Identification of Invasive Alien Species for Environmental protection strategy in the rangelands of Fafan Zone, Somali Region, Eastern Ethiopia

First Author; Esayas Elias Churko: Second Author; Fikre Zerfu,
Contact: Mobile: (+251) 911925940, E mail: esayas42@yahoo.com

Abstract— Encroachments by Invasive Alien Species (IAS) and undesirable woody plants on the rangeland have been one of threat for the pastoral production system in Eastern Ethiopia. As a consequence a study was conducted in three weredas (districts) of the Fafan zone of the Somali region, eastern Ethiopia. The main objective of the study was to identify IAS encroaching the rangelands. In this study six different rangeland sites were selected, and a total of 114 belts transect were used for vegetation census, sample collection, and identification. A total of 21 most abundant species of herbaceous weeds have been recorded. From these, seven invasive alien species, namely; PARTHENIUM hysterophorus, OPUNTIA stricta, LANTANA camara, CALOTROPIS procera, VERBESINA encelioides, TAGETUS minuta and ARGEMONE mexicana have been identified. As has been observed there was a limmtted growth and less production of other plants that are normally grwiwng in the area where these invasivre species were identified. These invasive alien species belonged to four families. *P. hysterophorus*, *O. stricta* and *L. camara* were found to be the foremost invasive weed species that cause a serious harmful impact on the rangelands. Therefore, to prevent exapansion of these invasive allian species; contnious identification, documentation and safeguarding of the other plants in the area, are recommended as some of the strategies for the protection the environment.

Index Terms— Invasive Alien species, Rangeland, Ethiopia Somali Region, environmental protection, Invasive plants identification,

1 INTRODUCTION

Invasive alien species are species that are introduced from outside its natural range of distribution (new geographic areas or regions or countries) [1]. These species iner in to the new environment either by intentional or unintentional human activity, where they become established and then proliferate and spread, to the detriment of human interests and natural systems. The Millennium Ecosystem Assessment and environemental protection classified invasive alien species along with climate change as the two drivers damaging ecosystem function and human well-being that are the most difficult to reverse [1,2].

Encroachments by invasive plant species and undesirable woody plants on the rangeland have been one of threat for the environment and the pastoral production system in Eastern Ethiopia [3, 4]. Their encroachment significantly reduces the production potential of the rangelands and affects the biodiversity and threatened the stability and viability of envirnemnt and pastoral livelihood of the study districts (Somali region, Ethiopia) [5, 6]. These invasive weedy plants are fundamentally changed the communal rangelands from open savannah grasslands to bush tickets [3, 4]. They reduced the quality of the environment and the quantity of natural grazing lands native palatable species. The native palatable species, of the natural grazing lands are the primarily sources of animal feed in the study area. It is apparent that the stocking rate in the rangeland is beyond the carrying capacity of the vegetation cover, where there is high cattle density/km^2. The name this area is called in the Fafan Zone. As a result the livestock productivity, conducviness of the enviroenment and survivality has tremendously declined in the last five years in the the zone. These area where encroachment was very intense, particulary identified as Kebribeyah, Gursum and Aw-bere districts of the Fafan Zone [7, 8, 9].

The challenges of managing invasive species and protection of the environment from their impact is an urgent issue. Because, these invasive plant species negatice impact is growing in scale with globalization enviornmntal damage and contributing for an altering of the normal climate [10, 11]. Many aspects of invasives weed management depend on, or benefit significantly from, the information needed reliably to recognise, name and identify species [2]. As to the Convention on Biological Diversity (CBE) quote from the comprehensive review of activities for the prevention, early detection, eradication and control of invasive alien species. The CBE quote: "*Basic biological knowledge (e.g. Identification) must be combined with evolving technologies and tools for invasive prevention and management used for prevention*". These measures rely heavily on the existence of reliable and taxonomically comprehensive data [12]. Moreover, identification of pathways, environmental and other plants health impacts and current status of invasive alien species are documented in the identification process. While as in the identification both previouse documentary sources and local respondents used side by side [10, 13, 14, and 15]. When the data collection and information gathering is in this way it is very important for risk analysis, prediction of possible invasions and prioritization for management, environmental protection and control options [16].

Importance of the study: This aspect in particular Identification of Invasive Alien Species for Environmental protection

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

strategy in the rangelands was never studied in the Fafan Zone of Somali regional state of Ethiopia. Because, the area is marginalized for transportation and also remote for researchers to access where very few facilities exists. This study is therefore the first attempt to identify and document invader plants that might be useful to prevent the environemtn and control or eradicate those alien species which threaten rangelands ecosystems in the Fafan Zone. This enthused the current study, which involved a survey with the objectives to identify the invasive alien plants for protecton of the environment and encroaching the rangelands of the Fafan Zone.

2 MATERIAL AND METHODS

2.1 Description of Study Area

The study was carried out in three district (Awebare, Gursum and Jijiga) of the Fafan Zone, located in the northern part of the Ethiopian Somali Region (Figure 1). The zone covers 40,861 km^2, of which the rangeland extends over 36,629 km^2 [17]. The landscape has physical property, ranges from flat to gentle slope and hilly and mountainous topography. About 52.6% of the landscape is flat to gentle slope, 31% is hilly and about 7% of it is steep slope [7]. The rainfall in generally low, unreliable and uneven distribution and has bimodal pattern. The heavier rains called "Karan" from mid-July to mid-October, the other rains called "Diraa" from mid-March to mid-May; and both of which are equally important for cultivation or maturation of crops, water availability and livestock pasture regeneration. The mean annual rainfall ranges from 700 to which is 900 mm [7, 18]. The mean minimum and the mean maximum temperature in this area are 20 ^{O}C and 35 ^{O}C, respectively [19]. The predominant geological formation are lime stone and sandstone, and significant areas are covered by vertic cambisols, euric cambisols, calcic, cambisols vertisols and lithososls [7]. The vegetation is characterized by the Acacia wooded grassland [20, 21].

2.2 Survey design and analysis

The survey areas were selected at six different rangeland sites in three districts of Jijiga Zone. The rangeland sites identified for the study were chosen based upon the response of the pastoralists to a question asked to list their major grazing areas and the representativeness of the sites for the grazing lands in the study districts in terms of the nature of the vegetation (herbaceous and woody), soil and altitude. These sites were 1) Gursum district (Fafan Kebele area); 2) Jijiga district (Elbayhi dam area, Karamara mountain areas and Hare); 3) Aw-bare district (Sheder areas and Lafa-Issa kebele area) (Fig 1).

A total of 114 belts transect were used for vegetation census, sample collection, and identification. Each of the sites were used different sampling units, these were a) Fafan Kebele area: 21 belts transects, b) Elbayhi dam area: 18 belts transects, c) Karamara mountain areas: 20 belts transects, d) Harae: 18 belts transects, e) Sheder area: 17 belts transects, f) Lafa-Issa kebele area: 20 belts transects. The size of each belt transect was 100 m * 6 m and these were intensively sampled for species of weeds, their numbers and other characters. The survey and data collection on the weeds had been carried out from June, 2012 to April, 2013, at the time when most plants were in the flowering stage. The study followed a random sampling method to avoid bias. Throughout vegetation data collection the following information were recorded: collection number, date of collection, local name, botanical name family, habit, habitat and impacts. The majority of weed species collected from the study sites were identified in the field. For species that were difficult to identify in the field, voucher specimen was collected, pressed and dried properly using plant presses and transported to the Ethiopia Somali Region Pastoral and Agro-pastoral Research Institute and Haramya University herbarium for identification and proper naming. "Flora of Ethiopia and Eritrea" Volume I - VII [22, 23], "Weeds and Invader plants of Ethiopian" [24] and other existing literature and information from web-based data were used to determine the alien origin of the weeds. Vegetation data collected in the field was tabulation and analysis was done following standard methods. The majority of weed species collected from the study sites were identified in the field. For species that were difficult to identify in the field, voucher specimen was collected, pressed and dried properly using plant presses and transported to the Ethiopia Somali Region Pastoral and Agro-pastoral Research Institute and Haramya University herbarium for identification and proper naming. "Flora of Ethiopia and Eritrea" Volume I - VII [22, 23], "Weeds and Invader plants of Ethiopian" [24] and other existing literature and information from web-based data were used to determine the alien origin of the weeds. Vegetation data collected in the field was tabulation and analysis was done following standard methods.

3. SECTIONS

3.1. Weeds communities

Twenty one, (the total counted number), the most common, and abundant weed species of known as shrub abd herbs respectively in the six sites were identified (Table 1 and Table 2). Out of the twenty one common weeds, seven species were from the Asteraceae, followed by Fabaceae (2); and while the other twelve species belonged to ten different families. Out of the twenty one comon weeds, seventeen species wereherbs, while the remaining four were shrubs (Table 1 and Table 2).

The highest average abundance value was for Parthenium hysterophorus, followed by Euphorbia hirta, Datura stramonium, Oxygonum sinuatum, Tagetus minuta, Opuntia strict, Indigofera schimperi and Commelina latifolia. Of the total 114 belt transects, E. hirta was present in the highest number of transects (90), followed by *O. sinuatum (89), P. hysterophorus (88), D. stramonium (76), Bidens pilosa (69), Justica schimperi (65), Medicago polymorpha (63) and Acanthospermum hispidium* (53).

3.2 Determination of the Alien Nature of the Species

The information from taxonomic records and information about the region of origin of the weeds were collected were used to identify the nature of species as to whether they are alien or not. Two reliable books were used for preliminary

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

identification of alien species [22, 23 and 24]. The common weed species are alien as identified from thplaces of origin and reference of the origin of seven species. But this species be exotic and are the speiecs which are come from out side. From the two books, it is known that *A. mexicana, O. stricta, P. hysterophorus, V. encelioides and T. minuta* were India and/or American in origin. There was no mention in the books of the other four plants *viz. C. procera, and L. camara*. Moreover, to confirm alien nature of species more information about these alien species was collected from the internet. These identified Seven species: *A. mexicana*, *O. stricta, P. hysterophorus, L. camara, V. encelioides, T. minuta* and *C. procera* are identified as alien species in Ethiopia (Table 4) as confirmed from online search. The native range of the seven species, most were Indian, American and South American origin, but *C. procera* was Tropical Africa and Asia by origin (Table 4). Mode of reproduction and reproductive vigour of identified seven alien species in study sites are given in Table 3. All of these alien species: *Parthenium, Opuntia, Lantana, Calotropis, Argemone, Verbesina* and *Tagetus* proved to have high reproductive vigour. The more vigorous modes of reproduction gave them the status of invasive alien species in rangelands of Fafan Zone (Table 5).

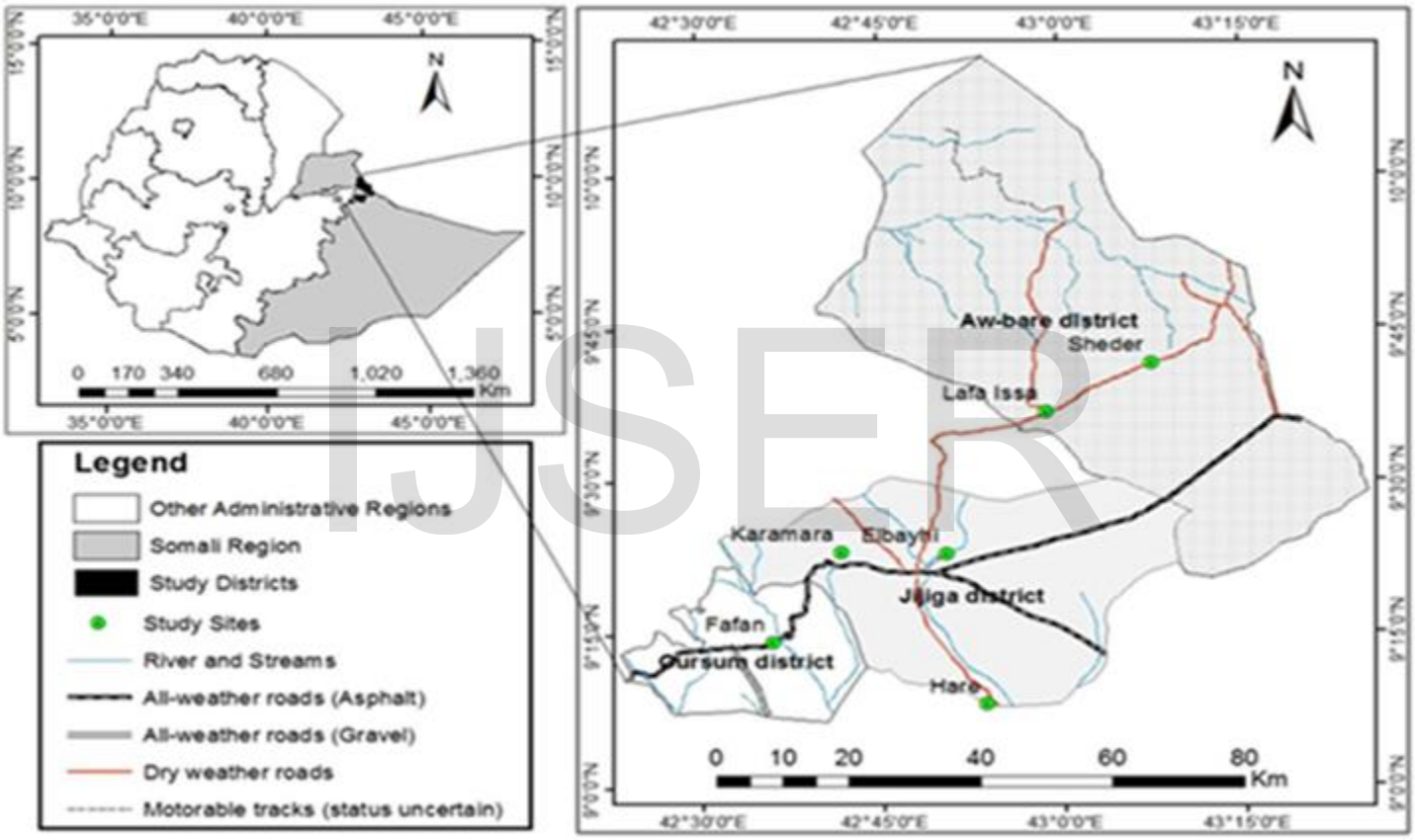

Fig1. The map of study area: detailed information

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

Table 1: Common weed species, identified as Shrubs,

Species	Family	Abundance range (average number)	Abundance (average number)	Present in transects Total=114	* Score
Calotropis procera Ait.	Asclepiadaceae	0.92 - 3.69	2.03	22	+
Indigofera schimperi Jaub. & Spach	Fabaceae	3.85 - 11.56	7.80	31	++
Justica schimperi (Hochst.) Dandy	Acanthaceae	2.65 - 9.06	4.95	65	++
Lantana camara L.	Verbenaceae	1.41 - 9.09	6.3	23	++

Table 2 Common weed species, identified as Herbs,

Species	Family	Abundance range (average number)	Abundance (average number)	Present in transects Total=114	* Score
Acanthospermum hispidium DC.	Asteraceae	1.64 - 15.47	6.43	53	++
Amaranthus graecizans L.	Amaranthaceae	2.85 -9.00	5.17	23	+
Argemone mexicana L	Papaveraceae	3.07 - 6.77	4.62	42	++
Bidens pilosa L.	Asteraceae	3.04 - 11.37	6.36	69	++
Chenopodium opulifolium Schr.	Chenopodiaceae	0.54 - 2.31	1.23	28	+
Commelina latifolia A. Rich	Commelinaceae	1.56 -12.65	7.01	42	++
Datura stramonium L.	Solanaceae	5.48 - 28.30	11.34	76	+++
Euphorbia hirta L.	Euphorbiaceae	3.65 - 24.06	12.95	90	+++
Medicago polymorpha L.	Fabaceae	0.34 - 4.31	2.23	63	+
Oxygonum sinuatum (Meissn.) Dammer	Polygonaceae	5.10 - 17.31	9.17	89	+++
Parthenium hysterophorus L.	Asteraceae	8.34 - 17.97	14.51	88	+++
Schkuhria pinnata (Lam.) Thell.	Asteraceae	0.88 - 10.05	3.90	17	+
Tagetus minuta L.	Asteraceae	1.00 - 17.4	8.87	34	++
Tribulus terrestris L.	Zygophyllaceae	0.12 - 4.02	1.24	11	+
Verbesina encelioides (Cav.) A. Gray	Asteraceae	0.56 - 5.54	3.3	16	+
Xanthium spinosum L.	Asteraceae	2.43 - 7.2	5.15	40	++

* Score +, + +, + + + based on average abundance of the 6 sites (+ = 1-5, + + = 6-15, + + + = 16 - 100).
Tribulus terrestris was recorded only in Hare areas; less abundant and grasses were not included.

Table 3 Reproduction and reproductive vigour of seven alien species of Fafan Zone, Ethiopia

Species	Vegetative reproduction	Sexual reproduction	Regeneration
Argemone mexicana	Nil	++	Absent
Calotropis procera	++	++	By root stocks, stems ++
Lantana camara	++	++	By root stocks, ++
Opuntia stricta	++	++	By breaking of segments, +++
Parthenium hysterophorus	Nil	+++	Absent
Verbesina encelioides	Nil	++	Absent
Tagetus minuta	Nil	++	Absent

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

Table 4. Information from the internet about alien species

Species	Native regions	Source of information
Argemone mexicana	Native in Mexico & West Indies	[25 and 26]
Calotropis procera	Native to West Africa as far south as Angola, North and East Africa, Madagascar, the Arabian Peninsula, southern Asia, and Indochina to Malaysia	[25 and 27]
Lantana camara	Native plant of North, Central and South America	[28 and 29]
Opuntia stricta	Native geographical range -Tropical & subtropical coast of eastern North America, Bermuda, West Indies & adjacent South America	[28 and 29]
Parthenium hysterophorus	Native to Mexico, Central and South America	[29]
Verbesina encelioides	The native North and South America, specifically Mexico and the south western United States of Texas, Arizona	[25]
Tagetus minuta	Native to South America	[25]

*Table 5: A*lien species in the rangelands of Fafan Zone, Ethiopia Somali Regional State

Scientific name	Local name	"Flora of Ethiopia and Eritrea" Volume I – VII	"Weeds & Invader plants of Ethiopian"	Indicated place of origin
Argemone mexicana	Shugux shugux	Argemone Linn. Represented by 28 species, mostly America, West Indies and Hawaii	Invader	Exotic species (West Indies and central America)
Calotropis procera	Boboco or Canole	Not mentioned	Invader	Exotic origin, not local member
Lantana camara	Bakarkatte	Not mentioned	Invader	Exotic origin, not local member
Opuntia stricta	Tine	*Opuntia stricta* Haworth native to Southeastern USA	Invader	Exotic origin, North America plant
Parthenium hysterophorus	Kaligii noole	Parthenium Linn. has 16 species; only *P. hysterophorus* introduced in Ethiopia; native to west indies, North America and northern and South America	Invader	Exotic species (India, North and South America)
Verbesina encelioides	Bil case	Verbesina Linn. about 150 species; *V.encelioides* recently introduced in Ethiopia, native of SW United State and Mexico	Invader	Exotic species (North and South America)
Tagetus minuta	Qadhmuune	Tagetus Linn about 50 species; *T. minuta* - noxious weed introduced in Ethiopia, native of west central South America.	Invader	Exotic species (South America)

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

4. Discussion

Most Abundant Weeds of the Six Sites: Altogether, seven herbaceous alien species were identified as abundant and dominant weeds of the rangelands of study sites.

The highest abundance was exhibited by *P. hysterophorus*, followed by *T. minuta, O. stricta, L. camara, A. mexicana, V. encelioides,* and *C. procera*. Among the total 114 transects examined, Parthenium was present in the highest number of transects, followed by *Argemone, Tagetus, Opuntia, Lantana, Calotropis* and *Verbesina*. Very vigorous reproduction were found in Parthenium and Opuntia followed by *Lantana, Calotropis, Argemone, Verbesina* and *Tagetus*. Many Invasive Alien Species (IAS) found in Africa are included on a global list of the 100 worst IAS (GISP, 2004). Among 100 of world's worst IAS, O. stricta and L. camara were identified as invasive alien land plants (Lowe et al., 2000; IUCN/SSG/ISSG, 2010). Similarly, EIAR, 2010, report stated that, in Ethiopia 32 IAP were identified. Some of them were *P. hysterophorus, O. stricta, L. camara, C. procera, Tagetus minuta* and *A. mexicana*. Moreover, *Parthenium weed, O. stricta, P. juliflora* and *L. camara* has identified as major IAP in the country and declared the need for their control and eradication by Federal Government of Ethiopia (Taye et al., 2007).

The most aggressive invasive species have a suite of characteristics that allow them to rapidly invade and dominate suitable habitats. These traits include prolific seed production and seedling survival, rapid growth rate, ability to spread asexually, and ability to survive in a wide range of habitats (Myers & Bazely 2003).

5 Conclusions

This survey demonstrated the presence and widespread occurrence of some of the world's worst invasive species namely; *P. hysterophorus*, *O. stricta, L. camara*, and *A. mexicana* have been found in the rangelands of the Fafan Zone. Besides, some other IAS, *V. encelioides, C. procera,* and *T. minuta*, which are becoming threat to the rangeland ecosystems and the environment of the study areas are likely being introduced from adjacent regions or countries (secondary introduction). In all studied location, the availability, diversity of native palatable plant species, animal and human health and community and their livestock free movement have been significantly affected by the invasive weed species. In order to manage the IAS in coordinated and sustainable manner requires to promote public awareness about IAS, and create a coordination mechanism and information. Data and information exchange systems at national, and regional levels and long-term programs of action should be established for the sustainability of IAS prevention and management activities. Also environmental protection form envasion of alian species encompass all the stakeholders and communities participation at the grassroots level. Partnership between government, NGOs, public and private sectors has to involve in different activities to address IAS, therefore, this activity should encouraged.

6. Acknowledgments

The authors' wishs to thank EEPA (Ethiopian Environmental Protection Agencies), Ministry of Education and JJU, Ethiopia

7. Conflict of Interests

The authors have not declared any conflict of interests

References

[1] MA. Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Current State and Trends. Volume 1. Island Press, Washington. 2006.

[2] Smith, R.D., Aradottir, G.I., Taylor, A. and Lyal, C. Invasive species management – what taxonomic support is needed? GISP, Nairobi, Kenya. 2008.

[3] Amaha Kassahun. Pastoralism and the need for the future intervention in pastoral areas of Ethiopia. Annual Review on National Dry land Agriculture Research System, Addis Abeba, Ethiopia. 2003.

[4] Gemedo Dalle, Maass, B.L, and Isselstein, J. Rangeland condition and trend in the semiarid Borena low lands, Southern Oromia Ethiopia. African Journal of Range and Forage Science, 2006; 23:49-58.

[5] EARO. Ethiopian Agricultural Research Organization. National dry land research strategic planning pastoral and agro pastoral research program. Addis Ababa, Ethiopia. 2003. 60p.

[6] ESGPIP. Ethiopia Sheep and Goat Productivity Improvement Program. Management for proper range use. 25th technical bulletin. Addis Ababa, Ethiopia. 2009.

[7] IPS. Industrial Project Service. Resource potential assessments and project identification study of Somali Region. Vol.3. Agricultural Resources. Industrial Projects Service. No. 09 (137)-91. Addis Ababa. 2002: 102-201.

[8] Ahmed Bashir. Soil condition and vegetation cover in human impacted rangelands of Jijiga, Somali Regional State. An MSc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. 2003.

[9] SoRPARI. Somali Region Pastoral and Agro-Pastoral Research Institute. Annual report of Range management and ecology research directorate. Somali region, Jijiga, Ethiopia. 2009. 99p.

[10] Wittenberg, R. and Cock, M.J.W. Invasive Alien Species: A Toolkit for Best Prevention and Management Practices. Global Invasive Species Programme, Cape Town. 2001.

[11] Shine, C. A toolkit for developing legal and institutional frameworks for invasive alien species. Global Invasive Species Programme, Nairobi. 2008.

[12] CBD. Convention on Biological Diversity. UNEP/CBD/SBSTTA/6/INF/3. Invasive alien species. Comprehensive review of activities for the prevention, early detection, eradication and control of invasive alien species. Note by the Executive Secretary, Convention on Biological Diversity, Montreal. 2001.

[13] CBD. Convention on Biological Diversity. UNEP/CBD/SBSTTA/11/INF/10. Towards the development of a joint work plan for the management of marine invasive alien species. Convention on Biological Diversity, Montreal. 2005.

International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019
ISSN 2229-5518

[14] Hilliard, R. Best Practice for the Management of Introduced Marine Pests – A Review. Global Invasive Species Programme, Cape Town. 2005.

[15] GISIN. Global Invasive Species Information Network. Results of the GISIN Needs Assessment Survey. Global Invasive Species Information Network, Reston, VA, USA. 2007.

[16] Shine, C., Williams, N. and Gündling, L. A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species. Environmental Policy and Law Paper No. 40. The World Conservation Union (IUCN), Gland, Switzerland/Cambridge and Bonn. 2000.

[17] World Bank. Pastoral Area Development in Ethiopia. Issues Paper and Project proposal. Discussion draft, April 10, 2001. Addis Ababa, Ethiopia. 2001: 27-49.

[18] SCUK and DPPA. Save the Children United Kingdom and Disaster and Preparedness Agency. Livelihood and Vulnerability – An Understanding of Livelihood in Somali Regional State, Ethiopia. Addis Ababa, Ethiopia. 2008: 98-108.

[19] NMSA. National Meteorological Service Agency. National Meteorological Service Addis Ababa, Ethiopia. 2012: 123-134.

[20] Partidario, M. R., and R. C. Gomes. 2013. Ecosystem services inclusive strategic environmental assessment. Environmental Impact Assessment Review 40:36-46.

[21] Pope, J., A. Bond, A. Morrison-Saunders, and F. Retief. 2013. Advancing the theory and practice of impact assessment: setting the research agenda. Environmental Impact Assessment Review 41:1-9

[22] Mesfin Tadesse. Flora of Ethiopia and Eritrea. Volume 4, part 2. The National Herbarium, Addis Ababa, Ethiopia and the Department of Systematic Botany, Uppsala University, Sweden. 2004

[23] Edwards, S., Mesfin Tadesse, Sebsebe Demissew and Hedberg, I. Flora of Ethiopia and Eritrea. Vol. 2. The National Herbarium, Addis Ababa, Ethiopia and the Department of Systematic Botany, Uppsala University, Sweden. 2000.

[24] EIAR. Ethiopian Institute of Agricultural Research. Weeds and Invader Plants Ethiopia. UNEP/GEF Project: 'Removing Barriers to Invasive Plant Management in Africa'. 2010.

[25] Invasive Species Compendium. CABI. 2013 http://www.cabi.org/datashee/6878

[26] Karlsson, L.M., Tamado T., Milberg, P. Seed dormancy pattern of the annuals Argemone ochroleuca and A. mexicana (Papaveraceae). Flora. 2003; 198:329-339.

[27] Rahman, M.A. and Wilcock, C.C. A taxonomic revision of Calotropis (Asclepiadaceae). Nordic Journal of Botany. 1991; 11(3): 301-308.

[28] Lowe, S., Browne, M., Boundjelas S. and De Poorter, M. 100 of The World's Worst Invasive Alien Species: A Selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG) of the World Conservation Union (IUCN), 2000, 12 pp.

[29] IUCN/SSC/ISSG. Global Invasive Species database. IUCN – the World Conservation Union Species Survival Commission, ISSG. 2013.