dactylon, A. hybridus, G. scabra, P. paradoxa, A. ochroleuca, X. spinosum, C. vulgare*
Vicia Sativa L.	*X. strumarium, C. dactylon, R.crispus, G. scabra, A. ochroleuca, X.spinosum, C. vulgare, P. paradoxa*

4.8 Direct Matrix Ranking of Five Commonly Cultivated Crops Against Invasive Species

Results of the direct matrix ranking indicated that Teff cultivation was highly affected followed by Wheat, Chickpea, Lentil and Vetch (Table 7). Regarding invasive species type that pose the negative impact on commonly cultivated crops in the study area *S. pumila, P. paradoxa, X. strumarium, C. dactylon, R. crispus, G. scabra, X. sinosum, A. ochroleuca* and *C. vugare* were ranked from 1st to 9th in decreasing order(Table 7)

Table 7. Direct matrix ranking of five commonly cultivated crops by five participants based on the degree of invasiveness of dominant weeds in Sebeta Hawas.

(4=Highly affect, 3=More affect, 2=Medium affect, 1=Less affect, 0=No affect)

Invasive Species	Crops										Total	Rank
	Wheat		Teff		Chicka		Lentil		Vetch			
	Informants(1-5)		Informants(1-5)		Informants(1-5)		Informants(1-5)		Informants(1-5)			
	A B C D E		A B C D E		A B C D E		A B C D E		A B C D E			
C. vulgare	1 3 4 3 2		3 3 3 2 3		2 3 2 1 2		3 2 4 2 2		3 2 2 2 1		60	7th
S. pumila.	4 2 3 3 4		3 4 4 4 4		4 3 2 4 3		3 1 3 2 0		1 2 3 4 2		72	1st
P. paradoxa	4 3 3 3 4		4 3 4 4 4		3 4 2 3 3		2 2 3 1 2		2 2 3 1 1		70	2rd
X. spinosum	2 2 3 2 2		4 3 3 2 2		2 2 2 3 2		3 3 2 4 3		1 1 2 2 1		58	8th
A. ochroleuca	4 2 1 4 3		2 4 3 2 2		2 3 3 1 1		3 1 1 1 1		2 3 2 2 2		55	9th
R. crispus	1 2 4 4 2		4 3 4 4 3		3 2 2 0 2		2 2 3 3 1		2 2 2 3 2		62	5th
C.lantus	1 2 1 1 2		2 2 2 2 1		2 1 2 1 0		1 2 1 2 0		1 2 1 2 0		34	17th
G. scabra	4 1 4 4 2		3 4 3 4 4		2 2 2 3 1		3 3 2 1 2		2 3 3 2 1		61	6th
M. citrodora.	3 2 1 3 2		2 2 3 2 1		2 3 3 3 1		3 3 1 1 1		3 3 2 2 2		54	10th
X. trumarium	1 3 4 3 2		3 2 4 4 2		2 4 3 3 2		2 3 4 3 1		3 1 2 2 3		66	3rd
E.spinosissmu	1 2 1 1 2		2 2 2 3 1		2 2 1 3 1		2 2 1 2 1		1 2 2 2 0		41	14th
A.hybridus	3 2 3 3 3		2 2 3 2 2		1 0 2 0 1		2 1 0 1 0		1 1 0 1 1		37	15th
A. fatua	4 3 2 3 2		0 3 2 2 3		3 2 2 0 3		2 1 1 1 0		1 2 3 4 0		49	13th
S. indicum	2 1 2 2 0		2 2 2 2 2		2 0 1 0 2		2 1 1 1 0		1 1 0 2 0		31	18th
D. stramonium	1 1 1 2 0		1 2 1 1 0		2 1 2 2 0		2 1 2 1 0		1 1 1 1 0		27	19th
C.dactylon	1 2 4 4 3		3 3 4 4 3		3 2 2 3 3		3 2 1 2 2		2 3 1 2 2		63	4th
B. pectinatus	3 4 1 3 2		2 3 2 3 2		3 1 3 2 3		3 1 2 1 1		2 1 1 0 2		51	12th
p. ystrophorus	2 1 2 1 1		3 2 3 2 3		0 1 2 2 0		1 3 0 0 0		1 1 2 2 0		35	16th
S. muricatus	2 2 1 3 2		4 4 3 2 0		2 2 1 3 1		2 3 4 0 2		3 3 1 2 1		53	11th
Total	211		244		184		148		145			
Rank	2nd		1st		3rd		4th		5th			

4.9 Factors Responsible for the Introduction and Spread of Invasive Species

Responsible factors for introduction and spread of identified invasive plants in Sebeta Hawas district were wind (31%), vehicles (11%), birds (15%), flood (19%) and animals (22%). However 2% of the cause were unknown (Figure 7)

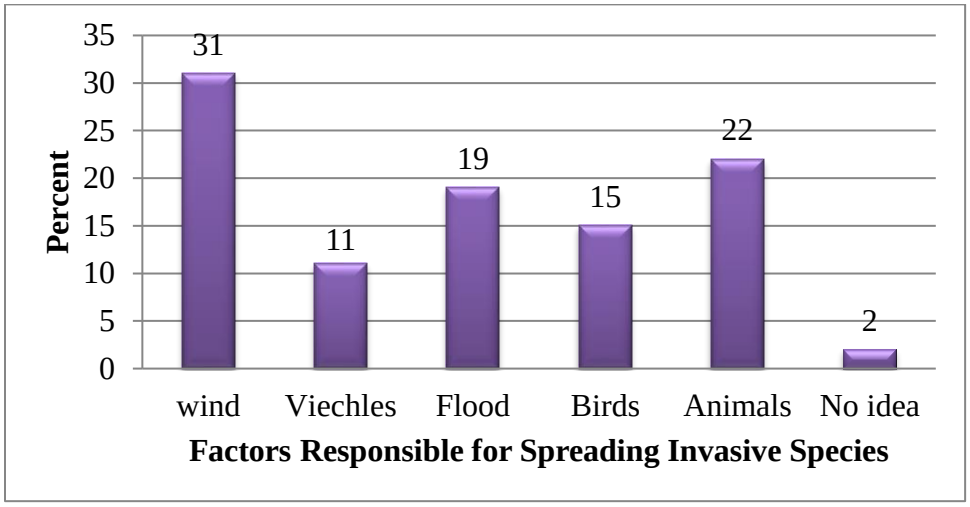

Figure 21. Responsible factors for introduction and spread of invasive species in Sebeta Hawas District

4.10 Invasive Species Controlling Method

The community was found to practice control of invasive plant species by different methods including manual, chemical, biological and integrated methods. As indicated (Figure 6) most of the rural communities (54%) adopted hand weeding techniques. Similarly Chemical spraying and burning were responded as second and third controlling techniques reported by 34% and 8% respondents respectively. On the other hand 5% of the respondents were not familiar with any action to stop the spreading of invasive plants to cultivated lands, grazing land and other communal areas.

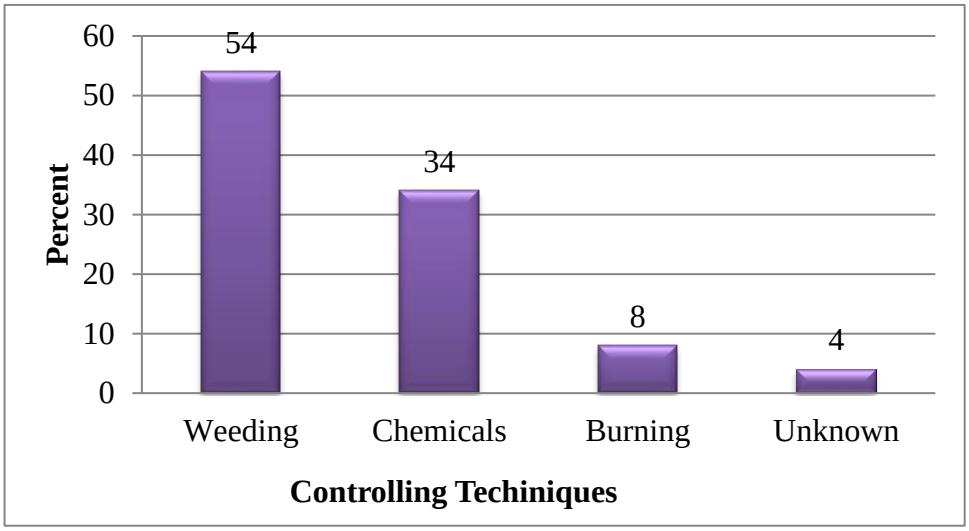

Figure 22. Activities used by respondents to prevent and control of invasive plants

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Invasive species identified by respondents

Results indicated that *Cirsium vulgare, Setaria pumila, Phalaris paradoxa, Xanthium spinosum, Rumex crispus, Carthamus lantus, Argemone ochroleuca, Guizotia scabra, Monarda citrodora,* and *Xanthium strumarium* were identified as major invaders of the sampled areas in decreasing order in degree of invasion.

Though the exact time of introduction to the environment is unknown as reveled by respondents , beyond increasing its population number in the preoccupied areas their invasion to new areas are increasing more rapidly. As reasoned out the degree of invasion of each species were differ depending on species type, ecosystem, growing season and human activity. *Cirsium vulgare Carthamus lantus, Argemone ochroleuca, Xanthium strumarium,* and *Xanthium spinosum,* were mostly found growing on roadside, uncultivated lands, disturbed areas during the dry season. As proved by respondents thorn bearing plants(body structure) attached easily to animals and move away by flood and wind apart from their original site to little water and humus bearing soils. Kok and Gassman (2016); Radosevich *et al*., (2007) explained persistent seed banks, vegetatively propagation, short generation time, easily dispersing (humans and animals), unfertile soil seeking and constant fitness over a wide range of environments are the precondition for invasive species to invade to many ecosystems and adapt it easily

Setaria pumila, Phalaris paradoxa, Amaranthus hybrbidus, Guizotia scabra and *Monarda citrodora,* were grown in cultivated land and pasture areas which contains excess amount of

water in it. Most of these plants have many small seeds which facilitate for easily disperse far away from their mother plants(new areas) either by wind, floods or through the contaminated seeds by human beings. According to UCS (2001) today, with modern, high-speed transport systems and extraordinarily complex global economic patterns, introduction of invasive plants at unprecedented rates across countless borders and ecosystems can be either deliberate or unintentional

5.1.2 Distribution of invasive plants

Results showed the presence of nineteen main invasive plants were found in most sampled kebeles in large quantities. Areas observed being affected by these invasive species were undisturbed, disturbed, riverbanks, roadsides, rural villages, cultivated and non-cultivated land. Majority of identified invasive plants were grown mostly on cultivated, roadsides, Un cultivated lands and disturbed areas. In line with this Wan *et al*.,(2017) and Booth *et al.* (2010) explained that, invasive species manage to invade new ecological areas arising from their native areas through different means and routes.

After establishment in invaded areas; the invasive plant species negatively impair functions and compositions of biodiversity; threat rare plant species and useful agricultural crops. In the present study area useful crops including Teff, Wheat, Chickpea, Lentil and Vetch were found highly invaded. McNeeley *et al*., (2001) and UCS(2001) reported that alien or non indigenous species bring harmful changes to ecosystems, biodiversity, health, economics and even human welfare when invade new areas.

The spread of invasive species in the area relates to high degree of human movements and activities. Humans are an important dispersal agent because of their unlimited mobility. As

revealed by Hester and Harrison (2007) various parts of invasive plants disperse via many routes including human beings that facilitate colonization of new area. Grazing and cultivated lands in the study district are still at risk of invasion by some or more invasive plants in each specific location and the finding is in line with the report by EARO (2003).

Cirsium vulgare (Savi)Ten.

The observation during this survey revealed that *C.vulgare* was found at varying level of infestation emerging with low population some years before to very extensively abundant numbers recently in the study districts (Table 2). The distribution status of *C.vulgare* was not remained restricted in some kebeles only but infested all selected kebeles though there were variation in abundance from area to area. From the total nine kebeles selected, severe infestation was found in Gora Harkiso, Balchi Jimjima, Inlamuna Tajab, Koye and Jawe kebeles. On the other hand low infestation of *C.vulgare* was found in Tafki, Bonde, Haro Jila, and Awash Balo kebeles in roadsides, wastelands and disturbed areas though some areas of these kebels were found free from *C.vulgare* infestation. The wide variation in distribution from area to areas in the selected district could relate to soil type, land topography, water availability, temperature, grazers and human activity. In line with this result Klinkamer and de Jong (1993) as cited in Kok and Gassman (2016) reported that apart from growing on disturbed soils which increase nutrients, water, and light availability; *C.vulgare* grows best on nitrogen rich neutral soils with moderate moisture but absent from sand, high humus content and pure clay soils.

The invasive species *C. vulgare was* observed during the field work in many areas including disturbed, undisturbed, roadsides, rural, grazing and communal sites. White (2008); Kok and Gassman (2016) reported that *C. vulgare* occurs in a wide variety of habitats commonly in

pastures, roadsides, building ruble, arable fields, bank of rivers and streams. The report from inhabitants of the study area confirms the fact that *C. vulgare* 's invasion has increased in many kebeles and it resulted in various adverse effects including reducing pasture, crop yields and affecting livestock health. On the other hand some informants responded that *C. vulgare* serves as a source of food for some animals(donkey) and also uses for fencing. In line of this research, USDA(2017) reported that *C. vulgare* was cited for inhibiting the growth of native plant species in the natural environment partially or completely by outcompeting for space, water, and nutrients. Similarly Kok and Gassman (2016) explained that *Cirsium vulgare* inhibited livestock movement, reduce wool quality, cause injury to animals and has little nutritional value for livestock.

Setaria pumila (Poir) Roam. and *Phalaris paradoxa* Thunb.

Setaria pumila and *Phalaris paradoxa* were the most dominantly and widely distributed grass species mentioned by respondents in the surveyed areas which invaded several areas next to that of *C. vulgare.* The fieldwork complies with the report and the species were observed in many ecosystems typically in rural villages, communal land and crop cultivated land. *S. pumila* and *P. paradoxa* found in all sampled kebeles (especially wheat and Teff sown areas) and in some villages they invaded Chickpea, Lentil and Vetch.

These weeds recently exerting negative impact in the district by reducing production yields, though using selective herbicide and hand pulling minimize its population to some extent temporarily. In line with this finding, Negewo *et al.*, (2011); Reynolds(2002); Ryves *et al*., (1996); BakerGabb (1988); Ansong and Pickering (2013) ; Gal and Alexandre (2000); Woldu and Saleem (2000) as cited in USDA (2016) reported that after *S. pumila* and *P. paradoxa*

dispersed unintentionally by humans, or naturally by wind, birds, and cattle the reduction of crop yields due to *S. pumila* and *P. paradoxa* was recently became prominent in the affected cropping system in Ethiopia.

Xanthium spinosum L.

X. spinosum was found growing almost in all sampled kebeles of the district though there is a wide variation in its population. It was prominently seen in pastures, along roads and disturbed areas including cultivated lands. As responded by the informants and observed during the field work the nature of plant species (hooked spines) together with the dispersing factors has played a great role for the distribution and intrusion to new ecosystem. Flood, wind and animals fur were the main dispersing factors in the sampled areas that enabled *X. spinosum* invade the new areas easily. In accordance with this response DiTomaso and Kyser,et *al*.,(2013) and Holm *et al*.,(1977) wrote that *X. spinosum* is highly invasive weed capable of growing in a wide range of environmental conditions mainly in cultivated land, along road, disturbed areas and also sometimes commonly found around water holding areas.

After intrusion and establishing themselves the new areas, *X. spinosum* causes plants yield loss and physical injury of animals including human beings. This threaten native wildlife by competing agricultural crops, altering habitats (increase erosion), affecting Water flow and quality (Witt and Luke, 2017).

Xanthium strumarium L.

Xanthium strumarium is a common monociuos annual herbaceous plant specious which belong to the Asteraceae family. This species was found wide spread in some parts of Tafki, Bonde and Haro jila kebeles. A single plant produce many seeds which contains burrs that facilitates its

dispersal to a wide area typically in, roadside, grazing areas , rural villages, cultivated and non cultivated landmasses.

Chickpea, Lentil and Vetch species were the most dominantly infested agricultural crops in the district and hence they exhibited a yield reduction. Similarly, *X.strumarium* causes reduction in forage production and also it causes physical injury of domestic animals, and humans. In supporting this idea, DiTomaso and kyser, *et al*.,(2013); White (2008) explained that *X. strumarium* is a widespread weed that can grow in most environment tolerating many soil types posing reduction of forage production crop yield reduction, toxicity to livestock and injury to humans.

Amaranthus hybridus L.

Amaranthus hybridus is a summer annual herbaceous weed which reproduce by its small seeds and hence high opportunity of dispersing by dispersing agents. The species is commonly found on cultivated fields, waste places, roadsides, and disturbed habitats. In Inline with this finding Monaco *et al*., (2012) explained that, *A. hybridus* reproduces by its small seeds and disperses easily by wind to a wide variety of lands like cultivated fields, waste places, roadsides, watery land and disturbed habitats.

This species found growing in crops like Wheat, Teff, Lentil and Vetch cultivated fields. The population number of *A. hybridus* is high during the summer season and more prominently found in Wheat cultivated lands. Its abundance results in competition for nutrients with other crops and hence reduces their yield. As revealed by respondents apart from reducing yield of crops they kill Cattles which consumed it at its maturity time. In supporting this idea, EARO (2019) and Volkenburg, *et al*.,(2020) reported that *A. hybridus* is a principal weeds that pose reduction of

harvesting efficiency and yield of crops, harboring of parasite and poisoning of cattle by its Nitrate content.

Argemone ochroleuca Sweet.

Results and the corresponding field observation confirmed that *Argemone ochroleuca* is found infesting most surveyed kebeles. It was reasoned out that the species ability to grow in less water contained soil type (or dried soil) provide it more opportunity to live in wide areas. In addition to this the availability of spine on its body facilitates for attachment to movable objects including living things that facilitates its dispersal. Inderji (2005) reported the dissemination of *A. ochroleuca* through transportation of construction material (sand) at large. Its soft spine and ability to grow in all climatic condition provides its more stability (UCS, 2001) which in turn prevents availability of vacant space for grazing even for sleeping and standing on the place (Witt and Luke, 2017; White, 2008).

5.1.3 Degree of impact of invasive plants

Results show that majority (97%) of the informants reported that invasive plants do have serious impact on their livelihood and environment. The perception of each respondents about the invasive species of their locality varies from area to area. The identified invasive plants are responsible to reduce yield of widely cultivated crops either by providing suitable habitats for pests in communal and uncultivated lands or competing for water, nutrient and sunlight during its growing time in the cultivated lands. Apart from displacing pasture and other native plant, they physically injure domestic and wildlife using their physical structures though some of them has some nutritional values and fencing purpose in the study area. Based upon these and other problems they come up with, in their life in their environment most of the respondents had more awareness regarding the degree of impact of invasive plants. In line with this result Witt

and Luke (2017) wrote that invasive plants interfere with crop and pasture production, serve as harboring agents, affect soil nutrient recycling, permanently alter natural ecosystems and benefits they provide in nature and to people. Generally, results indicated that degree of impact of the invasive is increasing with time.

5.1.4 Impact of invasive plants on commonly cultivated crops

From field observation and the respondents answer the most dominant invasive weed species found spreading in Teff cultivated fields in the study district were *P. paradoxa*, *S. pumila* and *R. crispus*. Similarly they answered that *S. muricatus, G. scabra* and *M. citrodora* were found infesting Teff crops but with limited quantity. These invasive grass weeds especially *S. pumila* was reported for its impact in reducing yield of crops (Wheat and Teff), deteriorating the quality of produced seeds and trim down the market value of wheat. In line with this UCS (2001), White (2008) ; Witt and Luke (2017) reported that weed or invasive plants interference is one of the most important factor contributing to the loss of crops yield, injuring livestock and reducing forage of animals.

X. strumarum, C. dactylon, R. crispus, G. scabra, A. ochroleuca, X. spinosum, and *C. vulgare*, were found spreading in Chick pea, Lentil and Vetch cultivated fields and pose negative Impacts(in decreasing order). The depth of the impact of invasive species varies based on the crop type, location and moisture content of the soil. In line with this answer, Radosevich, *et al*., (2007) and Asif *et al*., (2014) wrote that, nature of crops, cultural practice, cropping pattern, soil type, moisture availability, location and season cause variation in density and distribution of weed species found in a cropped fields.

Generally, invasive species infestation was very serious and less attended issue in Ethiopia, though there are some actions being taken in reducing it using traditional knowledge and chemicals. The invasive species infesting the commonly cultivated crops such as Teff, Wheat, Chickpea, Lentils and Vetch were one of the major factors reducing crop yield, deteriorate quality of crops and reduce farmers' income. In line with respondents answer White (2008) explained that invasive species are undesirable plants, which infest different crops and bring negative effect on crop yield either through competition for water or nutrients or space for light.

5.1.5 Factors responsible in spread of invasive species

The present finding indicated that the major factor responsible for spread of invasive plants was wind. Achenes of *C. vulgare*, burr of *X. strumarium* and seeds of *A. hybridus* and *R. crispus* were small in size and light in weight and assumed to spread by wind. The wide spread of *X. spinosum, X. strumarium, C. vulgare* and *A. ochroleuca* links with their morphology which aids them to attach to the fur and feather of domestic animals. In line with this Inderji (2005) reported that the hooked spines on the fruit of invasive species help adhere easily and cling firmly to fur and feather of animals which facilitates their spread to different land uses.

Respondents reported that vehicles loaded aid are one of the factors in introduction of *C. vulgare*, and *X. spinosum* into their respective localities. Floods may also serve as major factors for dispersal of invasive plants such as *X.strumarium* from region of infestation into other non-infested areas. Likewise, McNeely *et al*., (2001) and Monaco *et al*., (2012) explained that agents such as water, wind, vehicles, or livestock, are commonly responsible to transport seeds of plants at remarkably high speeds over long distances.

Ethiopian economy is starting diversifying with the emergence of different economic sectors that generates revenue to be invested in the other sector. This diversification in the economy facilitates the increasing of travels, tourism, access to port, new commercial development, expansion of airport terminals, new residential area establishment and brought significant changes in agricultural practices. The overall development undoubtedly increasing infestation of new invasive plant species into Oromia region adequately promoted infestation of invasive plants in the region during the past. In line with this, with modern, high-speed transport systems and extraordinarily complex global economic patterns (global change), species were changed at high rates across each borders and ecosystems (UCS, 2001)

5.1.6 Invasive species controlling methods

The community member reported that they practice the invasive species control using various methods, the common methods being manual, chemical, biological and integrated methods. Local communities in the study still utilize different controlling options to prevent further spreading and even complete removal (if possible) of it from the invaded areas. Most of the rural community (54%) respondents commonly practice hand weeding techniques. Chemical spraying was responded as second (34%) main controlling methods of invasive plants from further spreading. It was also reported that subsequent clearing and uprooting of invasive plants particularly for *C. vulgare*, from cultivated lands, grazing land and other communal areas was a prior for the community. To remove invasive plants mainly *P. paradoxa,* and *S. pumila* from farm land but not from non-farm areas, chemical spraying was referred more applicable . This option lessened burden to cultivate crops comparing with hand weeding. On the other hand, some respondents (8%) take action of removing invasive plants using burning of entire plants. This method kills the whole species in communal and grazing areas.

Almost the respondents informed the researcher during the data collection period that any containment effort was applied to control the most devastating invasive plants (*C. vulgare, S .pumila, P. paradoxa* and *X. strumarium*) across all locations of the region by land owners.

As suggested by many respondents all preventing and controlling measures were targeted to control invasive plants found on their individual farms. On the other hand they ignore those found in border areas of the farm and other communal areas. As written by McNeeley *et al*., (2001) engaging all communities and neighbors' knowledge cooperatively plays a significant role in management and preventions of invasive plant species

Thus, the approach of local communities in controlling of invasive plants was not conducted in a desirable and sustainable manner to bring long-lasting solutions. Local communities may destroy invasive plants temporarily infested their farm by adopting varied management options. This action may not address the sources of the problem which helps frequent invasion coming from farm border areas, communal area and backyards. Therefore, the sources and real problem of farm infestation was the regular spreading of these invasive plants found outside of the farm. It indicated that knowledge and perception of respondents on prevention and controlling measures of invasive plants in their respective localities was significantly poor. As most of the invasive plants present in eastern Africa were intentionally introduced, the most effective way is preventing their further introduction in the first place. After undertake a socio-economic survey among communities to determine the impacts of the invasive plant on livelihoods it is essential to implement a controlling methods which followed by rehabilitation or restoration(Witt and Luke (2017).

5.2 Conclusion

Introduction of undesirable non-woody plants have been threatened agricultural production system and other ecosystems across Sebeta Hawas District. For many years over grazing and expansion of cultivated lands for agricultural products due to rapid population growth have facilitated ecological disturbance and threatened biodiversity in the region.

After conducting this research nineteen invasive plants have been identified and recorded in the study areas. Among this *Cirsium vulgare*, *Setaria pumila*, *Phalaris paradoxa*, *Xanthium spinosum, Rumex crispus* and *Argemone ochroleuca* were highly distributed invasive species. They have been seen in almost all land use systems in the study area. Invasive species were found growing in disturbed, undisturbed, riverbanks, roadsides, rural villages and urban areas. It was recognized that majority of invasive plants were observed growing mostly in roadsides, non cultivated and disturbed areas(cultivated lands).

Invasive species negatively impair function and composition of other plant and agricultural crops in varied degrees. Teff, Wheat, Chickpea, Lentil and Vetch were widely cultivated agricultural crops and affected by invasive species in various degrees. *S. pumila*, *P. paradoxa* and *X. strumarium* were found to pose reduction of agriculture crops' yield

Wind, animals, flood, vehicles and birds were recognized as the spreading agents that make possible invasion of invasive plants. Wind, followed by animals play a great role in spreading many species. In the study area, communities commonly practice hand weeding, chemical, and burning as control options to prevent further spreading and complete removal of invasive plants from invaded area. The knowledge the respondents had regarding the degree of impact of the identified invasive species was high though the controlling methods applied so far were not

satisfactory. Some of the respondents' knowledge and perception on prevention of invasive plants in their respective localities have been significantly poor.

5.3 Recommendation

Early detection of the problem of invasive plants, preventive and management strategies to eliminate introduction of undesirable invasive plants are more likely to be effective.

- Farmers must use appropriate type of weed prevention techniques(cultural, mechanical, chemical and biological) either separately or in combination based on the nature of invasive species and given by agriculture expert
- Invasive plants grown in bare farm lands and other ecosystems must be collected and burnt before their seeds ripe time to avoid their further intrusion to new areas by farmers and communities
- Community members need to work cooperatively by prioritizing the invasive species impact in the ecosystems so as to get rid of it from not only from their own land but also from communal (non cultivated) lands
- Development agents together with the district administrator, should deliver appropriate awareness creation for farmers about invasive weed types of the area and the common agents which are responsible for expansion of invasive plants and their preventive techniques.
- Agricultural experts found at different levels(districts, zonal, regional and national) need to conduct research to produce new weed resistant agricultural crops
- Expertise and stakeholders should do further research at a regional and national level so as to minimize further spread and complete removal of invasive species
- Governmental and non-governmental agents must provide appropriate financial and materials support for researchers working on invasive species

Reference

Abebe Gizachew Abate .(2006). "Contested land rights: Oromo peasants struggle for livelihood in Ethiopia", Master's thesis, University of Troms, p. 44

Asif, M., Iqbal, M. Randhawa, H. and Spaner, D. (2014). Managing and Breeding Wheat for Organic Systems: Enhancing Competitiveness Against Weeds. New York Dordrecht London .Springer Briefs in Agriculture

Booth, B. D., Murphy, S. D. & Swanton, C. J. (eds.). (2010). Invasive Plant Ecology in Natural and Agricultural Systems, 2nd edition. London UK: CAB international in 2003.ISBN-13:978 0 8519 9528 1

Center for Agriculture and Bioscience International **(**CABI). (2019). *Amaranthus hybridus* (Smooth pigweed).Datasheet Type(s); Invasive Species ; pest ; Host plant…*Amaranthus hybridus* (smooth pigweed);flowering habit

Convention on Biological Diversity CBD .(2005). Invasive Book Species.: *http://www.biodiv.org/*programmes/crooscutting/book.

Convention on Biological Diversity(CBD). (2009). Ethiopia's 4th Country Report. Institute of Biodiversity Conservation.

Delivering Alien Invasive Species Inventories in Europe(DAISIE). (2008). Handbook of Alien Species in Europe: Invading Nature Springer series in Invasion Ecology Volume 3(1st Edition.). TN, USA

DiTomaso, J.M., G.B. Kyser et *al*. 2003.Weed control in Natural Areas in the Western United States. Weed research and information Center, University of California.544 pp.

Ethiopian Agicultural Research organization(EARO). (2003). Removing Barriers in Invasive Plant Management in Africa. Global Environmental Facility(GEF) Proposal for PDF Block Grant. EARO, Addis Ababa.

Hester, R. E. and Harrison, R. M. (2007). Biodiversity Under Threat. The Royal Society of Chemistry . ISBN: 978-0-85404-251-7.ISSN: 1350-7583?

http://www.fs.usda.gov/goto/r3/invasivespecies

Husen Azamal, Mishara,V.K, Semwal, K. and Dinesh. (2012). Biodiversity Status in Ethiopia and Challenges(In: 'Environmental Pollution and Biodiversity' Vol.-1,Bharati K.P.,Chauhan A. and Kumar P., Eds., Discovery Publishing House Pvt Ltd.New Delhi,India.pp. 31-79.(ISBN 978-93-5056-149-2).

Kohli, R.K., Jose, S., Singh, H.P. and Batish, D. R.(Eds.). (2009). Invasive Plants and Forest Ecosystems. CRC Press: London, New York

Kok, L.T. and Gassman, A. (2016). 19 BULL THISTLE (SPEAR THISTLE)-Biological control of Invasive Plants in the Eastern United States, USDA Forest Service Publication FHTET-2002-04,413p.

McNeely, J.A., Mooney, H.A., Neville, L.E., Schei, P., and Waage ,J. K. (eds.). 2001. A Global Strategy on Invasive Alien Species. IUCN Gland, Switzerland, and Cambridge, UK. x + 50 pp.

Monaco, T. A., & Sheley,R. L.(eds.) .(2012). Invasive Plant Ecology and Management: Linking Processes to Practice

PIER, (2013). Pacific Islands Ecosystems at risk., Honolulu, Hawaii, USA : HEAR, University of Hawaii.

Radosevich, S. R. , Holt,J. S. & Ghersa, C. M. (2007). Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management(3rd edition.). A John Willey & Sons, Inc. Hoboken, New Jersey, Canada

Union of Concerned Scientist(UNC). (2001). The Science of Invasive Species: An Information Update by Union of Concerned.

United States Department of Agriculture (USDA). (2016).Weed Risk Assessment For Phalaris Paradoxa L.(Poaceae)-Awaned Canary-Grass. Animal And Plant Health Inspection Service.

United States Department of Agriculture (USDA). (2017). Field Guide for Managing Annual and Biennial Invasive Thistles in the Southwest. `

Volkenburg,H.V. Guinel,F.C. and Vessuer,L.(2020). Impacts of Smooth Pigweed (Amaranthus hybridus) on Cover Crops in Southern Ontario). Department of Biology, Brock and Walifrid Laurier University: ON N2L 3C5,Canada.

Wan Fanghao, Jiang Mingxing and Zhan Aibin (Eds.). (2017). Biological Invasions and Its Management in China Vol.1. Invading Nature Springer Series in Invasion Ecology(11Eds.). Beijing, China: Springer Science Business Media B.V.

Weaver SE. (1984). Differential growth and competitive ability of Amaranthus retroflexus, A. Powellii and A. hybridus .Canadian Journal of Plant Science,64(3):715-724

White, M.R. (2008). Field Guide to Noxious and Invasive Weeds: Known to Occur or Are Potentially Occurring on the Apache-Sit greaves National Forests

Wilcox, C. P. and Turpin, R. B.(Eds.). (2009). Invasive Species: Detection, Impact And Control. New York. Nova Science Publishers, Inc.

Witt, A. and Luke, Q. (2017). Guide to the Naturalized and Invasive Plants of Eastern Africa. CAB international. Nairobi, Kenya.ISBN-13:9781786392145

APPENDICES

Appendix -1. Format for collecting status, distribution and impact of invasive species

(Checklist of Semi-structured Interviews to be answered by households (informants)

I. General information on respondents:

Name of the Informant----------

Age-------- Sex------

Marital status: Single----------married--------Divorced----------

Occupation----------

Level of education ----------Vernacular Name of the Species

II. Distribution status of invasive species

1. List invasive species(weeds) that found in your area?

2. Which of these weeds more dominantly found? List their dominancy level in decreasing order.

5. Which species has/have more rapidly spreading rate currently?

3. Which species has/have more widely distributing status in the area?

4. How the species is introduced?

A) intentional B) marketing C) accidental D) trade E) aid shipment

6. In which area do you find invasive species mostly?

A) disturbed area B) roadsides C) grazing areas D) undisturbed area E) rural villages

7. How is mechanism of encroachment or invasion?

A) seed production B) root system C) others

III. Impacts of invasive species

8. Is there any effect it can cause on other living organism? A) Yes B) No

9. How invasive species effect others?

A) allelopathy B) shedding C) consumption of resources/ nutrients, water

10. In which community does the species bring greatest impact?

A) grazing land B) crop field C) agro forestry D) plantations E) others

11.Which organism is affected by this species?

A) human beings B) livestock C) cultivated crops D) others

12.What type of health effect does the species brings on human beings?

13. List crops as much as you can and write invasive species(weeds) which affect each crops?

IV. Mechanism to be employed to wipe out the species

14. Is there indigenous knowledge to wipe out the species?

A) Yes B) No

15. How do you minimize the detrimental effects of the species? (Method employed to be beneficial

16. What is the beneficial aspect/economic importance of the species?

A) market value B)shading C) construction D) fuel wood/charcoal

E) forage/grazing value F) medicinal G) food

Appendix -2. List of invasive species identified (Scientific name, family, local name, habit /growth form/) in Sebeta Hawas District

Scientific name	Family	Local name	Growth form	Percent
Cirsium vulgare (Savi)Ten.	Asteraceae	Shokoru	Herb	C.G 5
Setaria pumila (Poir) Roam.	Poaceae	Migira Saree	Herb	C.G 6
Phalaris paradoxa Thunb.	Poaceae	Shishi	Herb	C.G 15
Xanthium spinosum L.	Asteraceae	Shokole	Herb	C.G 3
Argemone ochroleuca Sweet.	Papaveraceae	Naci-Labash	Herb	C.G 7
Rumex crispus L.	Amaranthaceae	Shulti	Herb	C.G 27
Carthamus lantus L.	Asteraceae	Qore dalacha	Herb	C.G 8
Guizotia scabra Vis.) Chiov.	Asteraceae	Hadaa	Herb	C.G 9
Monarda citrodora L.	Lamiaceae	Baaleweranti	Herb	C.G 18
Xanthium strumarium L.	Asteraceae	Bandaa	Herb	C.G 1
Echinops spinosissmu Turra.	Asteraceae	Qore adii	Herb	C.G 10
Amaranthus hybridus L.	poaceae	Fincan Loni	Herb	C.G 2
Avena fatua L.	Solanaceae	Sinara	Herb	C.G 11
Solanum indicum Cav.	Solanaceae	Hiddii	Herb	C.G 12
Datura stramonium L.	Poaceae	Manjii	Herb	C.G 13
Cynodon dactylon L.	Poaceae	Loa	Herb	C.G 1 4
Bromus pectinatus Thunb.	Asteraceae	Ginci	Herb	C.G 4
parthenium hystrophorus L.	Fabaceae	Faramsisa	Herb	C.G 16
Scorpiurus muricatus L.	Asteraceae	Kala	Herb	C.G 17

Appendix - 3. List of informants participated in invasive species study

No	Name	Sex	Age	Kebele	Work
1	Dibaba Ashetu	M	25	Balchi Jimjima	Farmer
2	Bikila Jimjima	M	29	Balchi Jimjima	Farmer
3	Tulu Furi	M	38	Balchi Jimjima	Farmer
4	Sena Bokona	F	28	Balchi Jimjima	Student
5	Sena Bokona	M	38	Balchi Jimjima	Farmer
6	Samuel Hirpa	M	26	Balchi Jimjima	Farmer
7	Worku Megersa	M	43	Balchi Jimjima	Student
8	Tayitu Irana	F	38	Balchi Jimjima	Farmer
9	Boro Hunduma	M	39	Balchi Jimjima	Officer
10	Abayinesh Galatu	F	27	Balchi Jimjima	Farmer
11	Gosa Disasa	M	44	Qoye	Officer
12	Abdisa Fayisa	M	37	Qoye	Farmer
13	Kaftamu Dajane	M	33	Qoye	Farmer
14	Balaynesh Gizawu	F	39	Qoye	Farmer
15	Tesfaye Begna	M	51	Qoye	Farmer

16	Amelework Chane	F	29	Qoye	Farmer
17	Damaka Baca	M	41	Qoye	Farmer and Merchant
18	Tamene Ragasa	M	43	Qoye	Farmer
19	Biritu Kasaye	F	20	Qoye	Farmer
20	Adugna Balcha	M	36	Jawe	Officer
21	Tsehay Gamachu	F	27	Jawe	Student
22	Zenbaba Negesa	M	60	Jawe	Farmer
23	Tarecha Saboka	M	26	Jawe	Farmer
24	Caltu Hunde	F	40	Jawe	Farmer
25	Arado Mokonin	M	38	Jawe	Merchant and Farmer
26	Lami Tulu	M	35	Jawe	Farmer
27	Shimalis Gabayo	M	32	Jawe	Farmer
28	Firu Megera	M	40	Jawe	Farmer
29	Gadisa Wakjira	M	38	Jawe	Farmer
30	Tsehay Tadasa	F	36	Jawe	Officer

31	Mekonin Abara	M	17	Tafki	Farmer
32	Fayisa Likisa	M	68	Tafki	Farmer
33	Ababa Lata	M	18	Tafki	Farmer
34	Dajane Tarecha	M	27	Tafki	Farmer and Merchant
35	Darare Lama	F	35	Tafki	Farmer
36	Alamayo Adugna	M	34	Tafki	Farmer
37	Badada Ragasa	M	20	Tafki	Student
38	Dasi Baca	F	50	Tafki	Farmer
39	Abush Galata	M	39	Tafki	Farmer
40	Zawudu Guta	M	38	Tafki	Officer
41	Gazagn Hirko	M	41	Awash Balo	Farmer
42	Abaru Sime	F	18	Awash Balo	Farmer
43	Lama Bonsa	M	41	Awash Balo	Farmer
44	Adunya Ayana	M	34	Awash Balo	Farmer
45	Bayana Abdi	M	42	Awash Balo	Officer
46	Bacaqa Badada	M	25	Awash Balo	Farmer

47	Kasahun Disasa	M	28	Awash Balo	Farmer
48	Lami Ragasa	M	39	Awash Balo	Farmer
49	Taji Mamo	F	25	Awash Balo	Farmer
50	Habte Amanu	M	28	Awash Balo	Farmer
51	Bayisa Calaa	M	40	Bonde	Farmer and Merchant
52	Jitu Kabada	F	35	Bonde	Farmer
53	Bayana Damise	M	40	Bonde	Farmer
54	Tanirat Homa	M	40	Bonde	Farmer
55	Taco Kacha	M	50	Bonde	Farmer
56	Gazu Shaya	M	43	Bonde	Merchant
57	Guta Nagasa	M	51	Bonde	Farmer
58	Adugna Gudata	M	60	Bonde	Farmer
59	Diriba Nada	M	28	Bonde	Farmer
60	Gete Emana	F	42	Bonde	Farmer
61	Balcha Lami	M	38	Haro Jila	Officer
62	Niguse Fiche	M	45	Haro Jila	Farmer

63	Taru Guta	M	27	Haro Jila	Farmer
64	Tadasa Ragasa	M	29	Haro Jila	Farmer
65	Badada Ragasa	M	45	Haro Jila	Farmer
66	Angecha Tulu	M	45	Haro Jila	Farmer
67	Ayele Abate	M	38	Haro Jila	Farmer
68	Ayantu Lama	F	24	Haro Jila	Farmer
69	Takele Amanu	M	35	Haro Jila	Farmer
70	Tamirat Asafa	M	47	Haro Jila	Officer
71	Tariku Shari	M	48	Gora Harkiso	Officer
72	Girma Lama	M	24	Gora Harkiso	Farmer
73	Caltu Yadata	F	25	Gora Harkiso	Farmer
74	Gudata Gamachu	M	24	Gora Harkiso	Farmer
75	Meto Cala	F	51	Gora Harkiso	Farmer
76	Guta Galan	M	27	Gora Harkiso	Merchant
77	Abara Nagashu	M	19	Gora Harkiso	Farmer
78	Balaynesh Ketema	F	39	Gora Harkiso	Farmer

79	Burtukan Ketaema	F	36	Gora Harkiso	Officer
80	Cemeda Tasu	M	23	Gora Harkiso	Officer
81	Kuma Gamachu	M	32	Enlamuna Tajab	Farmer
82	Mosisa Tadasa	M	29	Enlamuna Tajab	Farmer
83	Charu Mangasha	M	50	Enlamuna Tajab	Farmer
84	Angasa Kusha	M	24	Enlamuna Tajab	Farmer
85	Ababa Bikila	M	29	Enlamuna Tajab	Farmer
86	Amare Alamu	M	34	Enlamuna Tajab	Farmer
87	Kalbesa Balacho	M	42	Enlamuna Tajab	Farmer
88	Abebech Taklu	F	39	Enlamuna Tajab	Farmer
89	Dagim Wasihun	M	36	Enlamuna Tajab	Merchant
90	Hangare Abara	F	41	Enlamuna Tajab	Office
91	Zagaye Tayir	M	25	Balchi Jimjima	Student
92	Amilmal Balacho	F	39	Qoye	Farmer
93	Asefa Alemu	M	26	Jawe	Farmer
94	Ayele Gemu	M	22	Tafki	Farmer

95	Tamirat Haile	M	38	Awash Ballo	Farmer
96	Taye Dori	M	33	Bonde	Farmer
97	Dulume Wedajo	M	40	Haro Jila	Farmer
98	Kabtamu Gari	M	37	Gora Harkiso	Farmer
99	Tufa Hunde	M	37	Enlamuna Tajab	Farmer and Merchant
100	kasaye Jima	M	32	Qoye	Farmer

Appendix-4. Photographs of field activity during data and specimen collection

Figure 1. During collecting *Cirsium vulgare* (Savi)Ten. specimen from Jawe kebele, 2020

Figure 2. During collecting *Setaria pumila* (Poir) Roam. specimen from Gora Harkiso kebele, 2020

Figure 3. During collecting data using semi structured interview in Awash Balo Kebele),2020

Figure 4. During collecting *Monarda citrodora* L. specimen from Kudada(Tafki Kebele),2020

Figure 5. During Collecting *Argemone ochroleuca* Sweet.specimen from Inlamuna Tajab kebele, 2020

Figure 6. During collecting data using semi structured interview in Yuyu(Inlamuna Tajab kebele),2020

Figure 7. During collecting *Xanthium spinosum* L. specimen from Fiche (Gora Harkiso kebele,2020

Figure 8. During collecting *Amaranthus hybridus* L.specimen from Haro Jila kebele, 2020

Figure 9. During collecting *Rumex crispus* L. specimen from Soke (Awash Ballo), 2020

Declaration

I Cheru Geremew Wedajo confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. The material contained in this thesis has not previously been submitted for a degree at Addis Ababa University or any other university and all the sources of materials used for thesis are acknowledged.

Name Cheru Geremew

Signature----------

Date-August 2021

Place Addis Ababa University

This thesis has been submitted for examination with my approval an academic advisor

Advisor; Ermias Lulekal(PhD)

Signature----------

Date-August 2021