Invasive alien plant species: a threat to biodiversity and agriculture in Nepal

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Abstract Invasive alien plant species (IAPS) are a significant threat to agriculture, resulting in crop loss and increased production cost. Because of their detrimental effects on floral and faunal organisms and their ecosystems, they pose a significant threat to biodiversity. There are 219 species of alien flowering plants native to Nepal, 26 of which have been reported to be invasive with negative environmental impacts, including agricultural production. Four of them (Lantana camara L., Mikania micrantha Kunth, Chromolaena odorata (L.) King & Robb. and Eichhornia crassipes (Mart.) Solms) are among the 100 of the world’s worst invasive alien species in agro-ecosystems and range lands. The current status and impacts of invasive alien plant species are discussed in this paper.

Keywords: Invasive alien species, Biodiversity, Ecosystem, Biological species, Impacts

Introduction

Invasive alien plant species (IAPS) is a species that has been deliberately or inadvertently introduced to a place, area, or region where it naturally does not occur. They are endemic to one place or territory that affects biodiversity, ecology, and environments, and human safety and shows a tendency to spread out of control (CBD, 2002; Gaertner et al., 2009). The "invasive" label is generally reserved for plants that have been introduced from other regions and spread like wildfire in their new habitats. The main driver of global change is invasive species (Pejchar and Mooney, 2009) which can affect the biological diversity and mechanism of the environment (Clout and Poorter, 2005). A major component of global environmental change has been called biologic invasions (Vitousek, 1990), which was the leading cause of natural biodiversity degradation and depletion (Ricciardi et al., 1998), and biodiversity services (Peychar and Mooney, 2009). Besides, the composition and purposes of the goods and services offered by the environment are determined by the introduction of a new species into the environment (Wilcove et al., 1998). Such invasive plant species endangering and disrupting the natural environment and affecting agriculture in Nepal (Tiwari et al., 2005). In addition, invasive species may significantly reduce agricultural production and jeopardize significant cultural environments, eg. historic gardens (Richburg, 2008). Such disruption is exacerbated by climate change (Kriticos et al., 2003; Dukes and Mooney, 2004), deforestation, ecosystem destruction, and human- perturbation (Norbu, 2004). Some invasive species of plants such as Ageratina adenophora (Spreng.) King & Robb (Chhetri, 1986), Lantana camara L., Chromolaena odorata (L.) King & Robb. (Norbu, 2004), Mikania micrantha Kunth (Sapkota 2012; Rai and Scarborough, 2012), and Hyptis suaveolens (L.) Poit. are significant invasive species in the forest of Nepal that invade forest and shrubs land (Tiwari et al., 2005).

The main issue of invasive plant species continues to increase at high social, health and environmental level worldwide. The impacts of invasive plant species on developing countries like Nepal are very serious as they depend on resource-based livelihoods such as agriculture, aquaculture, fisheries, and forestry (Matthews and Brandt, 2004). Substantial advancement, economic expansion, and food security could also be attributed to social instability and economic disruption by invasive alien species (GISP, 2009). One of the key sources of environmental and economic disruption and the major factors of biodiversity loss has been a biological invasion (CBD, 1992). Invasive alien species are more widespread along the road and anthropogenic disruptions (Kohli et al., 2009). The widespread availability of available capital raises ecosystem susceptibility to invasion (Davis et al., 2000). Human actions raise invasive species proliferation pressure (Simberloff, 2009).
Bellard et al. (2016) and Downey and Richardson (2016) reported alien species were among the main causes of the decline in biodiversity (extermination of populations) and economic damage. In fact, the most significant threats to human loss and habitat destruction in the Island habitats worldwide may also be due to invasive alien species (Donlan et al., 2003). Invasive species alter hydrological flows and environments and adjust the composition of soil and its chemical properties (Randall and Marinelli, 1996). Furthermore, invasive alien species can hybridize with native plant relatives and are regarded to be biological pollutants (Westbrooks, 1991). This may result in unintended modifications to plant genetics makeup (Richburg, 2008).

Invasive alien plants performance is attributable to the existence of novel weapons such as allelopathic traits (Rai and Tripathi, 1982) and its evolution with improved competition (Callaway and Ridenour, 2004). The latest work reveals empirical similarities between the success of exotic human invasions and the success of exotic plant invasions-use of advanced arms (Callaway and Ridenour, 2004). Naturalized species are more invasive and free of natural rivals - Enemy release hypothesis (ERH) (Torchin et al., 2003; Eschtruth and Battles, 2009). Biotic resistance hypothesis (BRH) is the most plausible for biological invasions in abundant and dense woodland with monospecific stands (Pimm, 1984; Norbu, 2004). Invasive plants prosper from high rates of nitrogen (Brooks, 2003).

Anthropogenic practices had the greatest impact in raising the invasion of plant organisms, e.g. Chromolaena odorata in the decreased understory biomass and canopy exposure induced by human intervention (Joshi, 2001; Norbu, 2004). With the globalization of the commerce and human activities in all continents and climatic regions (Seebens et al., 2017), even in the high mountains and Polar Regions, the number of alien organisms has increased without any saturation indication (Pauchard et al., 2016). Recent trends have seen a significant increase in the pace and threat associated with the introduction of alien species as human population development and environmental improvements have steadily increased (Pimentel et al., 2000). The degree of invasion has been observed to be lowered slowly from near-study areas as human intervention is progressively decreased (Karki, 2009). The scale of biological invasion has gradually risen across many of the ecosystems and environments, as human movement and global commerce, have intensified. The adverse effects of alien organisms are exacerbated by current climate change, as the extent and severity of the biological invasion is expected to rise (Simberloff, 2000).

Most alien species effectively naturalize and disrupt native species and homogenization of ecosystem, alteration in hydrological characteristics, gene pools degradable by native species hybridization (Richburg, 2008), leading to a loss in biodiversity (Miththapala, 2007; Gaertner et al., 2009; Hui et al., 2011). A category of naturalized organisms dispersed so rapidly and widely that they had significant adverse effects on introduced ecosystems, biodiversity, the environment, human health and the economy called invasive alien organisms (Pysek et al., 2004). The biological invasion was therefore recognized as the second leading source of biodiversity destruction in tandem with the depletion of the ecosystem as a whole (Glowka et al., 1994).

All exotic species, though, are not invasive. A species must be naturalized to avoid aggressive and distributed throughout its territory. Just one percent of all introduced organisms are projected to be invasive (Keam et al., 2009). If the ecosystem in which it invades is disrupted, introduced species can be at significantly higher risk to native ecosystems and species diversity (Moore, 2000; Wilcove et al., 1998). Besides, the composition and roles of the goods and services offered by the environment are affected by the introduction of a new species in the ecosystem (Wilcove et al., 1998). Invasive species intrusion of alien plants has influenced native species by trade, predation, hybridization, pathogens and disturbances of local habitats and ecosystem processes and may re-emerge after the elimination of the invasive species (Andreu and Vila, 2011), in virtually any environment on earth and triggered hundreds of extinctions (McNeely et al., 2001). While it is possible to increase the number of species in a particular site in the short term with the introduction of an alien species, this would lead to a reduction in the diversity of species if the native species were reduced or eventually displaced from a particular site or region (Begon et al., 1990). In this paper, we highlighted a brief overview of the diversity, current status, impacts, benefits, and management of invasive alien plant species found in Nepal.

**Species attributes of IAPS**

Invasive plant species exhibit rapid vegetative development, ample seed production potential, higher germination rate, long-lived seeds, rapid sexual and reproductive maturation, and a high ability to develop a wide range of phenotypic plasticity (ability to physically adapt to new environments) and survival potential for a variety of food types and environmental factors (Tiwari et al., 2005). Invasive species may significantly change their ecosystem by releasing chemical compounds, abiotic factors, or herbivorous behaviors that may have a positive or negative impact on other organisms. Certain species, including Kalanchoe daigremontiana Raym.-Hamet & H. Perrier, develop allelopathic substances, inhibiting competitive organisms and disrupting other processes of soil such as carbon and mineralization of nitrogen (Herrera et al., 2018). Additional species such as Stapelia gigantea N.E. Br. tends to attract seedlings of certain plants from...
arid habitats by maintaining optimal microclimate conditions and suppressing herbivory in early growth phases (Huenneke, 1990).

**Current status of IAPS in Nepal**

There are at least 219 alien species of flowering plants that are naturalized in Nepal. Among them 26 species, mostly native of tropical Americas, have been reported to be invasive with negative impacts on the environment including agriculture production (Shrestha et al., 2017). In addition to them, four naturalized species Ageratum conyzoides L., Erigeron karvinskianus DC., Galinsoga quadriradiata Ruiz & Pav. and Spermacoce alata Aubl. (Syn. Borreria alata) have been also found to be invasive in agro-ecosystems and range lands. Among 26 IAPS, four species (Chromolaena odorata, Eichhornia crassipes, Lantana camara and Mikania micrantha) are included in world’s 100 worst invasive species (GoN, 2019). An assessment of invasive alien plant species (IAPS) was undertaken for the first time by IUCN Nepal during 2002 - 2003 in Nepal (GoN, 2019). Nepal’s ecosystem is vulnerable to alien plant species because it disrupts various habitats and environmental factors (Kunwar, 2003; Tiwari et al., 2005).

In eastern and central Nepal, the number of naturalized species and invasive plant species is higher than in western Nepal (Bhattarai et al., 2014). At least some alien species inhabited the east of Nepal first and spread gradually to the west. For example, Chromolaena odorata and Mikania micrantha is absent can only be identified in a few areas in western Nepal (Poudel 2016), both are primary invasive weeds areas for eastern and central Nepal (Tiwari et al., 2005).

A large number of alien organisms are also known for the middle mountain area with a subtropical to a temperate climate. There have only been a few alien species (eg Ageratina adenophora and Galinsoga quadriradiata) recorded from the high mountains and until now the High Himal area is free of invasive alien plant species (Shrestha et al., 2016). By 1972 in the eastern part of Nepal (districts of Ilam, Terhathum and Dhankuta), Procecidochares utilis entered Nepal gradually from India and became an established population (Sharma and Chhetri, 1977).

This is not unexpected, because over 3/4th of the native-born plant species (including alien species) in Nepal come from the world's subtropical and tropical areas (Tiwari et al., 2005; Bhattarai et al., 2014). In seven tropical and subtropical regions of Nepal with high species resources between 700 and 1500 masl, alien plants are most widespread (Bhuju et al., 2013). Many exotic plants exhibit invasive character as the exotic countries are exempt from natural enemies and rivalry, e.g. from tropical America to Nepal, because of which invasive organisms may expand quickly and propagate (May, 2007). In Nepal, most alien species come from tropical America (Tiwari et al., 2005). Not all incorporated is invasive but is likely to be invasive by invasion (Tiwari et al., 2005; Siwakoti, 2012), by the implementation, set-up, and distribution (Keam et al., 2009). Invasive alien species amount is also high in the southern lowlands (Tarai and Siwalik) of tropical to subtropical climate, while most alien organisms are from tropical America (Tiwari et al., 2005). The types of IAPS was given in Table 1. The common IAPS found in Nepal was given in Table 2.

| Table 1: Types of invasive alien plant species based on land use |
|------------------|------------------------------------------------------------------|
| Land use types   | Invasive alien plant species                                      |
| Agroecosystems   | Ageratum houstonianum, A. conyzoides, Mimosa pudica, Oxalis latifolia, Parthenium hysterophorus, Spergula arvensis, Alternanthera philoxeroides, Argemone mexicana, Erigeron karvinskianus, Galinsoga quadriradiata |
| Wetlands         | Alternanthera philoxeroides, Myriophyllum aquaticum, Pistia stratiotes, Eichhornia crassipes, Ipomoea carnea spp. fistulosa, Leersia hexandra |
| Grasslands and residential areas | Amaranthus spinosus, Bidens pilosa, Xanthium strumarium, Parthenium hysterophorus, Senna tora, S. occidentalis, Spermacoce alata |
| Forests and shrub lands | Mikania micrantha, Ageratina adenophora, Chromolaena odorata, Hyptis suaveolens, Lantana camara |

(Table adapted by Shrestha et al. (2017))
Table 2: List of invasive alien plant species (IAPS) of Nepal having negative impacts to the environment and agriculture production

| SN  | Common name         | Local name          | Scientific Name                     | Family          |
|-----|---------------------|---------------------|-------------------------------------|-----------------|
| 1   | Bushmint            | TulsiJhar            | *Hypitis suaveolens* (L.)           | Lamiaceae       |
| 2   | Bush morning Glory  | Besaram             | *Ipomoea carnea* sp.               | Convolvulaceae  |
|     |                     |                     | *Tisulosa* (Mart. ex Choisy)        |                 |
| 3   | Corn spurry         | Thangnejhar         | *Spergula arvensis* L.             | Caryophyllaceae |
| 4   | Crofton weed        | Kalo Banmara        | *Ageratina adenophora* L.           | Asteraceae      |
| 5   | Karwinsky’s Fleabane| Phule Jhar           | *Erigeron karvinskianus* DC.        | Asteraceae      |
| 6   | Parthenium          | Patijhar            | *Parthenium hysterocephorus* L.    | Asteraceae      |
| 7   | Rough cockle Bur    | Bhede kuro          | *Xanthium strumarium* L.           | Asteraceae      |
| 8   | Sensitive plant     | Lajjawati           | *Mimosa pudica* L.                 | Mimosaceae      |
| 9   | Shaggy Soldier      | Jhuse Chitlanga     | *Galinsoga quadriradulata* Ruiz & Pav. | Asteraceae     |
| 10  | Siam weed           | Seto Banmara        | *Chromolaena odorata* (L.),        | Asteraceae      |
|     |                     |                     | R.M. King and H. Roxb.             |                 |
| 11  | Sickle pod senna    | Tapre               | *Senna tora* (L.) Roxb.            | Caesalpiniaceae |
| 12  | Southern Cut grass  | Karaute ghans,      | *Leersia hexandra* Sw.             | Poaceae         |
|     |                     | Navo dhan           |                                    |                 |
| 13  | Spiny pigweed       | Kandelude            | *Amaranthus spinosus* L.           | Amaranthaceae   |
| 14  | Water hyacinth      | Jalkumbhi            | *Eichhornia crassipes* (Mart.) Solms | Pontederiaceae  |
| 15  | Water lettuce       | Kumbhika Panibanda  | *Pistia stratiotes* L.             | Araceae         |
| 16  | Alligator weed      | Jala jambhu, Patpate| *Alteranthera philoxeroides* (Mart.) | Amaranthaceae   |
|     |                     |                     | Griseb.                             |                 |
| 17  | Billygoat           | Raunne/Gandhe       | *Geratium conyzoides* (L.)         | Asteraceae      |
| 18  | Black jack/Hairy    | Kalokuro            | *Bidens pilosa* L.                 | Asteraceae      |
|     | beggar-tick Weed    |                     |                                    |                 |
| 19  | Blue Billygoat      | Nilogandhe          | *Geratium houstonianum* Mill.      | Asteraceae      |
|     |                     |                     |                                    |                 |
| 20  | Broadleaf buttonweed| AluPate Jhar        | *Spermacoce alata* Aubl.           | Rubiaceae       |
| 21  | Lantana             | Kirne kanda         | *Lantana camara* L.                | Verbenaceae     |
| 22  | Mexican poppy       | Thakal              | *Argemone mexicana* L.             | Papaveraceae    |
| 23  | Purple wood sorel   | Chari amito         | *Oxalis latifolia* Kunth           | Oxalidaceae     |
| 24  | Mile-a-minute weed  | Lahare banmara      | *Mikania micrantha* Kunth          | Asteraceae      |
| 25  | Parrot's feather    | -                   | *Myriophyllum aquaticum* (Vell.) Verdc. | Holarigaceae   |
| 26  | Corn spurry         | Thangejhar          | *Spergula arvensis* L.             | Caryophyllaceae |

(Source: Shrestha, 2017; GoN, 2019)

*Mikania micrantha* and its impacts

*Mikania micrantha*, a rapidly developing, perennial creeping vine from Central and South America, colonizes agricultural land and is vandalistic in the humid rainforest zones of Asia and particularly Southeast Asia (Choudhary, 1972; Holmes et al., 2009; Parker, 1972). *Mikania micrantha*, commonly referred to as mile-a-minute, stretches through woodland patches and grassland in the CNP buffer zone (Poudel et al., 2005; Sapkota, 2007). A research carried out in Chitwan National Park central region and community-buffer forest region found *M. micrantha* to severely overwhelm riparian locations, forest edges and sparsely treed, shrub lined grasslands, as well as lower canopy areas of both natural and planted forest (Sapkota, 2007). The results on the native plant species in the Buffer zone of CNP in Nepal has been well documented by *Mikania micrantha* colonization (Rai et al., 2012a; Sapkota, 2007). In the Koshi Tappu Wildlife Reserve, one of the major Ramsar sites in Nepal and IBA (Baral and Inskipp, 2005), the influence of mikania weeds on Nepal’s wetlands habitats is most evident. *Mikania micrantha* is regarded as an intermediary host for liver fluke and hence it is suffered from animals grazing around it (Tiwari et al., 2005). Invasive weeds are much more nuanced than the adverse environmental effects on agricultural areas. In rural areas, more than two-thirds of the populace lives and cultivates livelihoods. The conservation of forest resources and daily living services is very critical (Adhikari et al., 2004; Pandit and Bevilacqua, 2011).

Study and case studies have shown that the influence of alien species varies from habitat
degradation of endangered species to adverse effects on rural communities (Rai et al., 2012). By the native forage abundance and bio-mass, M. micrantha was harmful to rhino-food supply (Subedi et al., 2014). In the developing world, this is especially serious where a multitude of challenges threatens their livelihoods are exacerbated (Sapkota, 2007). The distribution of plants and the surface chemistry of grasslands have been greatly changed by another alien group Parthenium hysterophorus (Timsina et al., 2011). M. micrantha has appeared in the tropical and sub-tropical areas of Nepal as the most extreme weeds of the non-native species that have started to exhibit invasive characteristics (Tiwari et al., 2005; Rai et al., 2012; Murphy et al., 2013). It has been identified as one of the world's 100 worst invasive alien species (Lowe et al., 2001), and the second most damaging weed in South Pacific (Waterhouse and Norris, 1987). It has been documented as the worst in the world (Tiwari et al., 2005).

Impacts of IAPS in biodiversity and agriculture

Invasive species is the second largest reason for biodiversity loss after habitat defragmentation (Gaertner et al., 2009). Invasive species threaten biodiversity by causing disease, acting as predators or parasites, acting as competitors, altering habitat, or hybridizing with local species. Besides replacing the native species, invasive plants also change the ecology of a given habitat by changing the nutrient cycle and soil pH (Drenovsky et al., 2007). Invasive plants can significantly alter biodiversity including plants, insect and microbial communities. Species extinction, habitat transition (for example, nitrogen cycle, hydrology, fire regime) and development are biological and evolutionary consequences. For example, approximately 42% of the species reported under threats endangered are predominantly at risk from alien species (Pimentel et al., 2000). Invasive alien species are one of the crucial driving forces of inland waters biodiversity destruction (MEA, 2005). Comprehensive research and analysis to expose the status and impacts of invasive species in Nepal are mandated in some of the alarming impacts on the natural grasslands of national parks and conservation zones of invasive species such as Eichhornia crassipes and Mikania micrantha (Tiwari et al., 2005) wetlands.

Invasive plants can have a wide range of impacts on agriculture. They may act as new or additional hosts for new or existing crop diseases and pests, may cause crop yield reductions and may require increased use of pesticides to control them. This increases costs for farmers and reduces crop values. Invasive plants, which invade agricultural land, severely reduce productivity and land values. The invasion of pastures leads to loss of forages and forage value. Farmers have suffered major declines in crop yields and seed production in agro-ecosystems due to the invasion of many alien organisms. The development of Ageratum conyzoides in agricultural crops, particularly the ginger, millet, rice, and corn, has declined (Bhusal, 2009) and their productivity has also declined. (Oerke et al., 1994) officially confirmed that there was a 13% decline in agriculture production. Amaranthus spinosus which competes with crops for nutrients is a widespread agricultural weed (Tiwari et al., 2005). The research reported about 8000 species of plant exchanged or non-traded, and some 2500 of these are considered to be potentially hazardous, are thought to be agricultural weeds (Yaduraj et al., 2000). Among all taxa, which are estimated to be five times faster than that of terrestrial plant species in North America, at rates comparable to tropical forests (Ricciaiardi and Rasmussen, 1999), around 20% of the world's aquatic plant species, in accordance with the rest of the leading species, are at risk of extinction because of plant species in addition to other significant drivers of loss in biodiversity (Moyle and Leidy, 1992). The invasion of Nepal's wetlands is concentrated on the exotic aquatic plant, such as Eichhornia crassipes (water hyacinth), Alternanthera philoxeroides, Ipomoea spp, Myriophyllum aquaticum, Pistia, Leersia hexandra and stratiotes (HMGN/MFSC 2002; Poudel et al., 2005 and Sikawoti, 2007).

Invasive alien plant species may be repositories of pathogens or carriers of diseases that are spread across bodies, such as avian influenza A (H5N1) and humans and animals affecting both warm and tropical countries (Tiwari et al., 2005) illustrate a lethal modern pathogen. Ageratum conyzoides are allergic and create an unpleasant scent, sometimes contributing to sneezing, diarrhea, headache and fever. In comparison, other invasive alien plant species are poisonous to domestic animals, such as Xanthium strumarium, Ipomoea carnea, Lantana camara, Ageratum houstonianum etc. (Tiwari et al., 2005). Ageratum houstonianum is poisonous to grazing livestock, triggering liver lesions (Sanchez and Durand, 2004) cattle will often die when they are fed. In Mozambique, goats have been confirmed to have Ipomoea carnea induced lysosomal storage diseases, animals have stung, and head tumors that may trigger death (Tiwari et al., 2005). Xanthium strumarium burs are hazardous substances, Carboxyatractysloside which can kill animals, cattle, sheep and swine (Parsons and Cuthbersonet, 1992). Lantana camara creates impacts on the food web level and limits the suitability of wildlife environments in the forest (Prasad, 2007). Parthenium hysterophorus has widened its range to cover threatened mammal populations from urban areas and grasslands to woodland eco-systems (Shrestha, 2015) and raised its resources to the hardwood forests (Bhusal et al., 2014). Large coverage of Chromolaena odorata diseases could
also lead to invasion (Rejmanek 1995). It may be attributed to limited seed quantity, robust development, fast growth, low nuclear DNAs, strong competition capacity for nutrition.

Harmful allelopathic implications of *Argemone maxicana* have been recorded for 11 germinations and cultivated seedling of crops has documented *Cassia occidentalis*, *Bidens pilosa* reduces soil fertility, *Xanthium strumarium* common in wheat field decreases productivity in soil (Tiwari et al., 2005). The seedling development of *Lactuca sativa* and *Amaranthus mangostanus* has been significantly affected by *Xanthium strumarium* pigment named xanthinosin (Shao et al., 2012). *Parthenium hysterophorus*, which triggers allergic disorders including skin issues, hay fever, asthma, is an extremely noxious weed (McFadyen, 1995; Cheney 1998). *Argemone mexicana* seed is reminiscent of mustard (*Brassica compestris*) and *Argemone maxicana* seed produces non-edible toxic oils which trigger death dropsy when cooking oil (Tiwari et al., 2005). *Cassia occidentalis* also recently reported toxic in seed, fruit leaves, and roots. Also, 10 cause dark brown urine, diarrhea, etc. *Ipomoea carnea* causes vomiting and diarrhea and the smell of *Hyptis suaveolens* might cause headache (Tiwa Rei et al., 2005).

**Benefits from IAPS**

Anti-helminthic, antimicrobial, anti-malaria, anti-ulcerogenic properties and protozoocidic properties have been documented to be found in *Bidens pilosa* (Lewu and Afolayan, 2009). Also, in the North West of South Africa (Lubbe et al., 2007) found the traditional medicinal use of *A. achroleuca*. For the treatment of hypertension, *E. japonica* is registered. Emetic, expectorant, diuretic, laxative, Purgative, topical emollient, and diaphoretic have been identified as *Sambucus canadensis* (Charlebois, 2007). Future herbivores management attempts have been told of the release of Blackberry *Rubus niveus* levels from grazing pressure following goat eradication in the Galapagos area (Carrion et al., 2011). *Lantana camera* containing ß-caryophyllene, geranyl acetate, terpynil acetate bornyl acetate and limonene remarkably inhibited the growth of plant pathogenic fungus like *Stemphylium botryosum* of lentil (Subedi et al., 2015) and *Exserohilum turlicum* of maize (Subedi et al., 2019).

Throughout the UK countryside, common pheasants *Phasianus colchicus* is a source of hunters delight. The species was imported to the United Kingdom from China as a form of game from the 18th century (Scotland Statistical Accounts, 1791–1799). Many pheasants are now raised and published annually on UK sporting estates (Robertson, 1996). Originally imported to the UK as an ornamental herb, *Rhododendron ponticum* is ideal for gardeners as it promises simple maintenance, always green nature and colorful flowers. Introduced in Europe, North America (Pimentel et al., 2005), the introduction of the water hyacinth *Eichhornia crassipes* and purple loosestrife *Lythrum salicaria* and improves structurally in tropical environments. In Pokhara valley, the biomass of invasive species.

**Management of IAPS**

Invasive alien plant species are perceived to be one of the major challenges for the earth's natural habitats and, after deforestation, is seen as a second biggest danger to the survival of biodiversity (Tiwari et al., 2005). According to Rejmanek (2005), effective management of biological invasion should follow three main steps from prevention, early detection and eradication and control backed up by integrated management. Due to the increasing issue of invasive species across Nepal and around the world, the National Trust for Nature Conservation (Thapa et al., 2014) conducted an international workshop on invasive species in Chitwan National Park, in March 2014. Furthermore, the country has established many sectorial legislation (Plant Protection Act, 1972; Aquatic Life Protection Act, 1961; Seed Act, 1988; Water resource act, 1992; The Forest Act, 1993, The National Parks Agro biodiversity Policy 2008, revised 2013 Wildlife Conservation Act, 1973 and Local Self Governance Act, 1999) to regulate and eliminate native or invasive alien species of germs, pests and weeds in crops (MFS/CSUWN, 2011). An Integrated Pest Management (IPM) control approach (Wittenberg and Cock, 2001) also is the most effective.

In order to remove *E. crassipes* and *Pistia stratioites* from the Tikauli lakes (part of the Bishajari lakes system, Chitwan), the Hario Ban program was implemented by WWF Nepal where the project is now being carried out (WWF Nepal, 2013). To deter spread of plant pests, 111 countries have signed the International Plant Protection Convention (IPCC) since 1952 and World Trade Organization (WTO), (McNeely et al., 2001) accepts its requirements. In addition, current biological management methods will complement suppressive plants (Adkins and Shabbir, 2014) and re-vegetation of deteriorated sites with competitive native forage grasses (Wan et al., 2010), for successful handling of invasive species. In Nepal, these two invasive alien organisms are biological surveillance agents: Winter rust *Puccinia abrupta var.*
parthenicola (Jackson) Parmeelee for Parthenium hysterophorus (Shrestha et al., 2015) and leaf eating beetle Zygogramma bicolorata Pallister, leaf spot fungi Passalora ageratinae Crous and stem galling fly Procecidochares utilis Stone and A.R Wood for Ageratina adenophora (Winston et al., 2014).

Long-term solution to combating unwanted alien species is biological management and it is only successful to delay the cycle of invasion (Sun et al., 2004). In 1987, fungi were found to act as successful as gallfly by Entyloma compositarum and Mycovelosiella lantanae Chupp and (Wan and Wang 2001). Invasive alien plant species in Nepal tend to be the most effective biological control agent of Zygogramma bicolorata, but their population remains low and their efficiencies are unpredictable year by year (Shrestha et al., 2015). To monitor P. hysterophorus effectively, it seems appropriate to balance the regulation of Z. bicolorates with other biological control agents, redistribution by competitive plant and other economic, physical and chemical steps (Adkins and Shabbir, 2014). The immediate steps to monitor invasion and to reduce negative effects and application of herbicides in forest areas should be avoided by mechanical removal of weeds (Sankaran et al., 2014). For instance, where tiny satellite populations physically are eliminated to avoid their spread, alien species may be effectively managed during initial stages of growth (Wittenberg and Cock, 2001). It is uncertain if a standard quarantine screening should be carried out prior to its release, as did India when N. eichhorniae was released in 1984 (Jayanth, 1988). The concern for biological invasion has not yet been discussed adequately, the recently drawn up National Biodiversity Strategy and Action Plan has thoroughly embraced the invasive alien species challenge with several strategies to handle them.

Conclusion

Twenty-six invasive alien plant species with negative impacts on the environment and agricultural production have been reported to date in Nepal. The introduction of such species threatens to agriculture production and biodiversity. Micania macarantha including other species is serious weeds in agriculture field and national parks. Due to open borders and less effective quarantine (weed pest) in the Nepal-India border, any exotic species established in India can easily spread into Nepal sooner or later. Preventing the introduction, early detection and reporting of infestation of these species, awareness at the local level are recommended as a strategy for managing these species in Nepal.

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References

Adhikari S, Falco Di, Lovett JC.2004. Household characteristics and forest dependency: evidence from common property forest management in Nepal. Pp: 245-257

Adkins S, Shabbir A. 2014. Biology, ecology and management of the invasive parthenium weed (Parthenium hysterophorus L.). Pest Management Science. 70:1023–1029. http://www.managementofbiologicalinvasions.net/

Andreu J, Vila M. 2011. Native plant community response to alien plant invasion and removal. Management of Biological Invasions, Pp: 81-94.

Baral HS, Inskipp C. 2005. Important bird areas in Nepal: Key sites for conservation.

Begon M, Harper JL, Townsend CR.1990. Ecology: Individuals, populations and communities, 2nd edn. Blackwell, Oxford, UK.

Bellard C, Cassey P, Blackburn TM. 2016. Alien species as a driver of recent extinction. Biology Letters, 12: 20150623. DOI: 10.1098/rsbl.2015.0623

Bhattarai KR, Maren IE, Subedi SC. 2014. Biodiversity and invasibility: Distribution patterns of invasive plant species in the Himalayas, Nepal. Journal of Mountain Science, 11: 688-696

Bhuju DR, Shrestha BB, Niraula RB. 2013. Study on invasive alien species (IAS) as drivers to deforestation and degradation of forests in different physiographic regions of Nepal. A report submitted to REDD Cell, Ministry of Forest ad Soil Conservation by BS JV_API.

Bhusal K, Devkota MP, Shrestha BB. 2014. Vulnerability assessment of different land use types to invasion by Parthenium hysterophorus L. in western Chitwan, Nepal. In: Thapa GJ, Subedi N, Pandey MR, Chapagain NR, Thapa SK, Rana A (eds.). Proceedings of the International Conference on Invasive Alien Species Management. Kathmandu: National Trust for Nature Conservation, Nepal. Pp. 61-69.

Bhusal YR. 2009. Local people’s perceptions on climate change, its impacts and adaptation measures in mid-mountain region of Nepal: A case study from Kaski district. [B.Sc. Thesis],
Pokhara Nepal: Tribhubhan University, Institute of Forestry.

Bird Conservation Nepal, Kathmandu and Bird Life International, Cambridge, UK.

Brooks ML. 2003. Effects of increased soil nitrogen on the dominance of alien annual plants in the Mojave Desert. Journal of Applied Ecology, 40: 344–353.

Callaway RM, Ridenour WM. 2004. Novel weapons: invasive success and the evolution of increased competitive ability. Frontier Ecological Environments, 2: 436–443.

Carrion V, Donlan C, Campbell J, Lavoie C, Cruz F. 2011. Archipelago-Wide Island Restoration in the Galápagos Islands: Reducing Costs of Invasive Mammal Eradication Programs and Reinvasion Risk. PLoS One. 2011; 6(5): e18835. doi: 10.1371/journal.pone.0018835

CBD. 2002. Alien species that threaten ecosystems, habitats or species. Pp. 249-261. https://www.cbd.int/doc/decisions/cop-06-dec-23-en.pdf

Charlebois D. 2007. Elderberry as a medicinal plant. Issues in New Crops and New Uses. ASHS Press; Alexandria. Pp. 284–292.

Cheney M. 1998. Determination of the prevalence of sensitivity to Parthenium affected by the weed. [Master of Public Health Dissertation], Queensland, Australia: Queensland University of Technology.

Chettri MK. 1986. Effects of herbicides on Eupatorium adenophorum. [M.Sc Dissertation], Kathmandu: Central Department of Botany, Tribhuvan University, Nepal.

Choudhary AK. 1986. A threat to the forests and agriculture. Indian Forester, 98: 178-186.

Clout MK, DePoorter MD. 2005. International initiatives against invasive alien species. Weed Technology, 19: 523-527.

D’Antonio CM, Kark S. 2002. Impacts and extent of biotic invasions in terrestrial ecosystems. Trends Ecol. Evol., 17(5):202-204.

Davis MA, Grime JP, Thompson K. Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology, 88:528–534.

Dehnen- Schmutz K, Williamson M. 2006. Social, economic and ecological factors in its successful invasion. Rhododendron ponticum in Britain and Ireland: Environment and History, 12: 325–350

Donlan CJ, Tershy BR, Campbell K, Cruz F. 2003. Research for requiem: the need for more collaborative action in eradication of invasive species. Conservation Biology, 17:1850–1851

Downey PO, Richardson DM. 2016. Alien plant invasions and native plant extinctions: a six-threshold framework. AoB PLANTS, 8: plw047; DOI:10.1093/aobpla/plw047

Drenovsky RE, Batten KM. 2007. Invasion by Aegilops triuncialis (Barb Goatgrass) slows carbon and nutrient cycling in a serpentine grassland. Biol. Invasions, 9: 107–116.

Dukes JS, Mooney HA. 2004. Disruption of ecosystem processes in western North America by invasive species. Rev Chil Nat, 77: 411–437.

Eschtruth AK, Battles JJ. 2009. Acceleration of exotic plant invasion in a forested ecosystem by a generalist herbivore. Conservation Biology, 23(2): 388-399.

Gaertner M, Breeyen AD, Hui C, Richardson DM. 2009. Impacts of alien plant invasions on species richness in Mediterranean-type ecosystems: a meta-analysis. Progress in Physical Geography, 33: 319–338.

GISP. 2009. Invasive species and poverty: Exploring the links, GISP: Cape Town South Africa. http://www.gisp.org/

Glowka L, Burhenne-Guilmin F, Syngle H. 1994. Guide to the convention on biological diversity. Environmental policy and Law Paper No. 30. IUCN – The World Conservation Union

GoN. 2019. Invasive alien species: An emerging threat to agriculture and biodiversity in Nepal. Government of Nepal Ministry of Agriculture and Livestock Development, Plant Quarantine and Pesticide Management Center, Hariharbhawan, Lalitpur, Nepal

Herrera I, Ferrer P, José R, Benzo D, Flores S, García B, Jafet M. 2018. An invasive succulent plant (Kalanchoe daigremontiana) influences soil carbon and nitrogen mineralization in a neotropical semi-arid zone”. Pedosphere, 28(4):632–643.

HMGN/MFSC. 2002. Nepal Biodiversity Strategy. His Majesty’s Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu.

Holmes TP, Aukema JE, Holle BV, Liebhold A. 2009. Economic impacts of invasive species in Forests, past, present and future.
Shah et al. Ann N Y Acad Sci., 1162:18-38. doi: 10.1111/j.1749-6632.2009.04446.x.

Huenneke L. 1990. Effects of soil resources on plant invasion and community structure in California (USA) serpentine grassland. Ecology, 71(2): 478-491

Hui C, Richardson DM, Robertson MP, Wilson J, Yates CJ. 2011. Macro-ecology meets invasion ecology: linking the native distributions of Australian acacias to invasiveness. Diversity and Distributions, 17: 872-883.

Jayanth KP. 1988. Successful biological control of water hyacinth (Eichhornia crassipes) by Neochetina eichhorniae (Coleoptera: Curculionidae) in Bangalore, India. Tropical Pest Management, 34(3): 263-266.

Joshi C. 2001. Invasive Banmara (Chromolaena odorata): Spatial setection and prediction. [M.Sc. Dissertation], Enschede, Netherland: International Institute for Geo-information Science and Earth Observation.

Karki D. 2009. Ecological and socio-economic impacts of Parthenium hysterophorus L. Invasion in two urban areas in Nepal (M.Sc. Dissertation), Kathmandu: Central Department of Botany, Nepal.

Keam S, McCormick N, Howard G, Athanas A. 2009. Guidelines on bio-fuels and invasive species. IUCN, Gland, Switzerland

Kohli RK, Jose S, Singh HP, Batish DR. 2009. Invasive Plants and Forest Ecosystems. New York, CRC Press, Taylor and Francis Group.

Kriticos DJ, Sutherst RW, Brown JR, Adkins SW, Maywald GF. 2003. Climate change and the potential distribution of an invasive alien plant: Acacia nilotica subspecies indica in Australia. Journal of Applied Ecology, 40(1): 111-124.

Kunwar RM. 2003. Invasive alien plants and Eupatorium: Biodiversity and livelihood. Himalayan J. Sci., 1(2): 129-133.

Lewu FB, Afolayan AJ. 2009. Ethnomedicine in South Africa. The role of weedy species. Afr. J. Biotech., 8(6): 929-934.

Lowe S, Browne M, Boudjelas S, Poorter MDe. 2001. 100 of the world's worst invasive alien Species: A selection from global invasive species database. The Invasive Species Specialist Group (ISSG). Pp. 12-20.

Lubbe CS, Siebert SJ, Cilliers SS. 2007. Political legacy of South Africa affects the plant diversity patterns of urban domestic gardens along a socio-economic gradient. Pp: 2900–2910.

Maron JL, Vila M. 2001. When do herbivores affect plant invasion. Evidence for the natural enemies and biotic resistance hypothesis. OIKOS, Pp: 361-73

Matthews S, Brandt K. 2004. Africa Invaded: The growing danger of invasive alien species. Global Invasive Species Program. Cape Town, Africa.

May S. 2007. Invasive Terrestrial Plants. Chelsea House Publishers, New York.

McFadyen RE. 1995. Parthenium weed and human health in Queensland. Australian Family Physician, 24:1455–1459.

McNeely JA, Mooney HA, Neville LE, Scheir P, Waage JK. 2001. A global strategy on invasive alien species. IUCN on behalf of the Global Invasive Species Programme, Gland, Switzerland and Cambridge, UK.

MEA .2005. Ecosystems and Human Well-Being: Global assessment reports current state and trend. Washington DC. Island Press. Pp. 553-586

MFSC/CSUWN .2011. Wetlands invasive alien species management guidelines. Kathmandu, Nepal. Conservation and sustainable use of wetlands Nepal Project, Ministry of Forests and Soil Conservation.

Miththapala S. 2007. A strategy for addressing issues of aquatic invasive alien species in the Lower Mekong Basin. Colombo. IUCN: Mekong Wetland Biodiversity Program 56 and Regional Species Conservation Program. The World Conservation Union (IUCN), Asia, Sri Lanka.

Moore PD. 2000. MooreAlien Invaders. Nature, 403: 492-493.

Moyle PB, Leidy RA. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. In: Fiedler PL, Jain SK (eds.) Conservation biology: the theory and practice of nature 18 conservation, preservation and management. Chapman and Hall, New York. Pp. 127-169.

Norbu N. 2004. Invasion success of Chromolaena odorata (L.) king and Robinson in the Terai of Nepal. [M.Sc. Dissertation], Enschede, Netherland: International Institute for Geo-information Science and Earth Observations.

Oerke EC, Dehne HW, Schonbeck F, Weber A. 1994. Crop production and crop protection-
estimated losses in major food and cash crops. Elsevier Science, Amsterdam.

Pandit R, Bevilacqua E. 2011. Forest users and environmental impacts of community forestry in the hills of Nepal. For. Policy Econ., 13(5): 345–352

Parker C.1972. The Mikania problem. PANS, 18: 312-315.

Parsons WT, Cuthbertson EG. 1992. Noxious Weeds in Australia. Inakata press, Melbourne, Australia. Pp. 447-448.

Pauchard A, Milbau A, Albihn A, Alexander J. 2016. Non-native and native organisms moving into high elevation and high latitude ecosystems in an era of climate change: new challenges for ecology and conservation. Biological Invasions, 18: 345–353. DOI: 10.1007/s10530-015-1025-x

Pejchar L, Mooney HA. 2009. Invasive species, ecosystem services and human well-being. Trends in Ecology and Evolution, 24(9):497-504.

Piementeal D. 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. Second edition. ISBN 9781439829905, CRC Press.

Pimentel D, Lach L, Zuniga R, Morrison D. 2000. Environmental and economic costs associated with non-indigenous species in the United States. BioScience, 50; 53–65

Pimentel D, Zuniga R, Morrison D. 2005. Update on the environmental and economic costs associated with alien invasive species in the United States. Ecological Economics, 52(3): 273–288.

Pimm SL. 1984. The complexity and stability of ecosystem. Nature, 307:321–326

Polunin O, Stainton A. 1984. Flowers of the Himalaya. Oxford University Press, New Delhi, India. Pp: 315-320

Poudel A, Baral HS, Ellison C, Subedi K, Thomas S, Murphy S. 2005. Mikania micrantha weed invasion in Nepal: A summary report. The first national workshop for stakeholders, Mikania micrantha weed invasion in Nepal: A summary report. The first national workshop for stakeholders Himalayan Nature, IUCN-Nepal and CAB International, Kathmandu.

Prasad AE. 2007. Impact of Lantana camara, a major invasive plant, on wildlife habitat in Bandipur Tiger Reserve, Southern India. A report to the rufford small grants for nature conservation.

Pyšek P, Richardson DM, Rejmánek M, Webster GL., Williamson M, Kirschner J. 2004. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon, 53: 131-143.

Rai JPN, Tripathi RS. 1982. Allelopathy as a factor contributing to dominance of Eupatorium. Indian Journal of Ecology, 9:14–20.

Rai RK, Scarborough H, Subedi N, Lamichhane BR. 2012. Invasive plants -Do they devastate or diversify rural livelihoods? Rural farmers’ perception of three invasive plants in Nepal. Journal for Nature Conservation, 20(3):170-176.

Rai RK, Scarborough H. 2012. Valuing the damage caused by invasive plant species in a low-income community in Nepal. South Asia Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal. Pp:74-82

Rai RK, Sandilya M, Subedi R. 2012. Controlling Mikania micrantha HBK: How effective manual cutting is. J. Ecol. Field Biol., 35(3): 235-242.

Randall J, Marinelli J. 1996. Invasive Plants: Weeds of the global garden. Brooklyn Botanic Garden Club, Inc. Handbook No. 149:111

Rejmanek M. 2005. Invasive plants: Approaches and predictions. Austral Ecol., 25: 497–506.

Rejmanek, M. 1995. What makes a species invasive? In: Wade, M. (eds.). Plant Invasions: General Aspects and special Problems. SPB Academic Publications, Amsterdam.

Ricciaardi A, Rasmussen JB. 1999. Extinction Rates of North American Freshwater Fauna. Conservation Biology, 13(5):1220-1222

Ricciaardi A, Neves RJ, Rasmussen JB. 1998. Impending extinction of North American fresh water mussels (Unionoida) following the zebra mussel (Dreissena polymorpha) invasion. Journal of Animal Ecology, 67: 613-619.

Richburg J. 2008. Invasive Plant Management: Guidelines for Managers. The Trustees of Reservations.http://www.thetrustees.org/assets/documents/what-we-careabout/Invasives-Plant-Guidelines.

Robertson P. 1996. Naturalised introduced gamebirds in Britain. In Holmes JS, Simons JR. (Eds.) The introduction and naturalization of birds (pp. 63–69). London: HMSO.
Sanchez LM, Durand R. 2004. Ageratum houstonianum Mill. toxicois in Zebu cattle. Veterinary and Human Toxicology, 46(4):193-195.

Sankaran KV, Sajeev TV, Suresh TA. 2014. Invasive plant threats to forests in the humid tropics: A case study from Kerala State, India. In: Thapa GJ, Subedi N, Pandey MR, Chapagain NR, Thapa SK, Rana A. (eds.). Proceedings of the International Conference on Invasive Alien Species Management. National Trust for Nature Conservation, Nepal. Pp. 7-17.

Sapkota L. 2007. Ecology and management issues of Mikania micrantha in Chitwan National Park, Nepal. Banko Janakari, 17(2): 27–39.

Sapkota, L. 2012. Ecology and management issues of Mikania micrantha in Chitwan National Park, Nepal. Banko Janakari, PP: 27-39.

Seebens H, Blackburn TM, Dyer EE, Genovesi P. 2017. No saturation in the accumulation of alien species worldwide. Nature Communications, 8: 14435. DOI:10.1038/ncomms14435

Shao H, Huang X, Wei X, Zhang C. 2012. Phytotoxic Effects and a phytotoxin from the invasive plant Xanthium italicum Moretti. Molecules, 17(4): 4037-4046

Sharma KC, Chhetri GKK. 1977. Reports on studies of the biological control of Eupatorium adenophorum. Nepalese Journal of Agriculture, 12:135–157.

Shrestha BB, Shabbir A, Adkins SW. 2015. Parthenium hysterophorus in Nepal: a review of its weed status and possibilities for management. Weed Research, 55: 132–144.

Shrestha BB, Siwakoti M, Ranjit JD. 2017. Status of invasive alien plant species in Nepal. Conservation and utilization of agricultural plant genetic resources in Nepal (Joshi BK, KC HB, Acharya AK, (eds). Proceedings of 2nd National Workshop, 22-23 May 2017 Duhlikhel; NAGRC, FDD, DoA and MoAD; Kathmandu, Nepal

Simberloff D. 2000. Global climate change and introduced species in United States forests. The Science of the Total Environment, 15: 262(3): 253-261

Simberloff D. 2009. The role of propagule pressure in biological invasions. Annu. Rev. Ecol. Evol. Syst., 40: 81–102.

Siwakoti M. 2012. Threats and opportunity of invasive alien plant species in wetland conservation of Nepal. In: Proceedings of International Wetland. Ministry of Forest and Soil Conservation/Conservation and Sustainable Use of Wetlands in Pokhara Nepal, pp. 66-72.

Subedi N, Jnawali SR, Amin R, Lamichhane BR, Jhala Y. 2014. Effect on invasive Mikania micrantha on Greater One-Horned Rhinoceros Conservation in Chitwan National Park, Nepal.

Subedi S, Neupane S, BK S, Oli L. 2019. In-vitro evaluation of botanicals, fungi-toxic chemicals and bio-control agent for efficacy against turcicum leaf blight of maize. Journal of Nepal Agricultural Research Council, 5,73-80.

Subedi S, Shrestha SM, KC GB, Thapa RB, Ghimire SK, Gharti DB, Neupane S. 2015. Evaluation of plant extracts against stemphylium blight of lentil. Nepal Journal of Science and Technology, 16(1): 11-16.

Sun XY, Lu ZH, Sang WG. 2004. Review on studies of Eupatorium adenophorum, an important invasive species in China. Journal of Forestry Research, 15: 319-322.

Thapa GJ, Subedi N, Pandey MR, Chapagain NR, Thapa SK, Rana A. 2014. Proceedings of the International Conference on Invasive Alien Species Management. National trust for Nature Conservation, Nepal. Pp. 194-195.

Timsina B, Shrestha BB, Rokaya MB, Munzbergova Z. 2011. Impact of Parthenium hysterophorus L invasion on plant species composition and soil properties of grassland communities in Nepal. Flora, 206: 233–240.

Tiwari S, Adhikari B, Siwakoti M, Subedi K. 2005. An inventory and Assessment of Invasive Alien Plant Species of Nepal. IUCN-The World Conservation Union, Nepal

Torchin ME, Lafferty KD, Dobson AP, Mckenzie VJ, Kuris AM. 2003. Introduced species and their missing parasites. Nature, 421(6923): 628-630.

Vitousek PM.1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Oikos, 57(1):7–13

Wan F, Liu W, Guo J, Qiang S, Li B, Wang J.2010. Invasive mechanism and control strategy of Ageratina adenophora (Sprengel). Science China Life Sciences, 53(11):1291-1298
Wan FH, Wang R. 2001. Biological Weed Control in China: An Updated Report in Alien Invasive Species. IUCN Regional Biodiversity Program, Asia.

Waterhouse DF, Norris KR. 1987. Biological control Pacific Prospects. -319 Melbourne (Inkata Press) Deutsche Entomologische Zeitschrift, 37-40. DOI: https://doi.org/10.1002/mmnd.19900370412

Westbrooks R. 1991. Plant Protection Issues-I. A commentary on new weeds in the United States. Weed Technology, 5(1):232-237.

Wilcove DS, Rothstein D, Dubow J, Phillips A, Losos E. 1998. Quantifying threats to imperiled species in the United States. BioScience, 8(8): 607-615.

Winston RL, Schwarzländer M, Hinz HL, Day MD, Cock MJW, Julien MH. 2014. Biological Control of Weeds: A World Catalogue of Agents and Their Target Weeds, 5th edition. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia.

Wittenberg R, Cock MJW. 2001. Invasive Alien Species: How to address one of the greatest threats to Biodiversity, A toolkit of best prevention and management practices. CAB International, Wallingford, Oxon, UK.

WWF Nepal. 2013. Communities come together to protect wetland. Hario Ban Program, WWF Nepal. http://www.wwfnepal.org/?207351/Communities-come-together-to-protect-wetland.

Yaduraj NT, Bhowmik PC, Kushwaha S. 2000. The Potential Threat of Alien Weeds to Agriculture and Environment. At the cross road of the New Millennium. In: Jha PK, Karmacharya SB, Baral SR, Lacoul P (eds.) Ecological society (ECOS), Nepal. Pp. 229-234.