

# INVASIVE ALIEN SPECIES OF FLORA OF THE THAR DESERT OF BIKANER DIVISION, RAJASTHAN

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**Abstract:** Fragility of the different ecosystems due to Invasive Alien Species (IAS) is now a major focus of global concern. The increasing threat of invasive aliens to the native flora inspired the present investigation. The study has commenced for assessment of the distribution and abundance of invasive alien plant species in the Thar desert of Bikaner Division of the northwestern Rajasthan for initiating their effective management. The aquatic ecosystems of the region is invaded by *Typha angustata*, *Ipomoea carnea*, *Eichhornia crassipes*, *Hydrilla verticillata* and *Nelumbo nucifera*. The desert ecosystem, especially near areas of rural as well as urban settlements, are severely invaded by *Prosopis juliflora*, *Lantana camara*, *Parthenium hysterophorus*, *Ageratum conyzoides*, *Argemone Mexicana* etc. The most severe infestation occurred by *Prosopis juliflora*, which is posing threat to survival of native biodiversity of the desert. Such IAS are major problem and obstruction for conservation of biodiversity. The main purpose of the present study was to determine the presence of potentially invasive plants within different habitat of the Thar desert of the Bikaner Division and to suggest effective management practices for mitigating their adverse impacts on native flora.

**Key words:** Invasive Alien Species (IAS), Thar desert, Bikaner division, Biodiversity.

## I. INTRODUCTION

Desert is the area where average annual rainfall is less than 20% (Singhvi and Kar, 1992). The Thar desert is the seventh largest desert of the world, situated between 24° to 28° N latitude and 68° to 71° E longitude (Arora et. al. 2010). It covers an area of about 0.32 million sq. km., which is nearly 12% of the total geographical area of India. A major portion of the Indian desert lies in Rajasthan. The Thar Desert of Rajasthan comprises 13 districts stretching from Ganganagar district in North to Sirohi in South. Most of the area of the desert consists of dry undulating plains of hardened sand. The remaining region is largely a mass of loose sand, forming shifting sand dunes. The Desert environment is harsh for plants, wild animals and human population. Yet, the Thar Desert is the most populated desert in the world. Population density in the Thar desert is 84 persons/km<sup>2</sup>, while it is only 3-9 persons/km<sup>2</sup> in rest of the deserts of the world (Gehlot and Jakher, 2015). This diverse terrain supports exuberant vegetation and animal life, which has adapted to the harsh weather conditions. The state is rich in floral diversity, with 911 wild species belonging to 780 genera and 154 families (Shetty and Singh 1987; 1991 and 1993; Bhandari 1990). Grasses, shrubs, and trees withstand dry climates by sporting shallows, widespread roots that capture moisture and leaves that appear only after the rains fall.

The flora and fauna are homogenising at global level. The Thar desert of Indian sub-continent is not an exception. The homogenization of flora and fauna is due to rapid increase in invasive species (Mooney and Hobbs, 2000). The global climate change and biological invasion of alien species are two most important factors causing the loss of biodiversity (Norton et al., 2013). Due to its high ecological as well as economic costs, the biological invasion of alien species exerts severe environmental impacts (Armstrong, 1995; Chapin et.al. 2000) and it is one of the major reasons for extinction of species from different ecosystems (Mooney and Drake, 1987).

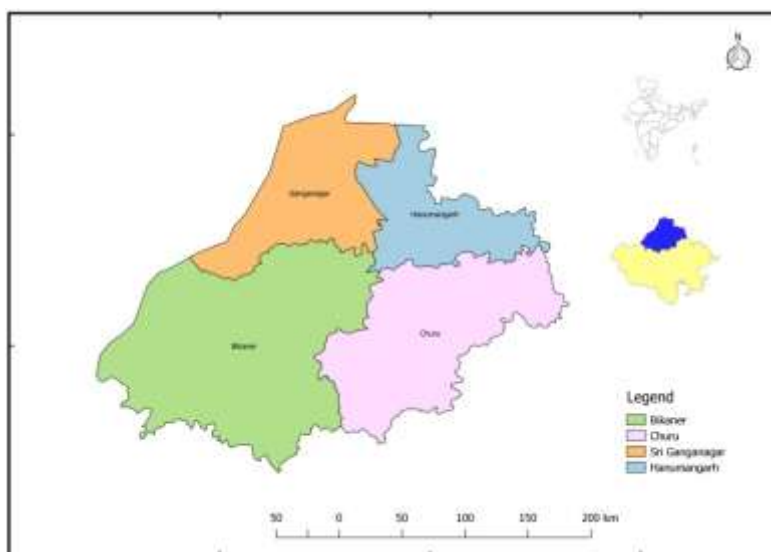
According to the Forest Service Framework for Invasive Species, an invasive species is defined as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (USDA Forest Service, 2013). Invasive alien species has become the second major cause of global biodiversity loss after direct habitat destruction (Sala et al., 2000). Naturalization is a process by which an alien species spreads into the wild and its reproduction is sufficient to maintain its population. Some of naturalized aliens become highly adapted to new areas and replace native species, disrupt nutrient cycles and cause changes in the pattern of plant succession, known as invasive species. After becoming dominant at local level, alien species invade natural communities and turn into Invasive Alien Species (Mandal, 2011). It is reported that in India, about 45000 plant species are existing (Kumar et. al, 2011), out of which, about 18000 plant species are alien species (CPREEC, 2016). Hence, about 40% of the Indian flora is alien. Out of these alien species, about 25% are IAS (Raghubanshi et al., 2005). Most of these alien species acts as weeds in agricultural fields (Khuspe et al. 1982, Nandpuri et al. 1986). They threatens valued environmental, agricultural or personal resources by the damage it causes (Marbuah, et al. 2014; Kelly and Goulden, 2008). It has noticed that every year about 30% loss in crop yield in India is due to presence of such invasive alien weeds (Singh, 1996). Many alien species support our agriculture, horticulture and forestry. Several economically important species from different corner of the world has dispersed in India. Some of these IAS are playing very important role in Indian agricultural system including food plants like sunflower, cashew nut, chilli, corn, and carrot are alien species introduced from North America. Similarly, radish, barley, fennel and sweet potato are introduced from Africa whereas; Australia contributed *Eucalyptus*, *Thuja*, *Casuarina*, *Mangium* and silver-oak to India (Reddy, 2008). The rate of infestation of alien species is increasing because of mobile society and the intentional transportation of ornamental and forage plants (Randall and Marinelli, 1996). The increasing trade and transcontinental transport, the flora of Indian subcontinent have a number of alien species from various parts of the world (Rana and Rastogi, 2017; Adhikari et al., 2015; Khuroo, et al., 2007).

The Bikaner division is getting water for irrigation and drinking by the Ganga Canal (completed in 1928) and Indira Gandhi Canal (completed in 1987). Due to availability of canal water for irrigation, the region is continuously being explored for extensive agricultural activities since last few decades. The barren sand dunes have converted into agricultural fields. The micro-climatic conditions of the region are changed. The use of synthetic fertilizers and pesticides has reached to its peak. The intentional or unintentional introduction of new plant species

has changed the entire ecology of the region. The native flora is facing severe threats from the introduced species. A systematic approach to develop techniques for rapid assessment of the status and movement of invaders and their potential impacts on various ecosystems are the prime need of the time. Therefore, the investigation and documentation on invasive alien flora of the Thar Desert of Bikaner division was undertaken to know the status of invasive alien flora in the region.

## II. MATERIAL AND METHODS

The inventurisation of invasive alien species of plants was carried out in the Thar desert of Bikaner division during July 2016 to June 2017 (Fig.1). Bikaner is headquartering of the division. The surveys, investigation, collection of samples and preparation of herbariums of plants of the area were arranged. The study area characterized with very little rainfall and extreme temperatures. In summer, temperatures exceed 50 °C while during the winter it dips to freezing point. The average annual rainfall of the region is in the range of 260–440 mm.



**Fig.1: Study area for present investigation**

The understanding and dealing with the invasive alien species may have many disputes. The identification of any species based on its origin is a challenging task. After an extensive review of literature on invasive species at global as well as local level and a series of field surveys, a list of invasive alien flora of the Bikaner division was prepared and identified. Plant identification was carried out according to existing literature (Bhandari, 1990; Shetty and Singh, 1987;91;93).

## III. RESULTS AND DISCUSSION

Extensive field surveys and review of literature on invasive species revealed that a total 96 species distributed in 74 genera and 35 families recorded as invasive alien species of the Bikaner division (Table-1).

**Table-1: Invasive Alien Species (IAS) of plants in Thar desert of Bikaner Division**

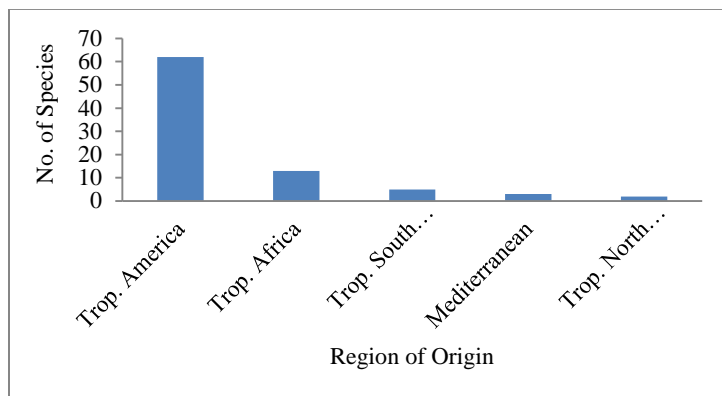
Species	Common name	Family	Habit	Nativity	Status
<i>Acanthospermum hispidum</i> DC.	Kantagokharu	Asteraceae	Herb	Trop. America	Invasive
<i>Achyranthes aspera</i>	Latjeera, Putjeera	Amaranthaceae	Herb	Trop. America	Invasive
<i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.	Bui	Amaranthaceae	Herb	Trop. America	Naturalised
<i>Aerva lanata</i> (L.) Juss.	Bui	Amaranthaceae	Herb	Trop. America	Naturalised
<i>Aerva pseudotomentosa</i> Blatt. & Hallb.	Bui	Amaranthaceae	Herb	Trop. America	Naturalised
<i>Ageratum conyzoides</i> L.	Jangli pudina	Asteraceae	Herb	Trop. America	Invasive
<i>Alternanthera pungens</i> Kunth	Garundi, Guroo	Amaranthaceae	Herb	Trop. America	Invasive
<i>Alternanthera tenella</i> Colla	Garundi, Guroo	Amaranthaceae	Herb	Trop. America	Invasive
<i>Amaranthus viridis</i> L.	Sandalio, Chandelo	Amaranthaceae	Herb	South America	Invasive
<i>Argemone mexicana</i> L.	Peeli Kantilee	Papaveraceae	Herb	Trop. Central	Invasive

Species	Common name	Family	Habit	Nativity	Status
				& South America	
<i>Asphodelus tenuifolius</i> Cav.	Piazi, jungli pyaji	Liliaceae	Herb	Trop. America	Invasive
<i>Bidens biternata</i>	Chirchitta	Asteraceae	Herb	Trop. America	Invasive
<i>Bidens pilosa</i> L.	Chirchitta	Asteraceae	Herb	Trop. America	Invasive
<i>Blainvillea acmella</i> (L.) Philipson	Dholu Fuladu	Asteraceae	Herb	Trop. America	Invasive
<i>Blumea eriantha</i> DC.	Kakronda, Jangli Muda	Asteraceae	Herb	Trop. America	Invasive
<i>Blumea lacera</i> (Burm.f.) DC.	Kakronda, Jangli Muda	Asteraceae	Herb	Trop. America	Invasive
<i>Calotropis gigantea</i> (L.) R.Br.	Shivji ka aak	Asclepiadaceae	Shrub	Trop. Africa	Invasive
<i>Calotropis procera</i> (Ait.) R.Br.	Aakda/ Aak	Asclepiadaceae	Shrub	Trop. Africa	Invasive
<i>Cassia auriculata</i> L.	Anwal, Anwala	Caesalpiniaceae	Shrub	Trop. America	Invasive
<i>Cassia italica</i> (Mill.) Spreng.	Sonamukhi, Bhinda-anwal	Caesalpiniaceae	Herb	Trop. America	Invasive
<i>Cassia obtusifolia</i> L.	Anwal, Anwala	Caesalpiniaceae	Herb	Trop. America	Invasive
<i>Cassia occidentalis</i> L.	Kesudo	Caesalpiniaceae	Herb	Trop. America	Invasive
<i>Cassia tora</i> L.	Sonamukhi	Caesalpiniaceae	Herb	Trop. South America	Invasive
<i>Catharanthus pusillus</i> (Murray) Don	Sadabahr	Apocynaceae	Herb	Trop. America	Invasive
<i>Celosia argentea</i> L.	Imarti, Kukari, Makhamal	Amaranthaceae	Herb	Trop. Africa	Invasive
<i>Chamaesyce hirta</i> (L.) Millsp.	Dhedi-Dudheli	Euphorbiaceae	Herb	Trop. America	Invasive
<i>Chamaesyce indica</i> (Lam.) Croizat	Dhedi-Dudheli	Euphorbiaceae	Herb	Trop. South America	Naturalised
<i>Chenopodium album</i> L.	Bathua	Chenopodiaceae	Herb	Trop. America	Invasive
<i>Chloris barbata</i> Sw.	Shiyad Punch	Poaceae	Herb	Trop. America	Invasive
<i>Chromolaena odorata</i> (L.) King & Robinson	Bagh Dhoka, Tivra-gandha	Asteraceae	Herb	Trop. America	Invasive
<i>Cleome gynandra</i> L.	Safed bagro, Safed hulhul	Cleomaceae	Herb	Trop. America	Naturalised
<i>Cleome viscosa</i> L.	Peeli hulhul	Cleomaceae	Herb	Trop. America	Invasive
<i>Clerodendrum phlomidis</i>	Arni / Arno	Lamiaceae	Shrub	Trop. Africa	Naturalised
<i>Corchorus depressus</i> (Linn.) Stocks	Cham Ghans	Tiliaceae	Herb	Trop. Africa	Invasive
<i>Corchorus tridens</i> L.	Chonch, Hade-ka-khet	Tiliaceae	Herb	Trop. Africa	Invasive
<i>Crotalaria burhia</i> Buch.-Ham. ex Benth.	Sania / Chag	Papilionaceae	Herb	Trop. America	Naturalised
<i>Crotalaria juncea</i> L.	Jhunjhunja, masina, San	Papilionaceae	Herb	Trop. America	Naturalised
<i>Croton bonplandianum</i> Boil.	Kala Bhangra	Euphorbiaceae	Herb	Temperate South America	Invasive
<i>Cuscuta reflexa</i> Roxb.	Amarbel	Cuscutaceae	Climber	Mediterranean	Naturalised

Species	Common name	Family	Habit	Nativity	Status
<i>Cyperus difformis</i> L.	Moth	Cyperaceae	Herb	Trop. America	Invasive
<i>Cyperus iria</i> L.	Moth	Cyperaceae	Herb	Trop. America	Invasive
<i>Datura innoxia</i> Mill.	Dhatura	Solanaceae	Shrub	Trop. America	Invasive
<i>Datura metel</i> L.	Dhatura	Solanaceae	Shrub	Trop. America	Invasive
<i>Dicoma tomentosa</i> Cass.	Ubio til-kant	Asteraceae	Herb	Trop. Africa	Invasive
<i>Digera muricata</i> (L.) Mart.	lolaru	Amaranthaceae	Herb	SW Asia	Invasive
<i>Dinebra retroflexa</i> (Vahl) Panz.	Naribalada ghas	Poaceae	Herb	Trop. America	Invasive
<i>Echinochloa colonum</i> (L.) Link	Jirio	Poaceae	Herb	Trop. South America	Invasive
<i>Echinochloa crus-galli</i> (L.) Beauv.	hama, Gobra, Jatghasha, Kayada	Poaceae	Herb	Trop. South America	Invasive
<i>Echinops echinatus</i> Roxb.	Unth kantilee	Asteraceae	Herb	Afghanistan	Invasive
<i>Eclipta prostrata</i> (L.) Mant.	Jal bhangro	Asteraceae	Herb	Trop. America	Naturalised
<i>Eichhornia crassipes</i> (C. Martius) Solms-Loub.	Jalkumbhi	Pontederiaceae	Herb	Trop. America	Invasive
<i>Emilia sonchifolia</i> (L.) DC.	Hirankhuri	Asteraceae	Herb	Trop. America	Invasive
<i>Eucalyptus indica</i>	Safeda	Myrtaceae	Tree	Australia	Invasive
<i>Evolvulus alsenoides</i>	Phooli	Convolvulaceae	Herb	Trop. America	Invasive
<i>Galinosoga parviflora</i> Cav.	Marchia, Pardesi	Asteraceae	Herb	Trop. America	Invasive
<i>Heliotropium indicum</i> L.	Kali bui,	Boraginaceae	Herb	Trop. America	Naturalised
<i>Imperata cylindrica</i> (L.) Raensch.	Sirhu, Dabh, Khans	Poaceae	Herb	Trop. America	Invasive
<i>Indigofera linifolia</i> (L.f.) Retz.	Lambio bekario	Papilionaceae	Herb	Trop. South America	Invasive
<i>Indigofera limnaii</i> Ali	Bekario	Papilionaceae	Herb	Trop. Africa	Invasive
<i>Ipomoea carnea</i> Jacq.	Besharmi	Convolvulaceae	Shrub	Trop. America	Invasive
<i>Ipomoea eriocarpa</i> R.Br.	Rota belari	Convolvulaceae	Climber	Trop. Africa	Invasive
<i>Ipomoea pes-tigridis</i> L.	Panchpatiya bel	Convolvulaceae	Climber	Trop. East Africa	Invasive
<i>Jatropha curcas</i>	Ratanjot	Euphorbiaceae	Herb	Trop. America	Invasive
<i>Jatropha gossypifolia</i> L.	Ratanjot	Euphorbiaceae	Shrub	Trop. America	Invasive
<i>Lantana camara</i> L.	Raimuniya	Verbenaceae	Herb	Trop. America	Invasive
<i>Leucaena leucocephala</i> (Lam.) de Wit	Subabool	Mimosaceae	Tree	Trop. America	Naturalised
<i>Malvastrum coromandelianum</i> (L.) Garcke	Kharenti	Malvaceae	Herb	Trop. America	Invasive
<i>Martynia annua</i> (Houstoun in Martyn) L.	Bagh-nakkhi	Pedaliaceae	Shrub	Trop. America	Invasive
<i>Mecardonia procumbens</i> (Mill.) Small	Makardana	Scrophulariaceae	Herb	Trop. North America	Invasive
<i>Melochia corchorifolia</i> L.	Chitrabeez	Sterculiaceae	Herb	Trop. America	Invasive

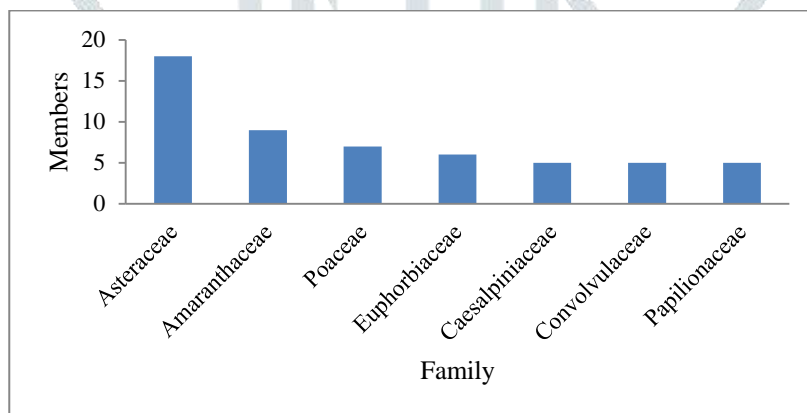
Species	Common name	Family	Habit	Nativity	Status
<i>Merremia aegyptia</i> (L.) Urban.	Rota bel	Convolvulaceae	Climber	Trop. America	Naturalised
<i>Moringa oleifera</i> Lam.	Senjana, Sanjano	Moringaceae	Tree	Trop. Africa	Naturalised
<i>Ocimum americanum</i> L.	Bapji, Rantulsi	Lamiaceae	Herb	Trop. America	Invasive
<i>Opuntia elatior</i>	Naagphani	Cactaceae	Shrub	Trop. America	Naturalised
<i>Oxalis corniculata</i> L.	Khatari	Oxalidaceae	Herb	Europe	Invasive
<i>Parthenium hysterophorus</i> L.	Congress grass	Asteraceae	Herb	Trop. North America	Invasive
<i>Pedaliium murex</i> L.	Bada Goghru	Pedaliaceae	Herb	Trop. America	Invasive
<i>Pennisetum purpureum</i> Schum.	Dhamanio	Poaceae	Herb	Trop. America	Invasive
<i>Peristrophe paniculata</i> (Forssk.) Brummitt	Kanger	Acanthaceae	Herb	Trop. America	Invasive
<i>Physalis minima</i> L.	Chirphoti, Pipat	Solanaceae	Shrub	Trop. America	Invasive
<i>Prosopis juliflora</i> (Sw.) DC.	Angreji babool	Mimosaceae	Shrub	Mexico	Invasive
<i>Ricinus communis</i> L.	Arandi	Euphorbiaceae	Shrub	Trop. Africa	Naturalised
<i>Ruellia patula</i>	Kali Dhraman	Acanthaceae	Herb	Trop. America	Naturalised
<i>Saccharum spontaneum</i> L.	Munja	Poaceae	Herb	Trop. West Asia	Naturalised
<i>Sesbania sesban</i>	Ekad	Papilionaceae	Shrub	Trop. America	Invasive
<i>Sida cordata</i> (Burm.f.) Borss. Waalk.	Adio-bal	Malvaceae	Herb	Trop. America	Invasive
<i>Solanum americanum</i> Mill.	Adkuntali	Solanaceae	Herb	Trop. America	Invasive
<i>Sonchus asper</i> Hill	Aakadiyo	Asteraceae	Herb	Mediterranean	Invasive
<i>Sonchus oleraceus</i> L.	Aakadiyo	Asteraceae	Herb	Mediterranean	Invasive
<i>Tribulus terrestris</i> L.	Chhota gokharu	Zygophyllaceae	Herb	Trop. America	Invasive
<i>Tridax procumbens</i> L.	Khal-muriya, Tal-muriya	Asteraceae	Herb	Trop. Central America	Naturalised
<i>Triumfetta rhomboidea</i> Jacq.	Chiki	Tiliaceae	Herb	Trop. America	Invasive
<i>Typha angustata</i> Bory. & Choub.	Patera	Typhaceae	Herb	Trop. America	Invasive
<i>Vachellia tortilis</i>	Keekar, deshi banwal	Fabaceae	Tree	Trop. Africa	Naturalised
<i>Xanthium strumarium</i> L.	Chhota dhatorea	Asteraceae	Herb	Trop. America	Invasive
<i>Ziziphus mauritiana</i> Lam.	Ber	Rhamnaceae	Shrub	Trop. Africa	Naturalised

The results of the study shows that invasive plant species found in the Bikaner division are native vegetation of 15 different geographical regions of the world and recorded as invader in the study area. Total 64.6% of these species contributed by tropical America followed by 13.5% by tropical Africa and 5.2% % by tropical South America region (Fig. 2).



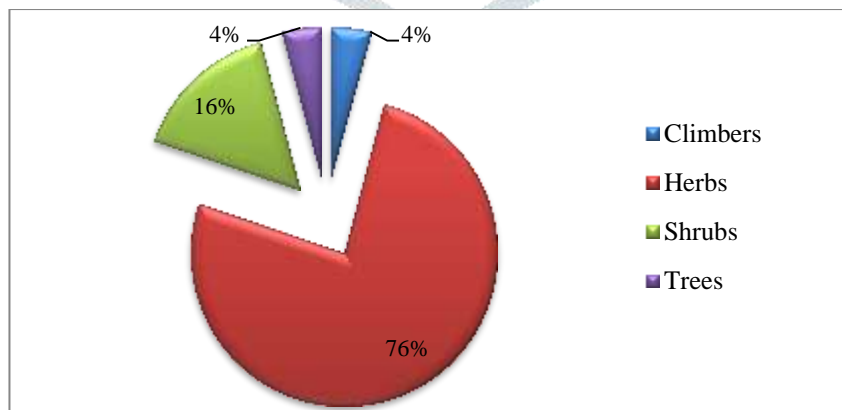
**Fig. 2: Top five native regions of invasive alien species of flora of Bikaner division**

The family wise assessment of IAS species in the region shows that the invaded members of different flora are belongs to 35 different families. Largest number of IAS plant species belongs to families of Asteraceae (18 species) followed by Amaranthaceae (9) and Poaceae (7) and the top three families together account for 36.46% of the total invasive alien flora of the study area. Relative to the number of the member as invasive flora in the region, Euphorbiaceae (6) stands at fourth position while Caesalpiniaceae, Convolvulacea and Papilionaceae are at the fifth position with 5 members each in the study area (Fig.3). Among the flowering plants in the world, Asteraceae is one of the major family. The seeds of the Asteraceae member are specific with the large number as well as parachute mechanisms, which help them for dispersion in wide range and boost their establishment in different climatic conditions (Udayakumar et al., 2014).



**Fig. 3: Top five families contributing invasive alien species of flora of the study area**

Among four habitat types, herbs dominated the total alien flora (76%), followed by shrubs (16%). The tree flora and climbers shared 4% each as total of invasive alien flora in the study area (Fig.4). The results of the study are in linearity with the earlier findings (Srivastava et. al., 2014; Khuroo et al., 2017). The greater ecological amplitude and tolerance to harsh climatic conditions could be probable reasons for dominance of herbaceous flora across the region.



**Fig. 4: Habitat-wise classification of invasive alien species of Bikaner Division**

**IV. CONCLUSION**

The invasive alien species amend the composition of native community, deteriorate species diversity, modify micro-climatic conditions which results in considerable economic as well as ecological imbalance. The monitoring programes on invasive alien species must be carried out on regular basis. The review of available literature revealed that many species are introduced to new area by human for ornamental, economical and

other purposes but some time such invasive species invaded accidentally during trade activities. A better planning is needed for early detection and reporting of infestations of new weeds. To mitigate the adverse impacts of such invasive plant species, the environmental education, public awareness campaigns about invasive alien species at national and local levels, biological, chemical and mechanical methods for eradication of invasive alien flora etc are the need of the time.

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## REFERENCES

- [1] Adhikari, D.; Tiwary, R. and Barik, S. K. (2015). Modelling Hotspots for Invasive Alien Plants in India. *PLoS One.*, 10(7): 1-20.
- [2] Armstrong, S. 1995. Rare plants protect Cape's water supplies. *New Scientist*. February 11:8.
- [3] Arora, J. Goyal, S. and Ramawat, K. G. 2010. Biodiversity, biology and conservation of medicinal plants of the Thar Desert. In: Ramawat, K.G. (ed) (2010), *Desert Plants, Springer-Verlag Berlin Heidelberg*.
- [4] Bhandari, M. M. 1990. Flora of the Indian Desert. Scientific publishers, Jodhpur, India.
- [5] C.P.R. Environmental Education Centre (2016). Govt to conduct study of alien plant species in bid to check invasion of forests. Ministry of Environment and Forests & Climate Change, Govt of India. <https://www.livemint.com> > Science.
- [6] Chapin, F.S. III., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L. and Hooper, D.U. 2000. Consequences of changing biodiversity. *Nature*, 405: 234–242.
- [7] Gehlot, H. S. and Jakher, G. R. 2015. Threats to Existence of Blackbuck (*Antelope cervicapra*) and Chinkara (*Gazella bennetti*) in the Thar region of Rajasthan, India. *International Journal of Recent Biotechnology*, 3 (1): 1-6.
- [8] Kelly, A. E. and Goulden, M. L. (2008). Rapid shifts in plant distribution with recent climate change. *Proc Natl Acad Sci*, 105: 11823–11826.
- [9] Khuroo, A. A.; Rashid, I.; Reshi, Z.; Dar, G. H. and Wafai, A. (2007). The alien flora of Kashmir Himalaya. *Biol. Invasions*, 9:269–292.
- [10] Khuroo, A. A.; Rashid, I.; Reshi, Z.; Dar, G. H. and Wafai, B. A. (2007). The alien flora of Kashmir Himalaya. *Biol Invasions*, 9:269–292.
- [11] Khuspe, V.S., Subbaiah, R., Mande, J.V., 1982. A Compendium of Indian Weed Science Research (1950–1981). Metropolitan Book Co, New Delhi.
- [12] Kumar, A. S.; Kavimani, S. and Jayaveera, K. N. (2011). A review on medicinal plants with potential antidiabetic activity. *International Journal of Phytopharmacology*, 2(2): 53-60.
- [13] Mandal, F. B. (2011). The management of alien species in India. *International Journal of Biodiversity and Conservation*, 3(9): 467-473.
- [14] Marbuah, G.; Gren, I. M. and McKie, B. (2014). Economics of Harmful Invasive Species: A Review. *Diversity*, 6: 500-523.
- [15] Mooney, H. A. and Drake, J. A. 1987. The Ecology of Biological Invasions. *Environment* 29 (5):12.
- [16] Mooney, H. A. and Hobbs, R. J. 2000. Invasive Species in a Changing World. *Island Press, Washington, D.C.*
- [17] Nandpuri, K.S., Singh, B., Kolar, J.S., Kang, M.S., Chahal, B.S. 1986. Field Problems of Important Crops. Punjab Agricultural University, Ludhiana, India.
- [18] Norton, D. A., Reid, N. and Young, L. 2013. Ultimate drivers of native biodiversity change in agricultural systems. *F1000 Research*, 2:214.
- [19] Raghubanshi, A. S.; Rai, L. C.; Gaur, J. P. and Singh, J. S. (2005). Invasive alien species and biodiversity in India. *Curr. Sci.*, 88(4): 539-540.
- [20] Rana, S. and Rastogi, J. (2017). Occurrence and floral details of four new invasive alien species in Uttarakhand, India. *Archives of Agriculture and Environmental Science* 2 (2): 113-118.
- [21] Randall, J.M.; Marinelli, J., eds. 1996. Invasive plants: weeds of the global garden. Handb. 149. Brooklyn, NY: Brooklyn Botanic Garden. 111 p
- [22] Reddy, C. S. (2008). Catalogue of invasive alien flora of India. *Life Sci J* 5: 84–89.
- [23] Sala, O. E., Chapin, F. S. III., Armesto, J. J., Berlow, R., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., Leemans, R., Lodge, D., Mooney, H. A., Oesterheld, M., Poff, N. L., Sykes, M. T., Walker, B. H., Walker, M. and Wall, D. H. 2000. Global biodiversity scenarios for the year 2100. *Science*, 287: 1770-1774.
- [24] Shetty, B. V. and Singh, V. 1991. Flora of Rajasthan. Vol. II. Botanical Survey of India, Howrah.
- [25] Shetty, B. V. and Singh, V. 1987. Flora of Rajasthan. Vol. I. Botanical Survey of India, Howrah.
- [26] Shetty, B. V. and Singh, V. 1993. Flora of Rajasthan. Vol. III. Botanical Survey of India, Howrah.
- [27] Singh S. P. (1996). Biological control. In: Paroda, R. S.; Chadha, K. L. (Eds). 1996. 50 years of crop science research in India. Indian Council of Agricultural research, New Delhi, pp. 88-116.
- [28] Singhvi, A. K. and Kar, A. 1992. Thar Desert in Rajasthan - Land, Man and Environment. *Geol. Soc. Ind, Bangalore, India*.
- [29] Srivastava, S.; Dvivedi, A. and Shukla, R. P. (2014). Invasive Alien Species of Terrestrial Vegetation of North-Eastern Uttar Pradesh. *International Journal of Forestry Research*, 1-9.
- [30] Udayakumar, M.; Bharathidasan, E. and Sekar, T. (2014). Invasive Alien Flora of Thiruvallur District, Tamil Nadu, India. *Sch. Acad. J. Biosci.*, 2 (4): 295-306.
- [31] USDA Forest Service. 2013. National Strategic Framework for Invasive Species Management. FS-1017. Washington, DC: U.S.