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Invasive Alien Weed Species Distribution, Impacts on Agriculture, Challenge and Reaction in Ethiopia: A Review

Gedyon Tamiru
Hawassa Agricultural Research Centre, Southern Agricultural Research Institute
P.O. Box 2126, Hawassa, Ethiopia

Abstract
Invasive Alien Species are of a great concern in Ethiopia, posing particular problems on agricultural lands, range lands, biodiversity of the country, national parks, water ways, rivers, power dams, roadsides and urban green spaces with great economic and ecological consequences. In Ethiopia, there are about 35 invasive alien species were identified. Foremost among these are *Parthenium hysterophorus* L., *Eichhornia crassipes* (Mart.) Solms, *Prosopis juliflora* (Sw.) DC**.**, *Lantana camara* L., *Argemone ochroleuca* Sweet, *Xanthium strumarium* L., *Ageratum conyzoides* L., *Datura stramonium* L., *Nicotiana glauca* Graham, *Senna didymobotrya* (Fresen.) Irwin & Barneby and *Senna occidentalis* (L.) Link. They have been identified as a threat to Agriculture land, biodiversity of the country and economic well-being of its people. Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia. Parthenium exert strong allelopathic effect and reduce the growth and reproductively of associated crops. Labor-intensive control of parthenium resulted in some of them developing skin allergies, itching, fever, and asthma. *Eichhornia crassipes* restrict proper water flow, water loss through excessive evapo-transpiration, interference with fishing, grazing and crop production activities, effect on power generation, increase siltation, flooding, and increase cost of production. Prosopis form impenetrable thicket that prohibits free movement of people and animals and its thorns damage eyes and hooves of animals. Current costs of Prosopis invasion in Ethiopia was estimated 2.2 billion Birr. More resources have to be invested to tackle the IAS problem as the estimated loss is disproportionate to the cost of investment on IAS research and development activities. This paper attempts to review the available research information on IAS, i.e, distribution and spread, impacts, control measures and suggest the future prospects on research and management.
Keywords*:* Alien Invasive Species, Ecological distribution, Ethiopia, Impact

1. Introduction

Invasive Alien Species refer to plants, animals or microorganisms that are not native to specific ecosystem and whose introduction threatens food security, biodiversity, health or economic development (McNeely *et al*., 2001). Invasive species are of concern because of their capability of spreading fast, their high competitiveness and ability to colonize new areas within short periods. The nature and severity of the impacts of these species on society, economic life, health and national heritage are of global concern (McNeely *et al*., 2001).

According to CBD (2005), invasive alien species are introduced deliberately or unintentionally outside their natural habitat, where they have the ability to establish themselves, invade, out-compete natives and take over the new environment. Invasive species have significant social, ecological and economic impacts. They reduce agricultural yields, irrigated crop lands, grazing areas, water availabilities, and contribute to spread of vector born diseases (Essa *et al*., 2006).

According to Raghubanshi *et al*. (2005), invasive alien species have unique characteristics over the native ones. They do not need special environmental requirement for seed germination, have rapid seedling growth and produce seeds for longer period of time as long as environmental condition permit, they are also highly tolerant to climatic and edaphic variations and have an ability to compete and drive off other species from their habitat. Moreover, they can reproduce sexually and asexually.

Ethiopia is rich in biodiversity and is one of the 12 Vavilovian centers of origin (UNEP, 2003). However, there are about 35 invasive alien species threat the biodiversity of the country (McGinley, 2007). Foremost among these are *Parthenium hysterophorus* L.*, Eichhornia crassipes* (Mart.) Solms*, Prosopis juliflora* (Sw.) DC**.***, Lantana camara* L., *Argemone ochroleuca* Sweet*, Xanthium strumarium* L., *Ageratum conyzoides* L., *Senna occidentalis* (L.) Link, *Datura stramonium* L.*, Nicotiana glauca* Graham and *Senna didymobotrya* (Fresen.) Irwin & Barneby (Boy and Witt, 2013). These IAS pose a serious threat to agriculture (crop and livestock), livelihoods and human health at various levels (Haysom and Murphy, 2003).

The aim of this paper is to review the research information on distribution, impact on agriculture, biodiversity and socio-economic aspects, control intervention and challenges of foremost invasive alien weed species; and the future prospects on research and management.

2. Major Invasive Alien weeds species

2.1. Parthenium hysterophorus L.

Parthenium hysterophorus, known as Parthenium weed, has in recent decades become one of the fastest spreading and most menacingly destructive of all alien plant invaders. Native to Mexico, Parthenium weed has long been a scourge on the Indian sub-continent and in Australia, having in both regions been introduced accidentally in the 1950s as a seed-contaminant in imported produce.

2.1.1. Local name

- Faramsiisa (Oromia); Harama dhimbil (Somalia)

2.1.2. Descriptive features

Erect, perennial herb, up to 60 cm high. Stem repeatedly branched. Leaves are alternate, pinnate to bi pinnate, grey-green. petiolate; petiole narrowly winged, up to 2.5 cm long; upper leaves simple, linear or bi-lobed at base. Receptacle is flat, small. Outer phyllaries are 5, oblong- ovate, 3-5-veined, keeled at base, green above and scarious below, appressed-pubescent commonly on the upper half and at margins. Ray floret, are female and fertile.. Disc florets are white, 4-lobed, and persistent; anthers excreted at anthesis; pollen grains white. Cypselas are black, oblanceolate to narrowly obovate, keeled toward apex on the inner side, glabrous on the lower half, densely papillose toward apex, margins narrowly hyaline. Pappus of 2 stiff hyaline scales, 0.5-0.8 mm long, entire or irregularly notched (Hedberg et al., 2004).

2.1.3. Introduced in Ethiopia

In Ethiopia, it is believed to have been introduced in 1976/77 with army vehicles from Somalia and has become a serious weed both in arable and grazing lands (Tamado et al., 2002). Others also believed that *P. hysterophorus* may have also been spread through the provision of humanitarian emergency food aid. For example, this weed was introduction to Africa through grain shipments for famine relief to Ethiopia (McNeely et al., 2001).

The weed was first seen in 1980s near food-aid distribution centers in Ethiopia (GISP, 2004). However, currently, it is widely distributed in Ethiopia. In eastern Ethiopia, Tamado (2001) reported that parthenium weed is the second most frequent weed (54%) after *Digitaria abyssinica* (63%). The presence of Parthenium in Kenya and Somalia (Njorage, 1991) and the capacity of the seed to travel long distance through wind, water, and other means also suggested the possible entry into Ethiopia from these neighboring countries.

2.1.4. Ecological distribution

In the Amhara region, it is estimated that about 37,105 hectares of land is infested with parthenium (Bezabieh and Araya, 2002). It is abundantly found in Gojjam, in south and north Gonder with the potential to spread to agricultural districts of Metama and SetitHumera (Bezabieh and Araya, 2002). Furthermore, the weed is well established in many districts of South, north, and central Tigray. In one district alone, Alamata, about 10,000 hectares of the land has been infested with parthenium (Bezabieh and Araya, 2002). In much of the low lands of Wello, Parthenium has become the most dominant weed. In these areas, the weed has been reported in 42 Woredas.

The weed is also a serious problem in the Regional State of Oromia although there is no actual survey data on the total area of land infested in the region. Currently, Parthenium is spreading at an alarming rate in Eastern Ethiopia; the central rift valley, and neighboring localities of Afar Region, East Shewa, and Bale and in Southern Ethiopia

Taye Tessema (2002) reported that the plant occurred in the towns, usually on roadsides, and vacant sites and grew only at irregular intervals.

2.1.5. Agricultural, Human and other Impacts

Reducing agricultural and pasture productivity: Parthenium exerts strong allelopathic effect and reduces the growth and reproductively of associated crops. It does these by releasing phyto toxins from its decomposing biomass and root exudates in soil. Bioassay, pot culture and field studies have revealed that all plant parts (shoot, root, inflorescence and seed) are toxic to plants (Jarvis et al., 1985). Parthenium roots of decayed plant release soluble sesquiterpene lactones, mainly partenin (Pandey et al., 1993). These chemicals inhibit the germination and growth of plants including pasture grasses, cereals, vegetables, and other plant species (Evans, 1997).

Health hazards to humans and livestock: Persons exposed to this plant for prolonged period manifest the symptoms of skin inflammation, eczema, asthma, allergic rhinitis, hay fever, black spots, burning and blisters around eyes. *Parthenium hysterophorus* also causes diarrhoea, severe papular erythematous eruptions, breathlessness and choking (Maishi et al., 1998). Exposure to *P. hysterophorus* also causes systemic toxicity in livestock (Gunaseelan, 1987). Alopecia, loss of skin pigmentation, dermatitis and diarrhoea has been reported in animals feeding on *P. hysterophorus*. The milk and meat quality of cattle and sheep deteriorate on consumption of this weed (Lakshmi and Srinivas, 2007).

Biodiversity loss: Parthenium is an aggressive weed and therefore poses a serious threat to the environment and biodiversity owing to its high invasion and allelopathic effect which has the capacity to rapidly replace the native vegetation (Pandey et al., 1993). It has been reported to be causing a total habitat change in native Australian grasslands, open woodlands, river banks and flood plains (Lakshmi and Srinivas 2007).

2.2. Eichhornia crasspies (Mart.) Solms

Eichhornia crassipes, commonly known as water hyacinth; common water-hyacinth; free-floating water-hyacinth is a perennial aquatic plant (or hydrophyte) native to the Amazon basin (to tropical and sub-tropical South America), and is often considered a highly problematic invasive species outside its native range (Harley et al., 1996).

2.2.1. Taxonomic Description

With broad, thick, glossy, ovate leaves, water hyacinth may rise above the surface of the water as much as 1 meter in height. The leaves are 10–20 cm across, and float above the water surface. They have long, spongy and bulbous stalks. The feathery, freely hanging roots are purple-black. An erect stalk supports a single spike of 8-15 conspicuously attractive flowers, mostly lavender to pink in colour with six petals. In their native range these flowers are pollinated by long tongued bees and they can reproduce both sexually and clonally (Toft et al., 2003).

2.2.2. Ecological distribution

Water hyacinth was the most abundant aquatic weed on the water bodies and perceived as one of the most important noxious weeds (Midgley et al., 2006).Water hyacinth has become a major invasive alien weed in the water regions of the country having successfully established and invaded the different water bodies. In all water bodies, there was a high degree of variability in water hyacinth infestation. Water hyacinth is problematic at Koka Dam along the Awash River, and in Gambela along Baro, Gilo, Pibor and Sobate rivers (Fig. 2). These lakes are located near the farm lands and even part of them is cultivated when the water level decreases.

2.2.3. Socio-economic and environment impact

As reported by different scholars, impact of water hyacinth gets higher whenever there were mats (Center et al., 2002). The most noticeable impacts that were reported by most researchers include: restricting proper water flow, water loss through excessive evapo-transpiration, interference with fishing, grazing and crop production activities (accessibility to land water hindered), effect on power generation, increase siltation, flooding, increase cost of production and effect on native plants (Mildgley et al., 2006).

Though vital epidemiological data pertaining to incidence of human diseases were not obtained during this review, there is a general increase in disease incidences as a result of provision of vector breeding grounds. Some of the human diseases reported include: skin rash, malaria, and bilharzias (Ding et al., 2001). These results showed that the impact of water hyacinth may be categorized into social, economical and environmental impacts. Fishers, riparian communities, Institute of Biodiversity, Agricultural Research Institute, sugar corporation/sugar factories, Ministry of

Energy and Water Resources, Ministry of Agriculture and Environmental Protection Authority were identified as the organizations and communities affected by this noxious weed (Mailu, 2001).

The negative impacts of water hyacinth are due to its dense, impenetrable mats which restrict access to water. These mats affect fisheries and related commercial activities, functioning of irrigation canals, navigation/transport, hydroelectric programmes and tourism (Navarro and Phiri, 2000).

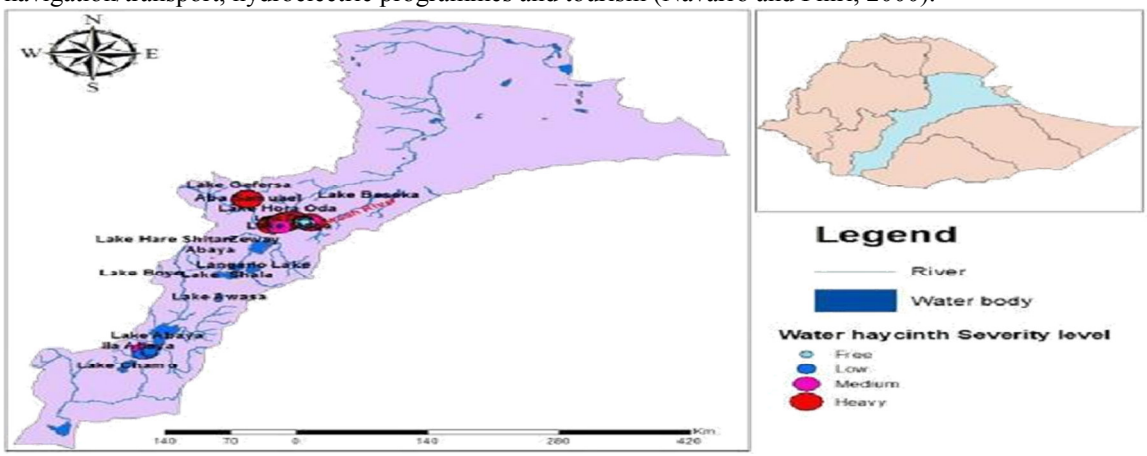

Fig 2. Distribution of water hyacinth in the Rift Valley water bodies of Ethiopia

2.3. Prosopis juliflora (Sw.) DC.

Prosopis juliflora is a shrub or small tree in family fabaceae, a kind of mesquite. It is native to Mexico and the Caribbean. It has become established as an invasive weed in Africa, Asia, Australia and elsewhere (Duke, 1983).

2.3.1. Local name

- Prosopis (name being adopted in Ethiopian Languages)

2.3.2. Characteristic features

Tree or shrub, armed with stipular spines and has stem with a diameter of up to 1.2 meters. Leaves with pairs of

pinnae; leaflets 6-29 pairs, glabrous. Flowers are yellowish in spiciform racemes. Pods are 20 to 30 cm long and contain between 10 and 30 seeds per pod. A mature plant can produce hundreds of thousands of seeds (Hedberg and Edwards, 1989).

2.3.3. Ecological distribution

It is the most aggressive weed that cause great devastation to subtropical grasslands and was thought to have been introduced to Ethiopia during the establishment of irrigation water development project at Middle Awash as wind break, shade and shelter (Abiyot and Getachew, 2006). This species is now commonly found in Afar National Regional State (ANRS) and spreading to Oromia, Amhara, Somali, and Dire Dawa regions. Nowadays it is repeatedly reported to be one of the invasive and problematic trees in the Afar region as well as in the country.

Many scholars reported that the species has been increasing in density as well as area coverage from year to year even from month to month (El-Keblawy and Al-Rawai, 2006). Currently, this noxious tree heavily infests most agricultural as well as potential range lands in the Afar region (Hailu et al., 2004). The thorny nature of the plant, remarkable ability to withstand adverse conditions, non-browse able nature, and above all, the nomadic nature of the people have paved the way to invade most potential lands of the region. El-Keblawy (2002) indicated that *P. juliflora* show a great depressive effect on the number, density, and frequency of native vegetation.

Currently, Prosopis invasion is estimated well above 1million hectares (1,117,510 hectares) taking over prime grazing and irrigable land in Afar region alone and the spread of the plant is advancing at the rate of about 50,000 hectares annually (Hailu et al., 2004).

2.3.4. Dispersal mechanism

Dissemination mechanisms of seeds by domestic and wild animals and the ability to germinate immediately after dispersal give *P. juliflora* great opportunity to grow faster and makes it a more adapted species to drought condition (Hailu et al., 2004). The number of *P. juliflora* seeds in the soil seed bank is greater than the seeds of native tree species (Al-Rawahy et al., 2003). The plant accumulates long lived dormant but viable seeds in the soil serving as a source of new *P. juliflora* plants in the event of disturbance that might eliminate the above ground stands (Hailu et al., 2004). According to Hailu et al. (2004), under optimal condition only a portion of the seeds (21%) germinate at any one time, suggesting that the seeds have high dormancy caused by the hard seed coat. This is particularly important for species survival in arid environments regardless of spatial and temporal rainfall distribution (El-Keblawy and Al-Rawai, 2006).

P. juliflora has two main ecological opportunity behaviors: seed dormancy (Hailu et al., 2004) and allelophatic effects (Warrage and Al-Humaid, 1998). They also reported that *P. juliflora* plants possess allelochemicals that inhabit germination, growth and survival of other species. El-Keblawy and Al-Rawai (2006) also explained that the density of *P. juliflora* seedlings is greater underneath the canopy of the same species than away from them. This indicates that the plant has little or no auto-inhibition effect under field conditions. Removal of *P. juliflora* enhances diversity of other species with its ameliorating effect of some soil characteristics through increasing in K, N and P and organic matter (El-Keblawy and Al- Rawai, 2006).

P. juliflora has many biological characteristics that promote for its invasion of new area. The plant produce mixture of seeds, few of them germinate immediately after dispersal and the majorities remain dormant for future germination; the pods are flesh and sweet that attract domestic and wild animals. These animals dispersed the seeds which are ingested along with the pods through their faecal. Moreover, when the above ground stands eliminated, seeds accumulated in the soil start to germinate and regenerate.

2.3.5. Impacts of Prosopis invasion

P. juliflora possess allelochemicals that inhibit the germination and spread of other plant species (Essa et al., 2006). The number of annual plants significantly reduced under the canopy of *P. juliflora* (Essa et al., 2006). The plant has little or no self allelopathic (auto-inhibition) effect under field condition (EI-Keblawy and AI-Rawai, 2006). This mechanism, combined with drought condition can inhibit other species and eliminate any kind of competition.

The invasion is threatening livelihood of pastoralists and agro-pastoralists due to loss of pasture and destruction of croplands. Dense thicket that is impossible for people or cattle to penetrate. Vine-like runners provide fine ground cover and protect land, but at the expense of productivity–native vegetation is smothered and traditional crops can no longer be grown. It affects the flood plains along the river Awash. Mechanical injuries to livestock and people and intestinal obstruction and jaw problems on livestock (Table 1) were impacts of *P. juliflora* in the area (Essa et al., 2006).

Table 1.The current costs of Prosopis invasion in Gewane, Amibara and Awash Fentale

Items of commodities Loss in Birr	Loss in Birr
Milk	14 million
Livestock weight	546 million
Negative impact on animal health	182 million
Negative impact on human health	470 million
Biodiversity (pasture)	1.04 billion
Total	2.2 billion birr

Source: Ilukor *et al*., 2014

2.4. Lantana camara L.

Lantana camara L. also known as big-sage; white-sage is fast-growing woody thicket-forming shrub, is native to tropical and sub-tropical South and Central America and currently widely distributed in many countries including Ethiopia (Zalucki et al., 2007). It is a species of flowering plant with in the Verbenaceae family.

2.4.1. Local name

- Yewof kolo (Amhara); Hamaressa, rate kate, shimbero (Oromia); Burkaati, qarfa-weyn (Somolia).

2.4.2. Characteristic features

Lantana camara L is small perennial shrub which can grow to around 2 m tall and form dense thickets in a variety of environments (Sharma et al., 2005). It has small tubular shaped flowers which each have four petals and are arranged in clusters in terminal areas stems. Flowers come in many different colours including red, yellow, white, pink and orange which differ depending on location in inflorescences, age, and maturity (Mohan Ram, 1984). After pollination occurs the colour of the flowers change (typically from yellow to orangish, pinkish, or reddish), this is believed to be a signal to pollinators that the pre-change colour contains a reward as well as being sexually viable, thus increasing pollination efficiency (Weiss, 1990).

2.4.3. Ecological distribution

It is found frequently in East and South Africa where it occurs at altitudes below 2000 m and often invades previously disturbed areas such as logged forests and areas cleared for agriculture (Sharma et al., 2005). Lantana has usually been deliberately introduced into various localities in Ethiopia particularly urban settings as an ornamental shrub, and has been quickly spread by birds and animals that eat its fruits but cannot digest the woody seeds. It is common in the eastern part of the country, the Somali region. Some people also grow it as an ornamental plant and use it for fencing in southern Ethiopia. The ability of *L. camara* to rapidly colonise areas of land which have been disturbed has allowed it to proliferate in countries where activities such as logging, clearance for agriculture and forest fires are common (FEPPC, 2005).

2.4.4. Impact of *L. camara* on Agriculture

In agricultural areas *L. camara* can become the dominant understory shrub, crowding out other native species and reducing biodiversity (Quentin, 1995). The formation of dense thickets of *L. camara* can significantly slow down the regeneration of forests by preventing the growth of new trees (Quentin, 1995).

The different parts of lantana contain allelochemicals mainly aromatic alkaloids and phenolic compounds which can interfere with seed germination and early growth of many plant species (Ahmed et al., 2007). Lantana can also interfere growth of nearby plants by outcompeting for soil nutrients (Dobhal, et al., 2010) and altering microenvironment (e.g. light, temperature) by forming dense thickets (Rosacia, 2004). Despite its recognition as among the worst invasive alien species in the world (Zalucki et al., 2007), information on the ecological interference of lantana on the growth and establishment of native plants, especially on agronomic crops, is scanty in Ethiopia.

3. Established and Emerging Invasive Alien weed Species

3.1. Argemone ochroleuca Sweet

Argemone ochroleuca is flowering plants in the family Papaveraceae commonly known as prickly poppies (Henderson, 2001). It is native to the West Indies and Central America; now a cosmopolitan tropical and subtropical weed. Argemone oil is semi-drying oil obtained from the seeds (Edwards et al., 2000).

3.1.1. Local names

- Dandaro (Amhara.); kosheshila, medafe (Tigrya.); (nec lebash), (nechlo (Amhara.); shoqat (Tigrya.); (yeahyasuf (Amhara).

3.1.2. Description

Herb to 1 m high, often branching near the base; stems spiny. Leaves are ternate, blue-green, sessile to clasping, lower leaves deeply lobed, upper more shallowly lobed. Flowers are 25-45 mm in diameter. Petals are white, yellow to orange, 20-30 mm long. Stamens are numerous. Stigma and style are persistent in fruit. Capsule 1-4 cm long, more or less covered in spines (Edwards et al., 2000).

3.1.3. Introduced, naturalized or invasive in Ethiopia
widespread weed and opportunistic plant, often growing in almost pure stands, particularly conspicuous in the dry season; sea level to 2400 m. Gonder, Gojam, Welo region, above and to the west of the 1000 m contour, Shewa region, above and to the west of the 1000 m contour, Arsi, Sidamo, Harerge region.

3.2. Ageratum conyzoides L.
Ageratum conyzoides is one such rapidly colonizing invasive alien species in family Asteraceae that has become a troublesome weed over a wide range of ecosystems in tropical and subtropical countries (Batish, 2008).
3.2.1. Local name
- Arema, gunyato (Oromia)

3.2.2. Characteristic features
Physiognomically, *A. conyzoides* is an annual erect aromatic herb that shows considerable variation in shoot height (59-120 cm) in a stand at maturity stage. The stern is erect, branched, cylindrical and decumbent, and covered with fine, white hairs. Leaves are opposite, ovate and triangular, and pubescent with the long petiole (1.5-2.0 cm or even up to 3.2 cm), covering an area of 31 cm2 and bearing trichomes (56 in number) on both surfaces (Arora, 1999). Plants have a shallow tap root system with a radius of spread of 8 cm. The plant bears blue-violet terminal inflorescence and a capitulum of homogamous disc florets (>70 capitula per plant) arranged in corymbose racemes (Arora, 1999).
3.2.3. Spread of *A. conyzoides* in different habitats
A. conyzoides is a serious problem of cultivated lands, where it forms dense thickets in commonly grown crops such as chickpea, rice, maize and wheat, and adversely affects crop yields (Kohli et al., 2006). Due to its enormous seed-producing capacity, fields left fallow are rapidly invaded and colonized by the weed. A study conducted by Reddi et al. (1977) demonstrated that *A. conyzoides* is a major weed in sugarcane crop fields with a population of 250-400 plants/m2.
3.2.4. Invasive potential of *A. conyzoides*:
Attributes for successful invasion of *A. conyzoides* include (Kohli et al., 2006):
- fast growth and rapid spread due to potential to become well established
- wide ecological amplitude
- high reproductive potential (both sexual and vegetative)
- long flowering and fruiting periods
- absence of natural predators/enemies/ competitors
- resistance to predators
- unpalatable due to high phytotoxin content; and
- Resource competition along with novel weapons such as allelopathy

3.3. Senna occidentalis (L.) Link
Senna occidentalis is a pantropical plant species. It is species of fabaceae family commonly known as coffee senna.
3.3.1. Local names
- Saccara (Oromia); shuna-shuna (Somalia)

3.3.2. Characteristic features
Erect, sometimes slightly woody herb, 0.2-2 m high. Leaves 10-25 cm long, with a large squat ovoid or globose sessile gland near base of petiole; leaflets pairs, lanceolate to ovate-elliptic, acute or acuminate, glabrous except for ciliolate margins and inconspicuous scattered glands beneath. Stamens: 3 large, 4 medium-sized, 3 small. Pods linear, usually slightly up curved, not or tardily dehiscent, subglabrous, transversely septate within. Seeds many, transversely arranged, grey-brown, ovate-circular, compressed minutely pimpled and with an elliptic areole on each face (Duke, 1981).
3.3.3. Habitat, invasive in Ethiopia
Usually a weed of cultivation, roadsides and waste places, also in wooded grassland and lakes or streams; (250-) 500-1700(-2400) m.a.s.l. Afar region and Harerge border, Tigray, Gondern, Welega, Shewa, Arsi, Kefa, Gamo Gofa, Sidamo region pantropical, possibly originating in America (Hedberg and Edwards, 1989).
3.3.4. Impacts of *Senna occidentalis*
The plant is reported to be poisonous to cattle. The plant contains anthraquinones. The roots contain emodin and the seeds contain chrysarobin (1, 8-dihydroxy-3-methyl-9-anthrone) and N- methylmorpholine (Burkill, 1995).

3.4. Datura stramonium L.
Datura stramonium, known by the common names Jimson weed, is a plant in the solanaceae family. *D. stramonium* is believed to have originated in Mexico, but has now become naturalized in many other regions.

3.4.1. Local name

- Banji (Afari); Menji (Gurige); Meichalhaka (Hadiya); Asangiraa, bengi, benj, manji (Oromia); Menji (Sidima); Qabooc, qabooc-guri; qobo (Somila)

3.4.2. Taxonomic description

Datura stramonium is shrubby annual herb up to 2 m tall but often much smaller, glabrescent or with few, straight, non-glandular hairs. Leaves are one or several at the nodes; petiole 1-5.5 cm long; blade broadly ovate to rhomboid or angular, asymmetrically cuneate at the base, acuminate at the apex, with irregularly sinuate, lobed or dentate margins. Flowers erect; pedicel 0.5 cm long. Calyx is 2.5-5 cm long, 5-lobed, lobes 6-8 mm long. Corolla is white, funnel-shaped, limb 5-lobed, lobes mucronate at apex, ending in 10 mm long points. Stamens included; anthers 3-5 mm long, filaments. Style 4-6 cm long; stigma held below or above the anthers. Seeds black, 4 mm in diameter (Hedberg et al., 2006).

3.4.3. Ecological distribution

Weedy and in disturbed places, waste ground, roadsides, frequent near water holes or in areas of impeded drainage; 600-2800 m. Gonder , Gojarn, Welo, Shewa, Welega, Arsi, Iiubabor, Kefa, Sidarno, and Harerge region; in Ethiopia. Distributed Sudan, Somalia and throughout tropical and South Africa; also widespread in Europe, parts of Asia and America (Hedberg et al., 2006).

3.4.4. Impact of *D. stramonium*

Although the plant has been recorded to be used for medicinal purpose, it is usually a weed. It is highly poisonous. All parts of Datura plants contain dangerous levels of the tropane alkaloids atropine, hyoscyamine, and scopolamine, which are classified as deliriants, or anticholinergics. The risk of fatal overdose is high among uninformed users, and many hospitalizations occur amongst recreational users who ingest the plant for its psychoactive effects (Preissel and Hans-Georg, 2002).

Datura intoxication typically produces delirium, hyperthermia, tachycardia, bizarre behavior, and severe mydriasis with resultant painful photophobia that can last several days. Pronounced amnesia is another commonly reported effect (Freye, 2009).

3.5. Xanthium strumtarium L.

Xanthium strumarium is a species of annnual plants. It probably originates in North America and has been extensively naturalized elsewhere (Everitt et al., 2007). It is family Asteraceae.

3.5.1. Local name

- Deha nikel (Amhara)); attamako (Silte); banda, bandoo (Oromia); karis-budeexe (Somalia).

3.5.2. Taxonomic description

X. strumarium is a much branched annual up to 1.2 m high. It has stout stems, green, brownish or reddish-brown in colour, often red-spotted that are rough and hairy. The leaves are alternate, dull green on the upper surface and paler below, with short bristly hairs on both surfaces. They are broad, and 3-5 lobed, 30-180 mm long by 30-180 mm wide on long petioles (stalks).

X. strumarium flowers are yellowish green, located in special, almost spherical apical capitula, inconspicuous, in the leaf axils. The corolla is true, tubular; stamens free. The involucre upon fruiting turns into dense ligneous prickly pericarp. The fruit is called a bur, its ovoid (oval shaped) and it measures about 1.3-3.5 mm long, green, turning yellow and then brown in stalked axillary clusters. Each bur has two stout, curved or straight horns and is covered with hooked spines (Hedberg et al., 2004).

3.5.3. Ecological distribution

X. strumarium is widely naturalised between latitude 53°N to 33°S, where it is most common in the temperate zone, but is also found in subtropical and Mediterranean climates. *X. strumarium* is considered to be invasive in parts of Ethiopia, Kenya, and Tanzania (Weaver, 1982). In Ethiopia this plant has been recorded in farmland, long roadsides ditches, and stream and river banks.

3.5.4. Impacts of *X. strumarium*

The seeds are dispersed through contaminated farm tools, waste soils and furry farm animals. In western Kenya, oxen often carry masses of the spiny fruits on their fur, from invaded farms during the ploughing season.

X. strumarium is a major weed of row crops such as maize, groundnuts, and cotton and soya beans. It can also invade pastures and grazing lands causing reductions in forage production. It is toxic to most domestic animals.

4. New Invasive Alien Invaders

4.1. Nicotiana glauca Graham

Nicotiana glauca is shrub or small tree in family Solanaceae, all parts glabrous and glaucous. It is known by the common name tree tobacco, desert tree tobacco, and wild tobacco.

Its leaves are alternate, not croweded gradually reduced in size towards the inflorescence; Flowers may in lax panicles up to 25 cm long. Panicles are 0.5- 1 cm long. Calyx is 1-1.5 cm long tubular; teeth triangular, equal, acute, 2 mm long. Corolla is yellow to red, tubular, 2.5-4.5 cm long. With short blunt erect or spreading

corolla lobes usually less than 2 mm long. Stamens sub-equal, enclosed with the style in the corolla tube. Capsules are ellipsoids, 0.7 – 1.6 cm long. Seeds are 0.5 mm in diameter (Hedberg et al., 2006).

4.1.2. Ecological distribution

Cultivated, escaped or naturalized in waste places and long roadsides: 1300-2300 m Tigray region, Wollo, Hararge, Shewa of Ethiopia, Eritrea West to the Sudan on the West. Tree tobacco is native to Argentina but it is now widespread as an introduced species on other continents. It is a common roadside weed.

The plant is used for a variety of medicinal purposes and smoked by Native American groups. The Cahuilla Indians used leaves interchangeably with other tobacco species in hunting rituals and as a poultice to treat swellings, bruises, cuts, wounds, boils, sores, inflamed throat, and swollen glands. It contains the toxic alkaloid an abasine. Ingestion of the leaves can be fatal. It is being investigated for use as a biofuel.

4.2. Senna didymobotrya (Fresen.) Irwin & Barneby

Senna didymobotrya is a species of flowering plant in the Fabaceae (Leguminosae) known by the common names African senna, (USDA, 2015) popcorn senna, candelabra tree, and peanut butter cassia. It is native to Africa, where it can be found across the continent in several types of habitat.

4.2.1. Taxonomic description and Distribution

It is bushy shrub 1-5 m high. Leaves are 10-30 cm long, eglandular; stipules ovate-cordate; leaflets 8-18 pairs, oblong-ellipse, pubescent. Racemes are 11-40 cm long. Petals are bright yellow, elliptic-ovate, 1.8-2.7 cm long. Stamens: 2 with large anthers, 5 medium-sized and 3 small. Pods oblong, flattened, dehiscent, transversely septate within, pubescent. Seeds transversely arranged, compressed, nearly oblong, apiculate near hilum, with an oblong areole on each face (Hedberg and Edwards, 1989).

Distribute in montane wooded grassland, evergreen thicket and bushland, often riparian or in disturbed places; 1450-2400 m. Eastern tropical Africa south to Zimbabwe and west to Sudan, Zaire and Angola (Hedberg and Edwards, 1989).

4.2.2. Impacts of *S. didymobotrya*

S. didymobotrya is capable of forming dense impenetrable thickets that impede the growth and regeneration of native plants and affects the movement of wildlife. It invades grasslands, woodlands, forests, riparian zones and coastal scrub. *S. didymobotria* can be termed a "bush encroacher", a native species that has become invasive. Such plants are likely to exist in a stable balance under natural conditions. However, under human-induced changes such as overgrazing, such species can increase in density to the detriment of other vegetation.

5. Control Intervention

Ethiopian Institute of Agricultural Research has teamed up with CABI Africa and IUCN to implement a UNEP/GEF assisted Regional Project entitled “Removing Barriers to Invasive Plant Management in Africa” involving three other pilot countries: Ghana, Uganda and Zambia (UNEP, 2005).

Major achievements perceived were:

- To enable the policy environment a NISSAP, was developed but not formally adopted, up to now. Guidelines for integration of IAS issues into the NBSAP prepared and this has already been achieved.
- The project has also made a significant contribution, through engagement with the education sector, to the integration of IAS issues into learning institution curricula. Support to research studies, with participants largely drawn from collaborating institutions, has enabled increased research on IAS issues.
- A national communication strategy for effective transfer of information on IAS between stakeholders has been produced. IAS risk analysis procedures and early detection and rapid response protocols for IAS have been established for quarantine authorities
- Comprehensive public awareness campaigns undertaken, with production of extension materials in local languages and use of different media sources such as TV and radio to communicate messages.

On-farm activities carried out included:

- Clearing 200 hectare of land from undesirable bushes using machineries or labor (uprooting the plants with a reasonable depth/20 to 30cm/ not to allow restoring). Clearing of the land was made by participation of the pastoralist communities.
- The project also availed tractors and heavy machineries for seedbed preparation and construction of irrigation canals.
- To strengthen the efforts of the communities the project also availed seven motorized chainsaws (tree cutting machines). Motorized saws speeded up the timely clearing of the rangeland from Prosopis and create an opportunity to increase the volume of work.

Biological control offers the prospect of sustainable control of *P. hysterophorus*. Agents have been released in Ethiopia, Asia with some success. The best method of control is to maximize competition against the *P. hysterophorus* by maintaining good grass growth, which requires exclusion of grazing livestock until grass has become re-established, followed by reduction in stocking rates to prevent reinvasion by the *P. hysterophorus*

(Tamado Tana, 2001). It was found that *Fusarium oxysporum* may be used as a possible biocontrol of witchweed. When seeds were soaked in herbicidal chemicals before planting there were up to an 80% decrease in infection.

6. Challenges

Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia. Another challenge to the long-term sustainability of the management activities is its heavy reliance on the food for work programme and inputs from Projects.

Several governments, non-government and development agencies have been working on invasive plant management for a number of years. However, there is poor coordination and sharing of experiences. Even though, IAS risk analysis procedures and early detection and rapid response protocols has been established for quarantine its implementation is not strong.

7. Conclusion

The threat by invasive alien plant species has been increasing with rapid growth of globalization. These species can affect crop production, animal husbandry, human health and biodiversity. Apart from their threat to biodiversity and ecological distribution invasive alien species have significant socio-economic impacts. Invasive alien species in general reduces the effectiveness of development investments by, for example, choking irrigation canals, fouling industrial pipelines and threatening hydroelectric schemes and contribute to social instability and economic hardship, placing constraints on sustainable development, economic growth, poverty alleviation and food security. In future, there should be strong local support, comprehensive awareness programmes, effective laws and commitment of the government for eradication and replacement appears to be well justified. Individuals will more likely invest in the control, management and/or eradication of invasive plants in their own private land.

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