

Invasive Alien Weed Species Impacts on Biodiversity and Socio-Economic Aspect in Ethiopia: A Review

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Abstract: In Ethiopia, there are about 22 invasive alien species were identified. The country has very heterogeneous in species diversity and has a rich endemic element. These invasive alien species (IAS) pose the biggest threat to biodiversity after habitat destruction and also pose a serious threat to agriculture (crop and livestock), livelihoods and human health in the country. Because of their unique characteristics they do not need special environmental requirement for seed germination, to have rapid seedling growth and produce seeds for longer period of time as long as environmental condition permit. Invasive alien weed species has their impact on socio-economic and bio-diversity aspects in the country. The spread of these weed recognized as one of the greatest threats to the ecological and economic well - being of the country. IAS are causing enormous damage to biodiversity and on agricultural system we depend on. These alien species outcompete, infect or transmit diseases, compete, hybridize with the native ones or attack them and these leads to sound effects on social instability and economic hardship, placing constraints on sustainable development, economic growth, poverty alleviation and food security. Therefore, the country should evaluate the ecological distribution, bio-diversity and socioeconomic impact of these species to take appropriate management and control measures.

Keywords: Alien Weed Species, ecological distribution, Ethiopia, Invasive Species

1. Introduction

Invasive species are recognized as one of the major threats to native species and ecosystems around the world (Kathiresan, 2004; Kathiresan *et al.*, 2005). Invasive Alien Species (IAS) refer to plants, animals or micro organisms that are not native to specific ecosystem and whose introduction threatens biodiversity, food security, 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 (2001), 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 now affected every ecosystem types on the planet and considered as the second greatest global threat to biodiversity, after habitat destruction (Essa *et al.*, 2006; Raghubanshi *et al.*, 2005). Apart from their threat to biodiversity and ecosystem services, invasive species have significant social, ecological and economical impacts. They reduce agricultural yields, irrigated crop lands, grazing areas, water availabilities, and contribute to spread of vector born diseases.

According to Raghubanshi *et al.* (2005), alien invasive 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.

In Ethiopia, there are about 22 invasive alien species (McGinley, 2007), and the country has very heterogeneous in species diversity and has a rich endemic element. These invasive alien species (IAS) pose the biggest threat to biodiversity after habitat destruction and also pose a serious threat to agriculture (crop and livestock), livelihoods and human health in the country (Haysom and Murphy, 2003). Among these invasive alien species Parthenium weed (*Parthenium hysterophorus*), Mesquites (*Prosopis juliflora*), Water hyacinth (*Eichhornia crassipes*), *Lantana camara*, and *Cactus (Opuntia spp)* are causing major problems in the country.

Parthenium weed (*Parthenium hysterophorus*), is an herbaceous invasive weed and, poses allelopathic effect on different crops and other plants (Evans, 1997a), health hazard to humans (Kololgi *et al.*, 1997) and animals (Chippendale and Panneta, 1994). It can also cause severe crop yield losses. In eastern part of the country, Parthenium is the second most frequent weed (54%) after *Digitaria abyssinica* (63%) and reduced sorghum grain yield ranging from 40 - 97 % depending on the year and the location (Tamado, 2001).

Mesquites (*Prosopis juliflora*) 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 Berhanu and Getachew Tesfaye, 2006). Now a day, this species is spreading to Oromia, Amhara, Somali, and Diradawa regions of Ethiopia (Figure, 2), but commonly found in Afar region of Ethiopia (EPP, 2006). In the Afar region of Ethiopia, where *P. juliflora* is having dramatic

impacts across the landscape, its spread and impacts on resources has been ranked as one of the leading threats to traditional land use, exceeded only by drought and conflict (EPP, 2006). Nationally, *P. juliflora* has been ranked as the most problematic plant invader in Ethiopia (Tessema, 2007).

Water hyacinth (*Eichhornia crassipes* [Mart.] Solms) is widely recognized as the world's worst aquatic weed (Julien *et al.*, 1999), invading lakes, ponds, canals, and rivers. Due to its extremely fast growth, the weed has become the major floating water weed of tropical and subtropical regions. In the absence of natural enemies, the weed quickly becomes invasive, colonizing slow moving waters resulting in thick and extensive mats (Edward and Musil, 1975) which degrade aquatic ecosystems and limit their utilization (Hill and Cotzee, 2008).

In the same report, it was indicated that this weed forms a dense impenetrable mats across water surface, limiting access by man, animals and machinery. Moreover, navigation and fishing are obstructed, and irrigation as well as drainage systems become blocked.

Therefore, this review aims to provide brief over view on the impacts of invasive alien weed species on ecology biodiversity, and socio economic aspects in Ethiopia.

2. Ecological Distribution and Socio-Economic Impacts of water hyacinth (*Eichhornia crassipes*)

Water hyacinth was the most abundant aquatic weed on the water bodies and perceived as one of the most important noxious weeds (Toft *et al.*, 2003; Midgley *et al.*, 2006) As reported by different scholars, impact of water hyacinth gets higher whenever there were mats. 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 (Center *et al.*, 2002; 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. These results showed that the impact of water hyacinth may be categorized into social, economical and environmental impacts. Fishers, riparian communities, Institute of Biodiversity, National 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 Ding *et al.*, 2001; Mailu, 2001). Similarly, other studies have indicated that the weed poses a great threat to agriculture, fisheries, transportation, hydroelectric power generation, health and the environment (Ding *et al.*, 2001; Mailu, 2001; Center *et al.*, 2002; Mildgley *et al.*, 2006).

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). Ecologically, benthic and littoral diversity is reduced (Masifwa *et al.*, 2001; Toft *et al.*, 2003; Midgley *et al.*, 2006), while population of vectors of human and animal diseases such as bilharzias and malaria are increased with water hyacinth infestation as these plants interfere with pesticide application (Harley *et al.*, 1996).

This review indicated that 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 (Figure 1). In all water bodies, there was a high degree of variability in water hyacinth infestation (Figure 1). Most of the lakes of Ethiopia were predominated with high water hyacinth infestation and a few spots had low to medium infestation. These lakes are located near the farm lands and even part of them is cultivated when the water level decreases.

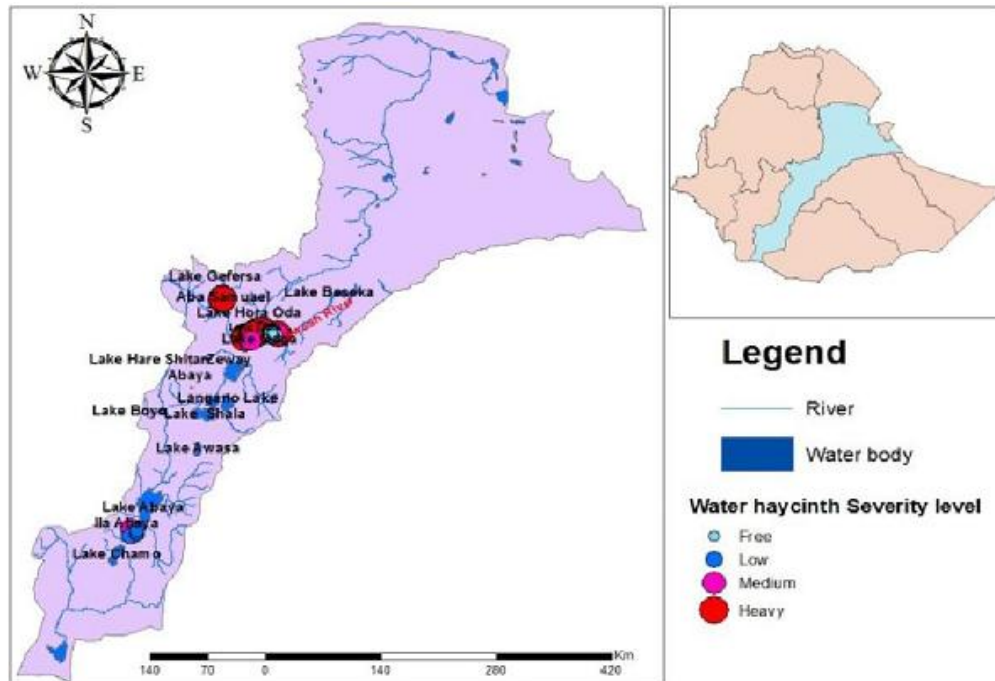


Figure 1: Distribution of water hyacinth in the Rift Valley water bodies of Ethiopia

3. Ecological Distribution and Socio-Economic Impacts of *Prosopis Juliflora* in Ethiopia

The invasive woody plant, *P. juliflora*, is an evergreen tree native to North and South America (Pasicznik et al., 2003). 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 Berhanu and Getachew Tesfaye, 2006). This species is now commonly found in Afar National Regional State (ANRS) and spreading to Oromia, Amhara, Somali, and Diredawa regions (Figure 2). 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 Shiferaw et al. (2004). The thorny nature of the plant, remarkable ability to withstand adverse conditions, non-browseable 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 vegetations. However, the long-term land use/land cover changes and density of *P. juliflora* on specific site of its first introduction, Amibara Woreda of the Afar National Regional State, is not well quantified. Much of the information is non quantitative description about area coverage or explanation on the biological characteristic of the plant.

According to Tesfaye Abebe (2004), *P. juliflora* shows better survival and growth rate under drought stress arid

areas. 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 (Al-Rawahy et al., 2003; Hailu Shiferaw 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 Shiferaw et al., 2004). According to Hailu Shiferaw 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 Shiferaw et al., 2004) and allelopathic effects (Warrage and Al-Humaid, 1998). Warrage and Al-Humaid (1998) 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).

According to Hailu Shiferaw et al. (2004), *P. juliflora* has many biological characteristics that promote for its invasion of new area. The seeds are covered by hard seed coat capable of surviving for longer period. 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.

In addition to these characteristics, *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.

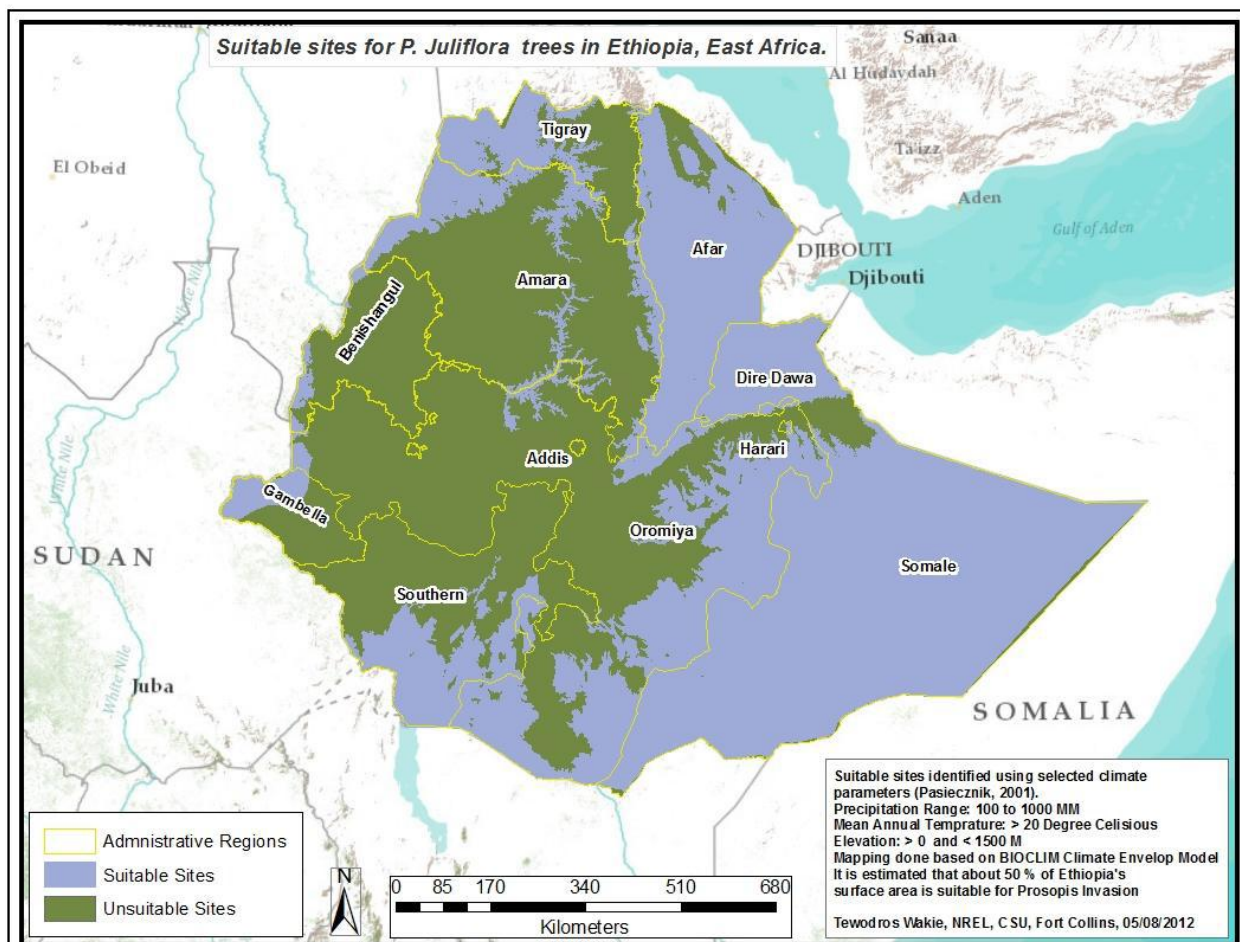


Figure 2: Map showing suitable habitat (blue) and potential distribution for *P. juliflora* in Ethiopia using environmental envelope model

4. Ecological Distribution and Socio-Economic Impacts of *P. hysterothorus* 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 Tana *et al.*, 2002). But in contrast to this, Hedberg *et al.* (2004) reported that it was introduced into Ethiopia around 1974. Others also believed that *P. hysterothorus* 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 Tana and Milberg (2000), and Tamado Tana (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, 1986) 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.

The weed spread rapidly, and soon came to dominate pastures and crop fields because it has allelopathic properties, releasing chemicals that suppress the growth and germination of neighboring plants (Tadelle Tefera, 2002; Singh *et al.*, 2005). Its invasion of Ethiopia has not only had a devastating effect on crop production, but also results in grazing shortages, since the weed is unpalatable to livestock; if it is mixed with fodder, it taints the meat and milk (GISP, 2004).

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 Setit Humera (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, Arsi, 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. The introduction in these area is very recent, probably since 1997 for there had been no parthenium weed observed in West Shewa region from 1995 – 1996 (Taye Tessema *et al.*, 1998) during which intensive qualitative and quantitative determination of weeds occurring in these areas took place.

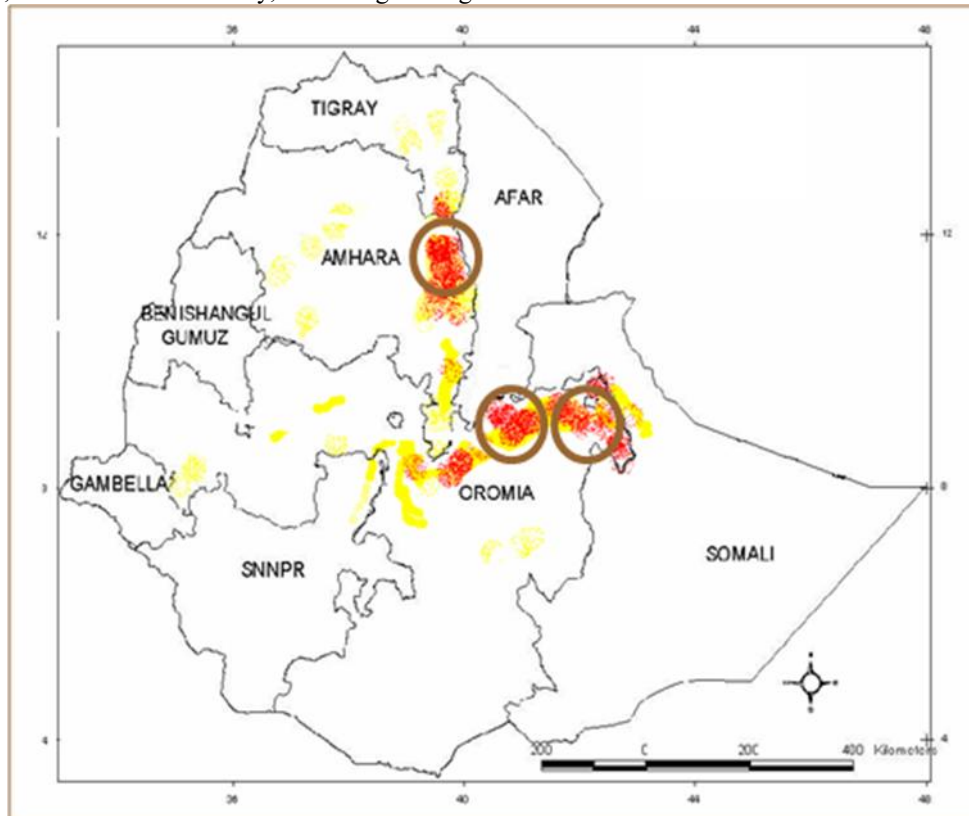


Figure 3: Distribution of *P. hysterophorus* in Ethiopia

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 suppresses and replaces the natural vegetation in a wide range of habitats due to its allelopathic potential and thus become a big threat to biodiversity. 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 (Yaduraju *et al.*, 2005). Parthenium roots of decayed plant release soluble sesquiterpene lactones, mainly parthenin (Jarvis *et al.*, 1985; Pandey *et al.*, 1993). These chemicals inhibit the germination and growth of plants including pasture grasses, cereals, vegetables, and other plant species (Evans, 1997; Navie *et al.*, 1996).

5. Conclusions

Apart from their threat to biodiversity and ecological distribution invasive alien weed species have significant socio-economic impacts. These weed can affect crop production, animal husbandry, human health and biodiversity. IAS in general and *P. hysterophorus*, Mesquites (*Prosopis juliflora*), Water hyacinth (*Eichhornia crassipes*), *Lantana camara*, and *Cactus (Opuntia spp)* in particular, 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. Therefore, there is a need to take a concerted look at the likely effects of invasive alien weed species on socio-economic and biodiversity impact and devise appropriate measures to mitigate the effects of these invasive weed species on food security.

References

- [1] Abiyot, B. and Getachew, T., 2006. The *P. juliflora* Dilemma, Impact on Dry land Biodiversity and Some Controlling Methods. *Journal of the Dry Lands* 1(2):158-164.
- [2] Bezabih, F. and Araya, T., 2002. Spread and status of parthenium in Tigray Regional State at Woreda level. Tigray Bureau of Agriculture and Natural Resources.
- [3] CBD (Convention on Biological Diversity), (2005). Invasive Alien Species. Convention on Biological Diversity. <http://www.biodiv.org/programmes/croocutting/alien>.
- [4] Center, T.D., Hill, M.P., Cordo, H., & Julien, M.H., 2002. *Water hyacinth*. In: Van Driesche, R.G., Lyon, S., Lossey, B.B., Hoddle, M., & Reardon R. (Eds.), *Biological Control of Invasive Plants in the Eastern United States* USDA Forest Service, Morgantown, WV (US), pp. 41–64.
- [5] Chippendale, J .F. and Panetta, 1994. The costs of parthenium weed in Queensland cattle industry. *Plant Protection Quarterly*, 9:73-76.
- [6] Ding, J., Wang, R., Fu, W., & Zhang, G., 2001. Water hyacinth in China: its distribution, problems and control status. In: Julien, M.H., Hill, M.P., Center, T.D., & Ding, J. (Ed.), *Proc. 2nd Meeting of the Global Working Group for the Biolo. and Integrated Control of Waterhyacinth, Beijing, China, pp. 29–32. 9–12 October 2000*. Australian Centre for International Agricultural Research, Canberra (AU).
- [7] Edwards, D., & Musil, C.J., 1975. *Eichhornia crassipes* in South Africa a general review. *J. Limnological Soc. Southern Africa*. 1: 23–27.
- [8] El-Keblawy, A., 2002. Causes and Consequences of the Invasion of the Exotic *P. juliflora* to the Environment of the UAE In: *Third Annual Conference for Research Funded by UAE University*
- [9] El-keblawy, A., and Al-Rawai, A., 2006. Effect of salinity, temperature and light on germination of invasive *P. juliflora* (Sw.) DC. *Journal of Arid Environment* 61: 555-565.
- [10] EPP, 2006. Proceeding of the Workshop on Afar Pastoralist *Prosopis* Project Immerring Issues.
- [11] Essa, S., Dohai, B., and Ksiksi, T., 2006. Mapping dynamics of invasive *P. juliflora* in the Northern Emirates of the UAE: An application of Remote Sensing and GIS.
- [12] Evans, H.C., 1997. *Parthenium hysterophorus* L. A Review of its weed status and the possibility of biological control. *Bio-control News and Information*, 18 :89-98.
- [13] Evans, H.C., 1997a. *Parthenium hysterophorus*: A review of its weed status and the possibilities for biological control. *Biocontrol News and Information* 18: 89-98.
- [14] GISP (Global invasive Species Programme), 2004. Africa Invaded: The Growing Danger of Invasive Alien Species. Global invasive Species Programme, Cape Town. <http://www.gisp.org/downloadpubs/gisp%20africa%20.pdf>
- [15] Hailu, S., Demel, T., Sileshi, N., and Fassil, A., 2004. Some biological characteristics that foster the invasion of *P. juliflora* (Sw.) DC. at Middle Awash Rift Valley, North-eastern Ethiopia. *Journal of Arid Environment* 58: 34-153.
- [16] Harley, K.L., Julien, M.H., and Wright, A.D., 1996. Water hyacinth: a tropical worldwide problem and methods for its control. In: Brown H, GW Cussans, MD Devine, SO Duke, C Fernandez-Quintanilla, A Helweg, RE Labrada, M Lanedes, P Kudsk and JC Streibig (eds.). *Proceeding of the 2nd International Weed Control Congress*, Copenhagen, Denmark, pp. 639 – 644.
- [17] Haysom, K.A. and Murphy, S.T., 2003. The status of invasiveness of forest tree species outside their natural habitat: a global review and discussion paper. Forest Health and Bio-security Working Paper FBS/3E. Forestry Department. FAO, Rome (unpublished).
- [18] Hedberg, I., Friis, I., Edwardes, S. and Mesfin Tadesse (Eds.), 2004. *Flora of Ethiopia and Eritrea*. V. 4: P.2. Addis Ababa, Ethiopia. Uppsala, Sweden.
- [19] Hill, M.P., & Coetzee, J.A., 2008. Integrated control of water hyacinth in Africa. *EPPO Bull.* 38: 452-457.
- [20] Jarvis, B.B., Pena, N.B., Rao, M.M., Comezoglu, N.S., Comezoglu, T.F. and Mandava, N.B., 1985. Allelopathic agents from *Parthenium hysterophorus* and *Baccharis megapotamica*. In: Thompson, A.C. (ed.), *The chemistry of allelopathy, Biochemical interactions among plants*, American Chemical Society, Washington D.C., 149-159.
- [21] Julien, M.H., Griffiths, M.W., and Wright, A.D., 1999. Biological control of water hyacinth. The weevils *Neochetina bruchi* and *N. eichhorniae*: biologies, host ranges, and rearing, releasing and monitoring techniques for biological control of *Eichhornia crassipes*. *ACIAR Monograph* No. 60, 87pp.
- [22] Kathiresan, R. M., 2004. Invasive weeds in agro-ecosystems of South India [Abstracts]. In: *National Workshop on Invasive Alien species and Biodiversity in India*, Banaras Hindu University, Vanarasi, India. 149 p.
- [23] Kathiresan, R. M., Gnanavel, I., Anbazzhagan, R., Padmaria, S. P., Vijayalakshmi, N. K. and Arulchezhian, M. P., 2005. Ecology and control of *Parthenium* invasion in command area. In: *Proceedings of Second International Conference on Parthenium Management* 5-7 Dec 2005. Bangalore, India. pp 77-80.
- [24] Kololgi, P.D., Kololgi, S.D., and Kololgi, N.P., 1997. Dermatological hazards of parthenium in human beings. pp.18-19. In: Mahadevappa M and VC Patil (eds). *Proceedings of the 1st International Conference on Parthenium Management*, 6 - 8 October 1997, University of Agricultural Sciences, Dahrwad, India.
- [25] Mailu, A.M., 2001. Preliminary assessment of the social, economic and environmental impacts of water hyacinth in the Lake Victoria basin and the status of control. In: *Biological and Integrated Control of Water Hyacinth, Eichhornia crassipes. ACIAR Proc. No. 102*.
- [26] Masifwa, W.F., Twongo, T., & Denny, P., 2001. The impact of water hyacinth, *Eichhornia crassipes* (Mart.) Solms, on the abundance and diversity of aquatic macroinvertebrates along the shores of northern Lake Victoria, Uganda. *Hydrobiol.* 452: 79–88.
- [27] McGinley. 2007. Effects of the biological invasion of algaroba: *P. juliflora* (Sw.) DC. On composition and

- structure of the shrub-tree stratum of the caatinga in Monteiro Municipality, Paraíba State, Brazil. *Biodiversity, Ecology and Environmental health* **20**(4): 887-898. ISSN 0102-3306.
- [28] McNeeley, J. A., Mooney, H. A., Neville, L. E., Schei, P. and Waage, J. K., 2001. Global Strategy on Invasive Alien Species. UCN – the World Conservation Union, Gland.
- [29] Midgley, J.M., Hill, M.P., & Villet, M.H., 2006. The effect of water hyacinth, *Eichhornia crassipes* (Martius) Solms-Laubach (Pontederiaceae), on benthic biodiversity in two impoundments on the New Year's River, South Africa. *Afr. J. Aqua. Sci.* **31** (1):25-30.
- [30] Navarro, L., & Phiri G., 2000. Water hyacinth in Africa and the Middle East. A survey of problems and solutions. International Development Research Centre, Ottawa (CA).
- [31] Navie, S. C., McFadyen, R. E., Panetta, F. D. and Adkins, S. W., 1996. The biology of Australian Weeds 27: *Parthenium hysterophorus* L. *Plant Protection Quarterly* **11**: 76- 87.
- [32] Njoroge, J. M., 1991. Tolerance of *Bidens pilosa* and *Parthenium hysterophorus* L. to paraquat (Gramaxone) in Kenya coffee. *Kenya-Coffee* **56**: 999-1001.
- [33] Pandey, H. N., and Dubey, S. K., 1989. Growth and population of an exotic weed *Parthenium hysterophorus* Linn. *Proceedings of Indian Academy of sciences, plant sciences* **99**:51-58.
- [34] Pasiecznik, N.M., Harris, P.J.C., and Smith, S.J., 2003. Identifying Tropical *P. juliflora* Species: A Field Guide. HDRA, Coventry, UK. ISBN: 0 90534330.
- [35] Raghubanshi, A.S., Rai, L.C., Gaur, J.P., and Singh, J.S., 2005. Invasive alien species and Biodiversity in India: *Current Science* **88**(4).
- [36] Singh, P. H., Batish, R.D., Pandher, K.J., and Kohli, K.R., 2005. Phytotoxic effects of *Parthenium hysterophorus* residues on three *Brassica* species. *Weed Biology and Management* **5**, 105–109.
- [37] Tadello, T., 2002. Allelopathic Effects of *Parthenium hysterophorus* Extracts on Seed Germination and Seedling Growth of *Eragrostis tef*. *J. Agronomy & Crop Science* **188**, 306–310. (Available at: <http://www.blackwell-synergy.com/action/showpdf>. Last accessed July 10, 2007).
- [38] Tamado, T., 2001. Biology and management of parthenium (*Parthenium hysterophorus* L.) in Ethiopia. *PhD thesis*. Swedish University of Agricultural Sciences, Uppsala.
- [39] Tamado, T., Schütz, W., and Milberg, P., 2002. Germination ecology of the weed *Parthenium hysterophorus* L. in eastern Ethiopia. *Ann. Appl. Biol.* **140**: 263-270.
- [40] Taye, T., Yohannes, L., and Belayneh, A., 1998. Qualitative and quantitative determination of weed occurrence in wheat in West Shewa Zone of Ethiopia. *10th regional wheat workshop for eastern, central and southern Africa*. 14-18 September 1998, University of Stellenbosch, South Africa.
- [41] Taye, T., 2002. Investigation of Pathogens for Biological control of *Parthenium* (*Parthenium hysterophorus* L.) in Ethiopia. *PhD thesis*, Humboldt–Universität zu Berlin, Landwirtschaftlich-Gärtnerischen Fakultät, Berlin. 152 pp.
- [42] Tessema, T., 2007. The Prospects of Biological Controls of Weeds in Ethiopia. *Ethiopian Journal of Weed Management* **1** (1): 63-78.
- [43] Tesfaye, A., 2004. Growth performance of some multipurpose trees and shrubs in the semi-arid areas of Southern Ethiopia. *Agro forestry system* **26**: 237-248.
- [44] Toft, J.D., Simenstad, C.A., Cordell, J.R., & Grimaldo, L.F., 2003. The effects of introduced Water Hyacinth on habitat structure, invertebrate assemblages and fish diets. *Estuaries* **26**(3):746–758.
- [45] Warrage, M.O.A., and Al-Humaid, A.I., 1998. Allelopathic effects of *Prosopis juliflora* foliage on seed germination and seedling growth of Bermuda –grass (*Cyanodon dactylon*). *Journal of Arid Environment* **38**: 237-243.