Archives of Current Research International

Volume 25, Issue 2, Page 111-132, 2025; Article no.ACRI.129110
ISSN: 2454-7077

Review on the Status and Geographical Distribution of Invasive Alien Plant Species in Bhutan

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2025/v25i21072

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/129110

Review Article

Received: 02/11/2024
Accepted: 04/01/2025
Published: 08/02/2025

ABSTRACT

Invasive Alien Plant Species (IAPS) are non-native, naturalized plants with high potential to spread over large areas at considerable distances. Considering its driving factor and adverse effect on global biodiversity loss and species extinction, the current study aimed to document the IAPS of Bhutan and its geographical distribution in the country. A total of 136 plant species were enumerated, including 22 major IAPS and 25 IAPS through a literature review. There are 9 IAPS in the country from the list of worlds 100 worst IAS. The families Fabaceae (24) constitute the maximum IAPS followed by Poaceae (20) and Asteraceae (19) respectively. IAPS in Bhutan are mostly herbs (73), followed by grass (23) and tree (15). Currently, IAPS was commonly found distributed on disturbed sites, roadsides, fallows, cultivated areas, and margins of wetlands and forest. Still, there is a need for further IAPS documentation, determination of invasive plant species status, and its impact assessment in the country along with its geographical distribution within the country.

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Cite as: *Tshering, Nythri, and Namgay Rinchen. 2025. "Review on the Status and Geographical Distribution of Invasive Alien Plant Species in Bhutan". Archives of Current Research International 25 (2):111-32. https://doi.org/10.9734/acri/2025/v25i21072.*

Keywords: Biodiversity loss, Invasive Alien Plant Species (IAPS); Invasive status, Geographical distribution.

1. INTRODUCTION

Invasive alien plant species (IAPS) pose significant threats to biodiversity and ecosystem functionality worldwide (Dueñas et al., 2021; Gentili et al., 2021; Pysek et al., 2006; Rai, 2021; Reynolds & Aldridge, 2021), and Bhutan is no exception (Dorji, 2014; Dorjee et al., 2020; Thiney et al., 2019; Tshewang et al., 2021). The unique geographical and climatic conditions of Bhutan, characterized by its diverse ecosystems ranging from subtropical to alpine environments (Banerjee & Bandopadhyay, 2016), create a conducive habitat for the establishment and spread of these invasive species (Dorjee, 2018; Thiney et al.,2019).

Recent studies indicate that invasive plants can severely disrupt native ecosystems by outcompeting indigenous flora, thus reducing biodiversity and altering ecosystem services across the globe and Bhutan (Thiney, Banterng, Gonkhamdee, et al., 2019; Wangmo et al., 2018; Dorji et al., 2021; Gentili et al., 2021; Peter et al., 2021; Szumańska et al., 2021; Kim et al., 2021). For instance, the parthenium weed (*Parthenium hysterophorus*), identified as one of the most aggressive invasive species in Bhutan, is predicted to invade approximately 2.83% of the country's land area, affecting 17 out of 20 districts (Dorji et al., 2021). This highlights the urgent need for comprehensive research on the distribution and impact of IAPS in Bhutan. The ecological implications of invasive species are profound, as they can lead to significant alterations in soil chemistry, hydrology, and habitat structure, ultimately affecting the entire ecosystem (Lone et al., 2019).

The Tibetan Plateau, which shares ecological similarities with Bhutan, has shown that the impacts of invasive species can vary widely depending on local conditions and species traits (Guan, 2023). This variability underscores the necessity for localized studies to understand the specific dynamics of invasive species in Bhutan's unique ecosystems. Furthermore, the introduction of IAPS often correlates with anthropogenic activities, such as agriculture and urbanization, which exacerbate their spread and impact (Tshering, 2012: Chhetri & Tenzin, K, 2012; Gentili et al., 2021; Peter et al., 2021; Szumańska et al., 2021). Similarly, it is also regarded as a cause in accelerating the rate and establishment of IAPS in the mountainous countries of Himalaya like Bhutan (Thiney, Banterng, Gonkhamdee, et al., 2019).

According to study on alien plant flora which includes cultivated taxa, Bhutan comprises a total of 964 plant species belonging to 545 genera spanning over 139 families. Of these, 626 species only occur in cultivation, whereas the other 388 species are found spontaneously in the wild; 131 (39%) casuals, 103 (31%) naturalized and 101 (30%) invasive (Dorjee et al., 2020).

Bhutan's biodiversity is rich, nonetheless most of the species are hitherto to be researched and documented (Nature Conservation Division, 2024). However, the lack of comprehensive data complicates conservation efforts and the management of invasive species. The country's commitment to maintaining its biodiversity, as reflected in its conservation policies, must be complemented by targeted research on IAPS to develop effective management strategies (National Biodiversity Strategies and Action Plan of Bhutan, 2014). As such, this review aims to synthesize existing literature on the status and geographical distribution of invasive alien plant species in Bhutan, providing a foundation for future research

2. LITERATURE REVIEW ON IAPS

2.1 Definition of Invasive Species: Concepts and Different Terminologies

For many years the term ‘Invasive species has been used by ecologist, conservationist and

others involved in the fields of biology and environment (Wijesundara, 2021). The ability of invasiveness and distribution of those species in geographically new areas has drawn attention of different people including scientists, ecologist, conservationist, the general public and even policy makers (Kim et al., 2021; Szumańska et al., 2021; Wijesundara, 2021). Within past few decades, the studies on Invasive species have gained great momentum and started to document the spatial distribution of those species and assess its impact on biodiversity and ecosystems functioning (Reynolds & Aldridge, 2021; U.S. Department of Interior, 2021). Studies recognized Invasive species as one of the primary causes for global biodiversity loss (Rai, 2021) and species extinction (Dueñas et al., 2021, GFRA 2015.).

Many definitions of Invasive species have been proposed by various workers during the last few decades (Wijesundara, 2021) and different terminologies like Invasive species, Invasive Alien Species (IAS) and Invasive non- native species (INNS) are commonly used (Reynolds & Aldridge, 2021; Szumańska et al., 2021). It is defined as non-native species with conspicuously high colonization rates and have the potential to spread over long distances (Ricciardi, 2017). According to IUCN, (2021), species is considered invasive, if alien species becomes problematic in the area.

To current study, the term invasive alien species (IAS) is used. The definition according to Szumańska et al., (2021), in line with the National Invasive Species Council (NISC) and the Invasive Species Advisory Committee (ISAC) of the United States (Beck et al, 2006). IAS is defined as non-native species, introduced accidentally or deliberately and has established itself in ecosystems or habitats that are either natural, semi-natural, or man-made. The Introduction of IAS in particular ecosystem causes or is likely to cause environmental or economic harm through detrimental impacts on human, animal, or plant health (Szumańska et al., 2021; U.S. Department of Interior, 2021).

In plant ecology, the term “invasion” best describes the invasive plants where the distribution and abundance of plants changes as a result of human activities (Wijesundara, 2021). Several terminologies in the literature on invasive plant species has been defined by Pysek et al., (2006) including native plants, aliens, aliens’ casual plants, naturalized plants, invasive plants, weeds and transformers. Accordingly, invasive plants are defined as a subset of naturalized plants, which has potential to spread over large area with the production of very large numbers of reproductive offspring at considerable distances from the parent plants (Pysek et al., 2006). Therefore, the term Invasive Alien Plant Species (IAPS) and definition provided by Pysek et al., (2006) will be used throughout the paper (Australia ’s 10 Worst Invasive Species, 2019).

2.2 Historical Progression of Studies in Invasive Alien Plant Species (IAPS)

The phenomenon of non-native species was observed as far back as the 18th century by many naturalists including A. P. De Candolle and Charles Darwin (Richardson & Pyšek, 2007). Nevertheless, its deleterious effect on habitats and ecosystems of biological invasion became aware to scientist only after 1950s (Pysek et al., 2006; Richardson & Pyšek, 2007). Charles Elton the ‘father’ of invasion biology, defined biological invasions as ‘ecological explosions’ which means ‘the enormous increase in number of some organism’ in newly invaded ranges (Richardson & Pyšek, 2007; Gentili et al., 2021). Hereafter, different studies related to biological invasions became a branch of systematic ecological science (Gentili et al., 2021; Pysek et al., 2006).

The new recordings of invasive alien species (IAS) continually increased worldwide during the last 200 years (Richardson & Pyšek, 2007; Gentili et al., 2021). Over the last 30 years, studies were confined in assessing IAS effects and numbers of studies confirmed the negative effect of IAS on native biodiversity, its ecosystem and the landscape. Today, biological invasion is regarded as one of the main drivers that cause biological loss and species extinctions of plants and animal taxa (Pysek et al., 2006; Rai, 2021; Reynolds & Aldridge, 2021).

With the advancement in scientific knowledge and technology, different branch of sciences is integrated to study the biological invasion, which includes ecological modelling and future predictions of IAS (Szumańska et al., 2021). The different methods of effective management of invasive plants are regarded as one of top priority of ecological management and environmental conservation (Ricciardi, 2017). Therefore, according to Gupta et al., (2021), recent progression in the GIS and Remote sensing technologies can assist in studying and

management of those invasive species with the impact of climate change.

2.3 Invasive Alien Plant Species Across the Globe

The frequency and magnitude of introduction of alien species across the globe are changing more rapidly than ever before at contemporary time (Moodley et al., 2020). Global Invasive Species Database listed 100 worst invasive species based on two criteria: their serious impact on biological diversity and/or human activities, and their illustration of important issues surrounding biological invasion. Invasive plant species accounts 36% of the total invasive species among 100 worst invasive species of the world with 9 aquatic plants and 32 terrestrial plants (Lowe et al., 2000; Luque et al., 2014).

Though the numbers of invasive species vary widely, researchers estimated the current invasive species across the globe. There are approximately, 50,000 non-native species in United States and approximately 4300 species have been considered invasive species (Corn et al., 2002). According to Demarco, (2015), American Association for the Advancement of Science listed alien (1201), or invasive (755) using the U.S. Department of Agriculture (USDA) PLANTS database, out of 13,575 plants in the continental United States. Currently there are 36 invasive plants and 30 invasive animals under European list of IAS of Union concern, which is regularly updated (JRC, 2021). Similarly, over 1650 alien plant species have become established in New South Wales of Australia, with at least 300 of these weeds considered as invasive (Frances et al., 2018). In addition, there are 427 invasive species in Korea according to data from the Korea National Arboretum (2016) (Kim et al., 2021).

The first catalogue of invasive plant species of India was compiled by Reddy (2008) with the total of 173 invasive alien species belonging to 117 genera under 44 families. In following years, many studies carried out on alien invasive plants and reported 1599 alien plant species belonging to 842 genera and 161 families with their native ranges and invasion status from India (Reshi & Khuroo 2012; Gupta et al., 2021). Inderjit et al., (2018) compiled about 471 invasive plant species in India and Pathak et al., (2019) reported a total of 297 naturalized alien plant species belonging to 65 families in the Indian Himalayan Region (IHR).

Among several invasive species *Chromolaena odorata*, *Ageratina adenophora* (Inderjit et al., 2018), *Lantana camara*, *Parthenium hysterophorus* and *Ageratum conyzoides* have been reported from most IHR which are among worst IAPS of the world (Pathak et al., 2019). Furthermore, plants like *Rubus niveus*, *Sapium sebiferm*, *Cassia tora*, *Argemone mexicana* and *Anthemis cotula* have also been reported as noxious plants from Indian Himalayan states (Ivanova et al., 2016;Gupta et al., 2021). The above-mentioned invasive plants are also considered by many studies as one of the concerned invasive alien plants among many across the globe (Bradshaw et al., 2021; Gupta et al., 2021).

2.4 Status and Distribution of Invasive Alien Plant Species in Bhutan

Biological invasions are considered as a serious threat globally, but particularly to developing countries like Bhutan (Dorjee et al., 2020; Dorji, 2014). The swift biological invasions in those developing countries are due to rapid growth of horticulture and livestock industries coupled with insufficient or non-existent management of plant introduction. There is limited number of comprehensive and systematics studies being carried out in the Bhutan with regards to exotics plants and invasive alien plant species. However, Bhutan is part of Eastern Himalayan biological hotspot and is highly vulnerable to invasive alien species (Dorjee, 2018). Thus, studies regrading to alien or exotics species and biological invasions are very essential.

With the rapid biological invasions and importance in environmental management strategies in the country, numerous studies are following up with time. The collaborative works of environment conservation organization in Bhutan like National Biodiversity Centre (NBC), National Plant Protection Centre (NPPC) with other agencies across the world and enthusiastic researchers in the country are studying on invasive plants of Bhutan and have made some publications so far. However, most of information regarding alien invasive plant is limited to different sectors, agencies and limited persons (Dorjee, 2018). There still needs more intensive studies on IAS in the country like assessment of its economic, environmental impacts and its future predictions on biological invasion (Chhetri & Tenzin, 2012; Dorjee, 2020, 2021).

Before 1950s, the "Flora of Bhutan" was mostly compiled by few botanists and horticulturist from British and later undertaken by different taxonomist from Royal Botanic Garden, Edinburgh, London (Grierson & Long, 1983). Flora of Bhutan consist of three volumes and nine parts. It is the key reference guide for the identification of plants found in Bhutan. First studies related to invasive plants and weeds was studied by Parker, (1992). He documented 187 species of weeds that are commonly found in Bhutan and mentions around 14 weed species that was introduced in Bhutan (Dorjee, 2018; Parker, 1992).

Study conducted by Dorji (2010), documented 247 exotic plant species that are commonly found in pastures, roadsides and human settlement areas. It accounts about 5.6% of the total recorded plant species in the country. The numbers of exotic species from different plant families documented in the study is as follows; Poaceae (43 species), followed by Asteraceae (32 species), Fabaceae (26 species), Solanaceae (13 species) and Euphorbiaceae (12 species). More than 300 species of exotic plants in Bhutan includes ornamental plants, fodder species, agricultural crops, fruits and vegetables available in the country (Dorjee, 2018).

According to National Biodiversity Centre, Bhutan has numerous invasive plant species, and some are even among the world's worst IAPS. About 200 invasive species were identified in the country, including both plants and animals (Dorji, 2014). Around 34 plant species were known to be naturalized in the country and with 14 species being invasive (Biodiversity Action Plan, 2009) and 30 invasive plant species in the county as of 2014 (NBC, 2014). IAPS mostly belongs to Asteraceae and Poaceae family (Dorji, 2014).

Global Invasive Species database recorded 46 Invasive Species from Bhutan out of which 11 are alien and NBC recorded more than 30 invasive plant species, out of which eight were categorized as major invasive plant species (NEC, 2015). *Ageratina adenophora* (Spreng.) R. King & H. Rob., *Chromolaena odorata* (L.) R. King & H. Rob., *Eichhornia crassipes* (Mart.) Solms, *Lantana camara* L., *Mikania micrantha* Kunth, *Opuntia monacantha* (Willd.) Haw., *Parthenium hysterophorus* L. and *Robinia pseudoacacia* L.) are considered as the major invasive alien plants in Bhutan (NBC, 2014; NEC, 2015;Thiney et al., 2019).

Environmental Impact Assessment (2017), listed eight noxious invasive plants including *Cardamine flexuosa*, *Commelina benghalensis*, *Chromolaena odorata*, *Lantana camara, Melilotus alba, Caesalpinia decapetal, Senegalia catechu, Mikania micrantha, Imperata cylindrica* from the buffer zones of Amochhu Land Development and Township Project (EIA, 2017). The National Biodiversity Centre published a "A Pictorial Guide to Major Invasive Plant Species of Bhutan" to address concerns over invasive plant species in the country (BBS, 2018). The book contains sixteen major alien invasive plant species with its geographical distribution in country and some of the commonly practiced control measures of IAPS management in country.

Due to rapid expansion of those invasive alien plants in the country with the globalization and climate change, ecological niche modeling has become essential to predict its invasion and distribution. Thus, study conducted by Thiney et al., (2019), showed that IAPS like *Ageratina adenophora* (Sprengel) King & Robinson*, Ageratum conyzoides* (L.) L. *Chromolaena odorata* (L) King & Robinson*., Lantana camara* L*., Mikania micrantha* Kunth in Bhutan will have the potential increase in the areas of invasion, whilst *Parthenium hysterophorus* L. will experience a northerly shift and decline in distribution (Thiney, et al., 2019). Similarly, Thinley et al., (2022) reported internationally recognized IAPS such as *Ageratina adenophora*, *Ageratum conyzoides*, *Chromolaena odorata*, *Parthenium hysterophorous*, *Mikania micrantha* and *Lantana camara*. And reported the presence of recently introduced IAPS such as *Eichornia crassipes*, *Pennisetum clandestinum* and *Trifolium repens*, and many other miscellaneous IAPS or agricultural weeds in country.

According to study on alien plant flora including cultivated taxa in Bhutan comprises of a total 964 plant species belonging to 545 genera and 139 families. Of these, 626 species only occur in cultivation, whereas other 388 species were found spontaneously in the wild; 131 (39%) casuals, 103 (31%) naturalized and 101 (30%) invasive (Dorjee et al., 2020).

2.5 Route of Invasive Plant Introduction in the Country

The process of species invasion in the area comprises a sequence of events which involves transport, introduction, establishment, and

spread of organisms into a new region (Ricciardi, 2017). Many studies suggest that human is one of the important vectors and key contributing factor for spreading IAPS across the globe. People introduce alien plants purposely with intention or unintentionally (Bacaro et al., 2015; Szumańska et al., 2021). According to Richardson & Pyšek, (2007), a combination of colonial rule, swift economic development and global trade exchanges across borders and continents are the key role in human-mediated distribution of IAS in new regions outside their natural range.

Many exotics species have been intentionally introduced for beneficial uses like food production, landscape restoration or for ornamental purposes in parks, along communication routes, and into home gardens (Bacaro et al., 2015; U.S. Department of Interior, 2021). Furthermore, promotion of tourism and increasing roads networks passing through forest have had led to alien plant invasion in forest and alpine ecosystems in Himalaya (Richardson & Pyšek, 2007).

Rapid globalization in Bhutan led to constant movement of people and goods with increase in trade and travel, intensive agriculture practices, constructions of roads in forest and infrastructure in natural habitats, that are considered as the main routes of IAPS introduction in the country (Dorji, 2014; Dorjee et al., 2020). IAPS were concentrated in human settlement areas and decrease as altitude increases with less human settlements (Chhetri & Tenzin, K, 2012). According to Dorjee et al., (2020), The majority of naturalized alien plants in the country were introduced as pasture species (32%), ornamental (24%) and from intentional sources (22%). Whereas, a majority of invasive species were introduced unintentionally (76%), as ornamental (15%) and pasture species (3%). Literatures also suggest that climate change is viewed as a cause in accelerating the rate of invasion by IAS in addition to the globalization and anthropogenic activities (Gentili et al., 2021; Peter et al., 2021; Szumańska et al., 2021). Similarly, it is also regarded as a cause in accelerating the rate and establishment of IAPS in the mountainous countries of the Himalayas like Bhutan (Thiney et al., 2019).

2.6 Impacts of Invasive Alien Plant Species

Biological invasions are considered as one of the main drivers causing biodiversity loss and species extinctions in the major plant and animal taxa across the world (Richardson & Pyšek, 2007). Over the last 100 years, rigorous invasion of IAS has decreased the average abundance of native plants, animals and insects by at least one-fifth across many ecosystems (Moodley et al., 2020). For instance, within Australia there are about 1533 threatened plant and animal species that was affected by invasive species (*Australia ' s 10 Worst Invasive Species*, 2019).

In Europe, IAPS are considered as the second greatest threat to protected area (Bradshaw et al., 2021). The plant invasion is one of the progressively important environmental challenges across the globe with significant impact on native biodiversity (Kariyawasam et al., 2019). IAPS can alter ecosystem functioning and structure, affecting native biota and abiotic conditions (Reynolds & Aldridge, 2021). IAPS affects soil, its microbial association, and thus affect the native plants, often leading to displacement of habitat and ecosystem. Therefore, IAPS affects both floral and faunal diversity of the affected area. It disturbs the normal functioning of the ecosystem and deprive its beneficial ecosystem services (Gentili et al., 2021; Peter et al., 2021; Szumańska et al., 2021).

Besides biodiversity loss, literatures on IAS mentioned that IAS have negative impacts on agriculture, forestry, ecosystem services and on human health, eventually causing serious economic losses (Kim et al., 2021). Economic losses due to IAS includes the costs related to the direct damage caused by the species as well as those to be credited to their prevention, control and management (Richardson & Pyšek, 2007). IAS poses a threat to both natural ecosystems and crops, human health, and some branches of industry, such as tourism. Therefore, considerable financial resources are often required for IAS control and management activities (Gentili et al., 2021;Peter et al., 2021; Szumańska et al., 2021). For instance, Australia itself spent or suffered losses tallying at least US$298.58 billion or AU$389.59 billion from invasive species since the 1960s (Bradshaw et al., 2021).

In Bhutan, the invasive plant species are reported to be posing problems to agriculture, human and animals' health and invasion of forests land (BBS, 2018). According to NBC, (2018), IAPS have negative impacts on ecosystem as well as agriculture system in the

country. IAPS compete with the crops and affects the crop yield and some species are also known to be hazardous to human health. Farmers in the country have reported that along with climate change, invasive plants have started to colonize highland pasture and prevents fodder grass regeneration (Thiney et al., 2019;Thinley et al., (2022). Similarly, according to Wangmo et al., (2018), the grassland conditions in the subtropical region of the country has degraded over the years due to the invasion by IAPS. However, further extensive and systematic study regarding the impact of IAPS in the country is found to be essential to know the economic losses incurred by IAPS in the country.

3. METHODS

Literature search was conducted on databases such as Google Scholar, Research gate, Elsevier, Science Directs, Springer, PubMed, Web of Science and other scientific electronic libraries using the key words “alien species”, “non-native”, “invasive” “IAPS” and “exotic”. The data on IAPS of the country was listed from sources including published literatures, books, national reports produced by National Biodiversity Centre (NBC) of Bhutan, Weeds of Bhutan (Parker, 1992), Invasive Species in Ecological Habitats of National Parks in Bhutan (Dorji, 2014) and accessed online websites such as Global Register of Introduced and Invasive Species-Bhutan (GRIIS), Invasive Alien Species of Bhutan-INaturalist, Bhutan Biodiversity Portal (BBP), Invasive Plants of Bhutan (Google sites) and Invasive Species Compendium maintained by Centre for Agriculture and Bioscience International (CABI).

4. RESULTS

4.1 Invasive Plants in Bhutan

A total of 136 plant species were recorded, including 22 major IAPS and 25 IAPS in the country (Table 1). There are 9 IAPS in the country from the list of worlds 100 worst IAS. Fabaceae (24) constitute the maximum IAPS followed by Rosaceae (20) and Asteraceae (19) respectively. IAPS in Bhutan are mostly herbs (73), followed by grass (23) and tree (15) (Fig. 1).

5. DISCUSSION

The current study on documentation of Alien invasive plant species of Bhutan listed a total of 136 IAPS in the country. It includes plants species that are considered as IAPS in literatures, National Biodiversity reports of NBC from 2009 to 2014. Besides, it also includes those commonly distributed alien plants which were considered as weeds in the country. The botanical name, common or local name, habitat, its geographical distribution, its threatand its invasive status are presented in Table 1.

Out of 136 plants enumerated in the current list, 47 plant species were assigned with status of its invasiveness in the country as invasive plant species or major invasive plant species. There are 22 plant species which are considered as major invasive plant in the country posing serious environmental threats and found commonly distributed across the country with reference to NBC report, 2014. The total of 9 major IAPS including *Arundo donax* L., *Chromolaena odorata* (L) King & Robinson, *Leucaena leucocephala* (Lamarck) de Wit., *Eichhornia crassipes* (Martius) Solms., *Lantana camara* L., *Imperata cylindrica* (L.) Raeusch., *Mikania micrantha* Kunth. and, *Rubus ellipticus* Sm. and *Hedychium gardnerianum* Sheppard ex Ker Gawl are among the world’s worst invasive species found in the country (Lowe et al., 2000). Furthermore, 25 plant species were considered as invasive plants in the country.

The other IAPS found in the country are distributed in different districts of the country with different bio-status of invasiveness. Most of the listed plants are considered as common weeds of cultivated field, open disturbed areas, grasslands and pasturelands, river banks and wetlands across the country (Dorji, 2014; Wangmo et al., 2018; Thiney et al., 2019; Thinley et al., 2022). Therefore, currently their invasive status were not assigned by National Biodiversity of the country. However, different studies conducted in the country considered other above listed plants in their respective study as IAPS in reference to other reports and online resources like Global Register of Introduced and Invasive Species-Bhutan (GRIIS), Invasive Alien Species of Bhutan-INaturalist, Bhutan Biodiversity Portal (BBP), Invasive Plants of Bhutan (Google sites) and Invasive Species Compendium maintained by Centre for Agriculture and Bioscience International (CABI). Therefore, present study listed all IAPS considered by different studies accounting total of 136 IAPS in the country as of now. However, the enumerated list will change, and its invasive status will keep on updating with further validation with National Biodiversity center of Bhutan.

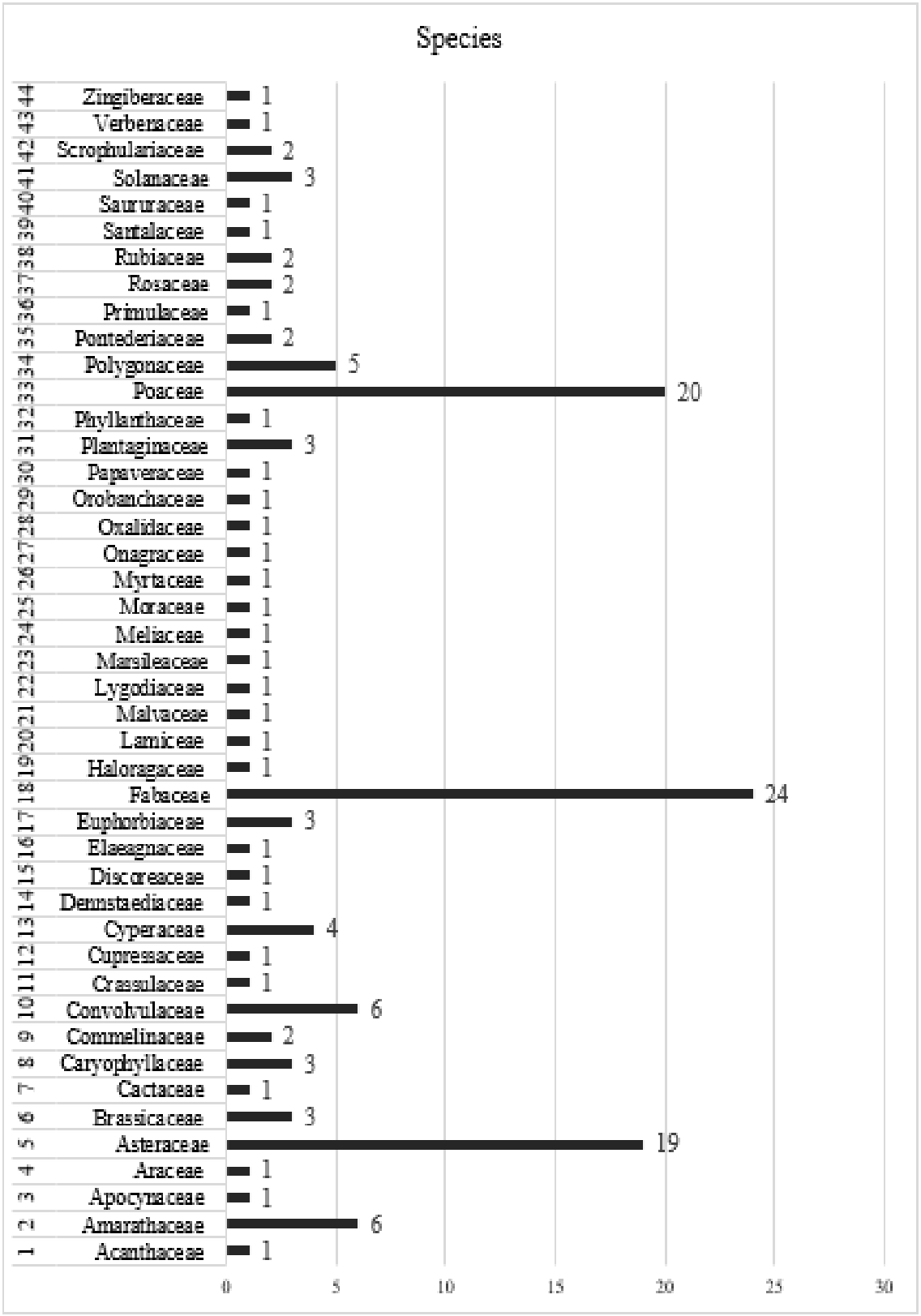

Fig. 1. IAPS list from different plant families recorded in Bhutan

Table 1. Invasive Alien plant species of Bhutan and its geographical distribution, threat and status in the country

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
1	*Acacia melanoxylon* R. Br.	Australian blackwood (Eng.)	Forest margins, roadsides, river and stream banks, grassland	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Agriculture, forest	Alien Invasive
2	*Acacia farnesiana* L. (Willd).	Huisache (Eng.)	Pastures, grasslands, wastelands	Punakha	Degrade pastureland, hazard to livestock	Less common
3	*Acanthospermum hispidum* DC.	Bristly starbur (Eng.)	Arable land, pastures, roadsides, wastelands	Mongar, Punakha, Trashigang, Wangdue (upto 500m).	Hazard to livestock	Alien Invasive
4	*Achyranthes aspera* L.	Devils horsewhip (Eng.)	Cultivated land, grassland, forest, forest trial, roadsides, wastelands	Punakha	Crops, landscape	Common Weed
5	*Acmella uliginosa (SW). Cass*	March para cress (Eng.); Heydonam (Dzo.)	Disturbed area, roadsides, cultivated fields, marshes, streams, pasture, meadows, forest	Chhukha, Mongar, Punakha, Samchi, SamdrupJongkhar, Trashigang, Thimphu, Trongsa (upto 2500m).	Agriculture crops, native plants	Alien Invasive
6	*Ageretina adenophora* (Sprengel) King & Robinson	Croftonweed (Eng.)	Forest margins, Grasslands, agriculture lands, roadsides, wastelands	Chukha, Sarpang, Trongsa, Punakha, Mongar, Lhuntse, Trashigang, Trashi Yangtse, Samdrupjongkhar, Gasa, Pema Gathsel, Tsirang, Wangdue, Dagana, Paro.	Degrade pastureland, hazardous to animal and human health	Alien Invasive
7	*Ageratum conyzoides* (L.) L.	Billy goat weed (Eng.); Elamey (Nep.); Rogpu-ngon (Sha.)	Grassland, pasture, roadsides, wasteland, forest, riparian, wetland	All districts (mainly at lower altitudes up to 2000 m).	Reduce crop yield	Common dryland weed
8	*Albizia julibrissin* Durrazz.	Silk tree (Eng.)	Roadside slopes, disturbed area, stream banks	JDNP, JSWNP, RMNP, TNP, BWS, JWS, PWS, JKSNR	Native plant	Native Invasive
9	*Albizia lebbeck*(L.) Benth.	Indian seris (Eng.)	Disturbed area, natural forest, riverbanks	Trashigang (300-900m).	Native plant	Less Common
10	*Albizia saman* (Jacq.) Merr	Rain tree (Eng.)	Deciduous forest margins, disturbed areas, roadsides, riverbanks		Native plant	Less Common
11	*Alternanthera pungens* Kunth.	Khaki weeds (Eng)	Roadsides, footpaths, forest	Trashi Yangtse, Trongsa	Native plants	Alien Invasive
12	*Alternanthera sessilis* (L.) R. Br. ex. DC.	Sessile joyweed (Eng.)	Roadsides, pathways, wastelands, irrigation canals, wetlands, fallows	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR (mainly below 2000m in all districts).	Agriculture crops: rice weed	Native Invasive
13	*Amaranthus hybridus* L.	Smooth pigweeds (Eng.); Ludeyjhar (Nep.); Lasomo (Sha.)	Cultivated fields, wastelands, roadsides, riverbanks, disturbed habitats	Bumthang, Lhuntshi, Paro, Trashigang, Thimphu, Wangdi (mainly above 1200 m).	Agriculture crops	Common
14	*Amaranthus spinosus* L.	Spiny amaranth (Eng.); Naumoth (Dzo.); Ludeyjharkadey (Nep.)	Weeds in agriculture field, orchards, pasture, secondary forest	Chukha, Lhuntshi, Mongar, Punakha, Trashigang (Mainly below 1500 m).	Unpalatable, Agriculture; Widespread dryland weed	Alien Invasive
15	*Anagallis arvensis*L.	Scarlet pimpernel (Eng.)	Disturbed area, Agriculture field	Punakha, Trashigang (between 1000 - 2000m).	Agriculture crops	Less Common dryland weed
16	*Arceuthobium minutissimum*Hook. f.	Himalayan dwarf mistletoe (Eng.), Lamteka (Dzo).	Host plants: *Pinus* sp., (forest), orchard fruit tree	Temperate Blue pine forest (2000-3000m)	Forest, orchard tree parts	Common in coniferous pine forest
17	*Arundo donax* L.	Giant reed (Eng.)	Riparian habitats of stream, ditches, river	Chhukha, Punakha, Wangdue, Trashigang (1220-2000m).	Riparian plant ecosystem	(World's worst IAPS).

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
18	*Argemone mexicana* L.	Mexican poppy (Eng.); Satya nasi (Nep.)	Arable land, pastures, roadsides, wastelands, fence rows, construction sites	Trashigang, Mongar (below 1000m).	Agriculture crops	Alien Invasive
19	*Avena fatua* L.	Wild oats (Eng.); Jangali jar (Nep.)	Cereal field, wastelands, pastureland	Bumthang, Chhukha, Haa, Mongar, Punakha, Trashigang, Thimphu, Wangdue (over 1000m)	Cereal crops	Common
20	*Axonopus compressus* (SW) P. Beauve.	Carpetgrass (Eng.)	Roadsides, gardens, waste areas, plantations	Trongsa	Agriculture crops, forest plantations	Alien Invasive
21	*Bacopa monnieri* (L.) Wettst	Water hyssop (Eng.)	Wetlands, streams, ditches, riverbank	Southern parts of country; Chukhha (below 1000m).	Deleterious to native plants and animals, deteriorates water quality	Native Invasive Less common
22	*Bidens Pilosa* L.	Blackjack (Eng.); Khaedu (Dzo); kuro (Nep.),	Roadsides, disturbed area, fallow lands, forest margins.	All districts (up to 2400 m).	Agriculture crops	Alien Invasive
23	*Borreria latifolia* (Aubl.) K. Schum.	Broadleaf buttonweed (Eng.)	Roadsides, agriculture field, riverbanks		Weeds of agriculture field	
24	*Brachypodium sylvaticum* (Huds.) P. Beauv.	Slender false brome (Eng.)	Forest, meadows	Wangdue Phodrang	Forest (coniferous)	
25	*Bryophyllum pinnatum* (Lam.) Oken	Cathedral bells (Eng.)	Disturbed sites, roadsides, slope dry forest		Island ecosystem	
26	*Caesalpinia decapetala* (Roth) Alston	Mysore thorn (Eng.)	Open area, grassland, forest edges	JDNP, JSWNP, RMNP, TNP, BWS, JWS, PWS, SWS, JKSNR	Native plants	Native Invasive
27	*Casia tora*	Sickle Senna	Roadsides			Alien Invasive
28	*Calotropis procera* (Aiton) Dryand.	Apple of sodom (Eng.)	Arid, semiarid area fallows, roadsides, grasslands		Pasturelands native plants	
29	*Cardamine flexuosa*With.	Wavy bittercress (Eng.)	Cultivated areas, wastelands, forest field (common weed)	JDNP, JSWNP, RMNP, WCP, BWS, PWS, SWS, JKSNR	Agriculture, forest	Alien Invasive
30	*Chenopodium album* L.	Fat hen (Eng.); Hethu (Dzo.); Bathu, Bethe (Nep.); Bethu (Sha.)	Cutivated areas, wastelands, pasturelands, roadsides, riverbanks	All districts (mainly above 1000 m).	Agriculture winter crops	Common weed
31	*Chromolaena odorata* (L) King & Robinson	Siam weed (Eng.); Achame (Nep.); nayra-ngon (Sha.)	Roadsides, wastelands, fallow lands, grasslands	Chukha, Samtse, Sarpang, Punakha, Tsirang, SamdrupJongkhar, Pema Gatshel, Trashigang, Trashi Yangtse, Mongar, Lhuntse, Trongsa, Dagana, Wangdue, Zhemgang (200-1450 and upto 1511m).	Plant displacement, Reduces regeneration of trees.	Alien Invasive (World's worst IAS)
32	*Commelina benghalensis* L.	Spreading dayflower (Eng.); Kaney jhar (Nep.); Humbatenang (Sha.)	Roadsides, wastelands, grasslands, rice fields	JDNP, JSWNP, RMNP, TNP, PWS. Lhuntse, Mongar, Punakha, Trashigang, Thimphu, Trongsa (up to 2300 m).	Agriculture crops; Common weed of lowland areas	Native Invasive
33	*Convolvulus arvensis* L.	Bindweed (Eng.)	Open area, cultivated area, pastures, roadsides		Agriculture and horticulture crops	
34	*Conyza bonariensis* L. (Cronquist)	Hairy fleabane (Eng.)	Wastelands, fallows, roadsides	Mongar, Thimphu (wide range of altitudes and probably in most districts).	Weeds in protected area	Invasive
35	*Conyza canadensis* L. (Cronquist)	Canadian fleabane (Eng.)	Wastelands, fallows, roadsides	Chhukha, Paro, Trashigang, Thimphu, Wangdue	Weeds in protected area	Invasive

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
				(restricted to higher altitude, mainly above 2000 m).		
36	*Conyza sumatrensis* (S.F.Blake) Pruski & G. Sancho	Sumatran fleabane (Eng.)	Orchards, plantations		Native Plants	
37	*Cosmos bipinnatus* Cav.	Garden cosmos (Eng.);	Roadsides, fallows	Bumthang, Paro, Trashigang, Trashiyangtse, Thimphu. (Mainly above 2000 m).		Alien Invasive
38	*Crassocephalum crepidioides* (Benth.) S. Moore	Redflower ragleaf (Eng.); Dhadungphuley (Nep.)	Roadsides, riverbeds, wet sites, open areas	Chhukha, Lhuntshi, Mongar, Punakha, Trashigang, Trashiyangtse, Tongsa (mainly at lower, wetter altitudes up to 2000 m).	Native plants	Common
39	*Cryptomeria japonica* (Thunb. Ex L.f.) D. Don	Japanese cedar (Eng.)	Roadsides, forest plantations	All districts	Forest, hazardous to animal health	Alien Invasive
40	*Cuscuta campestris* Yunck	Field dodder (Eng.)	Parasitic	Lhuntshi, SamdrupJongkhar, Trashigang, Thimphu.	Crops	Sporadic parasitic plant
41	*Cuscuta europaea* L.	European dodder (Eng.)	Parasitic		Crops	
42	*Cuscutareflexa*Roxb.	Dodder (Eng.); Roba-je (Dzo.); Swarnlata, Amar lata (Nep.)	Parasitic	All districts (widespread at higher altitudes, over 600 m).	Crops	Common weed
43	*Cynodon dactylon* L. Pears	Bermunda grass (Eng.); Rampa (Dzo.); Dubo (Nep.); Saram (Sha.)	Pasture, fallows, waste areas	All districts (below 2500 m).	Crops	Serious weed.
44	*Cyperus compressus* L.	Annual sedge	Wasteland, rice field	Trashigang district	Crops (rice)	Less common
45	*Cyperus iria* L.	Rice flatsedge (Eng.); Guchen, Ochumani, Chow (Dzo.); Mothey (Nep.)	Riverbanks, ditches, rice field	All districts (from 500 up to 2500 m).	Crops (rice)	Common weed
46	*Cyperus rotundus* L.	Purple nutsedge (Eng); Guchen (Dzo.); Mothey (Nep.)	Cultivated areas, wasteland, roadsides, pastures, riverbanks, sandbanks, irrigation channel, natural area.	All districts (from 500 to 2300 m).	Crops (vegetables, ornamentals)	Common weed
47	*Dalbergia sissoo* DC.	Shisham (Eng.)	Riverbanks	RMNP, PWS, TSNR (Phuntsholing, Sarpang, Gelephug, 300m)		Native Invasive
48	*Datura stramonium* L.	Jimson weed (Eng.); Dhaturo (Nep.); Nyangmo-throkchang (Sha.)	Roadsides, disturbed lands, wastelands, pasturelands, woodland gap	Trashigang, Trashiyangtse, Paro, Thimphu, Wangdue (mainly above 1000m).	Agriculture crops, plants	Invasive
49	*Delonix regia* (Hook.) Raf.	Flam boyant (Eng.)	Roadsides, disturbed areas, ornamental garden	Mongar, Trashigang, Trashi Yangtse	Prevents regeneration of native plants	
50	*Digitaria ciliaries* (Retz.) Koeler	Southern crabgrass (Eng.); Tampula (Dzo.); Chittreybanso (Nep.)	Disturbed open area, roadsides, wasteland	All districts (mainly above 1000m).	Agriculture crops (cereals)	Common
51	*Digitaria longiflora* (Retz.) Pers	False couch grass (Eng.)	Disturbed open area, roadsides, wasteland	Trashigang	Agriculture crops	
52	*Dioscorea bulbifera*L.	Air potato (Eng.)	Cultivated, forest	Subtropical forest of country	Forest (displace native plants)	Native Invasive

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
53	*Drymaria cordata* (L.) Wild. ex Schult.	Tropical chickweed (Eng.); Ovizalo (Nep.)	Damp roadsides, gardens	Bumthang, Chhukha, Mongar, Punakha, Sarbang, Trashigang (2600 m).	Agriculture crops	Invasive
54	*Echinochloa colona* (L.) Link	Jungle rice (Eng.); Jam, Jama (Dzo.); Sama, Molera (Nep.)	Gardens, pasture, roadsides, disturbed area, water ways	All districts (upto 2000m).	Agriculture crops (paddy)	Common weed
55	*Echinochloa crus-gallii* (L.) P. Beauv.	Banyard grass (Eng.); Jam, Jama (Dzo.); Sama, molera (Nep.)	Field (paddy), wetlands, grassland, disturbed area	All districts	Crops, high nitrate content can poison livestock	Common weed
56	*Ecliptaprostrata*(L.) L.	Eclipta (Eng.)	Damp places, near swamps and rivers, ditches	Chukha, Punakha, Samtse, SamdrupJongkhar, Trashigang, Trongsa, Wangdue (upto 1800m).	Crops (rice)	Common weed
57	*Eichhornia crassipes* (Martius) Solms	Water hyacinth (Eng.)	Freshwater ponds, rivers	Chukha, Sarpang, Gelephu, Wangdi Phodrang	Water ecosystem	Alien invasive in country. (World's worst IAPS)
58	*Elaeagnus umbellate* Thunb.	Autumn olive (Eng.)	Hillside wastelands, roadsides, forest edges, river sides		Animal, native plants	
59	*Eleusine indica* (L.) Gaertn.	Goose grass (Eng.); Cholep (Dzo.); Dadey, Kode jhar (Nep.)	Forest margins, grassland, marshes, stream banks, fallows	All districts	Native plants	Common weed
60	*Erigeron karvinskianus* DC.	Karwinsky'sfleaban (Eng.)	Open areas, hillsides, cliffs, open forest	Trongsa (Mangdichu).	Native plants	High risk weed
61	*Euphorbia heterophylla* L.	Wild poinsettia (Eng.)	Waste place, cultivated area	Mongar, Trashigang, Wangdue (between 700 and 1700m).	Agriculture crops	Invasive
62	*Euphorbia hirta* L.	Garden spuge (Eng.)	Cultivated area, roadsides, fallows, wasteland s, ditch banks	Probably in all districts (1500 m).	Agriculture crops	
63	*Ficus macrocarpa* L.f.	Indian Laurel tree (Eng.)	Roadsides, forest	RMNP, PWS, TSNR	Invades pine rock-lands and hardwood forest	Invasive
64	*Galinsoga parviflora* Cav.	Gallant soldier (Eng.); Jagyouma, Jagasuju (Dzo.); Udasoy (Nep.); Yurungpa (Sha.)	Gardens, roadsides, disturbed area, water ways	All districts	Agriculture crops	Invasive
65	*Gliricidia sepium* (Jacq.) Steud.	Gliricidia (Eng.)	Disturbed area, roadsides, fallows, near cultivation area	Manas National Park	Invade road sites	
66	*Hedychium gardnerianum* Sheppard ex Ker Gawl.	Kahili Ginger (Eng.)	Undisturbed areas, forest, forest margin, roadsides	Broad leave oak forest (910-2130 m).	Native plants	World's worst IAPS.
67	*Houttuynia cordata* Thunb.	Chameleon plant (Eng.); Dachu (Dzo).	Fallow, forest margins, roadsides	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Native plants	Common weed
68	*Hygrophila polysperma* (Roxb.) T. Anderson	Indian swamp weed (Eng)	Lakes, ditches, wetlands, swamps, water canals	JDNP, JSWNP, TNP, WCP, BWS, SWS	Native plants, water ecosystem	
69	*Hyptis suaveolens* (L.) Poiteau	Pignut (Eng.)	Streamside, fallow lands, open and rocky forest	Samtse, Chukha, Sarpang, SamdrupJongkhar	Native plants	Major invasive
70	*Imperata cylindrica* (L.) Raeusch.	Cogon grass (Eng.); Becho (Dzo.); Khar, Sirru (Nep.)	Roadsides, fallow lands, grasslands, deforested areas, river margin	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Crops, native plants	Major invasive in country. (World's worst IAPS)

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
71	*Ipomoea hederifolia* L.	Scarlet creeper (Eng.)	Roadsides, scrub, open forest	Chukha, Mongar, SamdrupJongkhar (200-600m and upto 964m)	Crops, native plants	Major invasive
72	*Ipomoea purpurea* (L.) Roth	Tall morning glory (Eng.)	Roadsides, fallows, disturbed areas, fence lines	Thimphu, Paro, Trashigang	Agriculture crops	Invasive
73	*Jatropha curcas* L.	Jatropha (Eng.); Zhoshing (Dzo)	Disturbed sites, roadsides, open woodlands, pasture, abandoned garden	Trashi Yangtse, Trashigang, Wangdue, Punakha	Native plants	
74	*Lantana camara* L.	Lantana (Eng.)	Roadsides, wastelands, open forest	Chukha, Sarpang, SamdrupJongkhar, Samtse, Wangdue	Native plants, crops, poisonous to livestock	Major invasive (World's worst IAPS).
75	*Lemna perpusilla* Torr.	Duckweed (Eng.)	Paddy fields, lakes, irrigation and drainage canals	Thimphu, Paro, Punakha, Trashigang (1000-2400m).	Crops (rice), water ecosystem	
76	*Lespedeza cuneata* (Dum. Course) G. Don.	Sericeae lespedeza (Eng.)	Rangelands, grasslands, roadsides, disturbed sites	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Pasturelands native plants	Invasive
77	*Leucaena diversifolia* (Schltdl.) Benth	White leadtree	Wastelands, roadsides, disturbed sites		Native plants	
78	*Leucaena leucocephala* (Lamarck) de Wit.	Leaucana (Eng.); Tsashing (Dzo.)	Roadsides, disturbed sites	Samtse, Chukha, Punakha, SamdrupJongkhar, Wandue, Trashigang (500-1500m).	Native plants	Major invasive (World's worst IAPS).
79	*Limnophila sessiliflora* (Vahl.) Blume	Asian marshweed (Eng.)	Paddy fields, irrigation and drainage canals	JDNP, JSWNP, RMNP, TNP, BWS, JWS, PWS, SWS, JKSNR	Crops (paddy), clogs water canals	Common plant
80	*Lepidium virginicum* L.	Virginian pepper cress (Eng.)	Roadsides, field	Paro, Trashigang, Thimphu	Agriculture crops	Invasive
81	*Lotus corniculatus* L.	Bird's-foot treefoil (Eng.)	Old fields, grassy places, roadsides	JDNP, JSWNP, RMNP, TNP, WCP, BWS, PWS	Native species	
82	*Ludwigia hyssopifolia* (G. Don) Exell	Water prim rose (Eng.)	Paddy field, wetlands		Crops (paddy), wetland native plants	
83	*Lygodium japonicum* (Thunb.) Sw.	Japanese climbing fern (Eng.)	Swampy disturbed area, marshes, floodplain forest, timber plantations	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Plantation forests	Common
84	*Marsilea minuta* L.	Pepper wort (Eng.)	Ponds, pools, ditches, swamps, low land paddy field	Punakha, lower altitudes of southern districts (below 1500 m).	Crops (paddy)	Common weed
85	*Melilotus alba* Medik.	Honey clover (Eng.)	Meadows, disturbed sites, riparian areas	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Agriculture, native plants	
86	*Melia azedarach* L.	Chinaberry (Eng.)	Roadsides, forest margins, forest, marshes	Trashi Yangtse, Trashigang, Wangdue, Punakha, Paro, Thimphu (probably in all districts)	Native plants	Common
87	*Melinis minutiflora* P. Beauv.	Molasess grass (Eng.)	Roadsides, forest margins, woodlands, disturbed sites, pasture	Trongsa	Agriculture, pasture,	
88	*Mikania micrantha* Kunth	Bitter vine (Eng.); Titaylaharo (Nep.)	Roadsides, wastelands	Chukha, Samtse, Sarpang, Punakha, Tsirang, SamdrupJongkhar, Pema Gatshel, Trashigang, Mongar, Lhuntse, Trongsa, Dagana, Wangdue Phodrang, Zhemgang	Agriculture crops, forest, plantations	Major invasive in country. (World's worst IAPS)
89	*Mimosa pudica* L	Sensitive plant (Eng.)	Roadsides, agriculture lands, construction sites	Samtse, Chukha, SamdrupJongkhar, Mongar, Sarpang (below 1000 m).	Agriculture crops, native plants	Major invasive
90	*Monochoria vaginalis*	Pickerel weed (Eng.);	Wetlands, streams, ditches, swampy	All districts	Crops (rice)	

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
	(Burm.f.) C. Presl	Damperu, Olasam (Dzo)	areas, rice field			
91	*Murdannia nudiflora* (L.) Brenan	Doveweed (Eng.)	Wetlands, streams, ditches, swampy areas, rice field, wet pastureland	Trongsa, SamdrupJongkhar	Agriculture crops (rice), water ecosystem	
92	*Myriophyllum spicatum* L.	Spike watermilfoil (Eng.)	Waterbodies; marshes, wetlands, ditches		Water ecosystem	
93	*Neyraudia reynaudiana* (Kunth) Keng ex Hitchc.	Burma reed (Eng.)	Warm subtropical; moist soil, stream and river sides, roadsides, disturbed area.	Warm subtropical region of the country; JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR.	Forest, agriculture crops	Invasive
94	*Nicandra physalodes*(L.) Gaerten	Apple of Peru (Eng.)	Wastelands, roadsides	Chhukha, Lhuntshi, Punakha, Trashigang, Thimphu, Wangdue (above 1000m)	Native plants	Invasive
95	*Opuntia vulgaris* Miller	Pickly pear (Eng.); Gewringa (Dzo),	Hillsides in dry valleys, roadsides.	Chukha, Punakha, Trongsa, Wangdue, Trashigang (250-1500m).	Native plants, animal	Major invasive
96	*Oxalis latifolia* Kunth	Sorrel (Eng.)	Orchards, plantations, gardens.	Paro, Trashigang, Thimphu, Wangdue, Trashigang (900 to 2700 m).	Plants	Invasive
97	*Paederiafoetida* L.	Skunkvine	Sunny disturbed area, deciduous forest, woodlands, roadsides.	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Agriculture, forest	Invasive
98	*Parthenium hysterophorus* L.	Parthenium weed (Eng.), Dushing (Dzo)	Roadsides, fallow lands	Punakha, Mongar, Wangdue, Trashigang, Trongsa, Chukha, Tsirang, Dagana, Lhuntse, Sarpang, Pemagathsel, Trashi Yangtse, Zhemgang, Thimphu.	Agriculture crops, animal and human health.	Major invasive
99	*Paspalum conjugatum* P.G. Berguis	Buffalo grass (Eng.)	Disturbed area, roadsides, forest margin, pastures and grassland	Below 1000 m in all low-altitude districts of southern Bhutan.	Pasture, grassland, agriculture, forest	Invasive
100	*Paspalum distichum* L.	Knotgrass (Eng.); Jagarampa (Dzo.); chittrey (Nep.)	Wetlands, wastelands, grasslands, rice field	Lower altitudes and up to 2500 m in all districts.	Crops (rice)	Invasive
101	*Paspalum scrobiculatum* L.	Rice grass paspalum (Eng.)	Wastelands, field	Southern parts of country	Native pant s	Common wetland weed
102	*Pennisetum clandestinum* Hochst. Ex Chiov.	Kikuyu grass (Eng.)	Roadsides, agriculture lands, orchards, wastelands	Bumtang, Gasa, Chukha, Mongar, Punakha, Samtse, SamdrupJongkhar, Sarpang, Thimphu, Trashigang, Trashiyangtse, Trongsa, Lhuntse, Zhemgang (mostly over 1000 m).	Agriculture, forest, pasturelands	Major invasive
103	*Pennisetum pedicellatum* Trin.	Deenanath grass (Eng.)	Cultivated fields, fallows, grassland	Trongsa	Agriculture crops	Rarely abundant
104	*Phalaris minor* Retz.	Littleseedcanarygrass (Eng.)	Irrigated conditions	Punakha, Wangdue, Trashigang (1200-2300m).	Agriculture crops	Localized weed
105	*Phyllanthus urinaria* L.	Leafflower (Eng.)	Cultivated fields, roadsides, wastelands	Punakha, Trongsa	Agriculture crops	
106	*Pithecellobium dulce* (Roxb.) Benth.	Manila tamarind (Eng.)	Forest, roadsides, urban area	Trashigang, Trashigang to Samdrupjongkhar highway	Pasture grass and native plants	
108	*Plantago lanceolata* L.	Ribwort plantain (Eng.)	Grasslands, wastelands	Haa, Bumthang (Ura)	Agriculture crops, pastures	
109	*Poa annua* L.	Annual meadow grass (Eng.)	Grasslands, pasture,	All districts (mainly above 2000 m).	Agriculture crops, native plants	Common winter weed

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
110	*Polygonum aviculare* L.	Prostrate knotweed (Eng.)	Irrigated conditions	Paro, Thimphu, Wangdue (above 1000m).	Irrigated crops, native plants	Common winter plant
111	*Persicaria barbata (*L.) H. Hara	Knot grass (Eng.)	Irrigated conditions; marshes, ditches, streams, paddy field		Crops (rice), native plants	Less common
112	*Persicaria hydropiper* (L.) Delarbre	Marsh pepper (Eng.); Piprejhar (Nep.)	Wherever moist soil and standing water; wetlands, roadsides	Phuntsholing, Chukkha, Haa, Punakha, Trashigang (200-2750).	Agriculture crops, native plants	Common wetland weed
113	*Persicaria nepalensis* (Meisn) Miyaba	Nepal persicaria (Eng.); Shido (Dzo.); Berkheyratnaulo (Nep.); Gangchuma (Sha.)	Cultivated area, disturbed area	All districts (above 1000m).	Agriculture crops	Common and dominant
114	*Persicaria maculosa* (Raf.) Gray	Redshank (Eng.); Pirat (Dzo.)	Moist areas; wastelands, roadsides, disturbed sites, meadows, croplands	Mongar, Punakha, Trashigang, Thimphu (mainly between 1000 and 2000 m).	Agriculture crops, native plants	Common but rarely dominant
115	*Pueraria montana* var. *lobata* (Wild.) Sanjappa& Pradeep	Kudzu (Eng.)	Plantation forest, along river and roads, field margins, abandoned		Native plants	
116	*Pteridium aquilinum* (L.) Kuhn	Bracken (Eng.); Unew (Nep.)	Pastureland, deciduous and coniferous forest, hillsides	All districts (higher altitudes, above 1000 m).	Native plants	Serious weed of grassland
117	*Robinia pseudoacacia* L.	Black locust (Eng.)	Forest margins, disturb dry slopes	Thimphu, Paro, Chukha, Dagana, Punakha (1200-2500m).	Hazardous to animals, native plant displacement	Major invasive
118	*Rubus ellipticus* Sm.	Yellow himalayan raspberry (Eng.)	Slopes, sparse forest, thickets, roadsides and forest edges	Warm subtropical region of the country; JDNP, JSWNP, RMNP, TNP, WCP, BWS	Hazardous to animals, native plant displacement	Major invasive. (World's worst IAPS)
119	*Rubus niveus* Thunb.	Mysore raspberry (Eng.)	Agriculture land, forest, grasslands, riparian land	JDNP, JSWNP, RMNP, TNP, WCP, BWS, JWS, PWS, SWS, JKSNR	Hazardous to animals, native plants displacement	Major invasive
120	*Scoparia dulcis* L.	Sweet broom weed (Eng.)	Dryland field margins	Chhukha, Mongar, Samtse Sarbang, Thimphu, Trongsa. (Below 1500m).	Agriculture crops	Invasive
121	*Senna obtusifolia* (L.) H. S. Irwin & Barneby	Sicklepod (Eng.)	Agriculture land, wastelands, roadsides, woodlands, natural grasslands		Agriculture crops, native plant displacement	
122	*Senna occidentalis I*(L.) Link	Coffee senna (Eng.)	Roadsides, arable lands, degraded pasture, wasteland	Punakha	Agriculture crops, forest plantations	
123	*Senegalia catechu* (L. f.) P. J. H. Hunter & Mabb.	Black cutch (Eng.)	Mixed deciduous forest, hills, riverbanks, watersheds		Native plants	
124	*Sida acuta* Burm. fil.	Sida (Eng.); Balu jhar, Cannaino, Jaharu, Khareto (Nep.)	Pastures, rangelands, roadsides, fallow lands	Samtse, Chukha, Sarpang, Trashigang, Dagana, Trashi Yangtse, Punakha, Mongar, Lhuntse, SamdrupJongkhar (200-1200m).	Pasturelands, rangelands	Major invasive
125	*Solanum viarum* Dunal	Tropical soda apple (Eng.)	Drought affected pasture, forest, riverbanks, roadsides	Thimphu, Wangdue, Paro, Trashigang, Trashiyangtse, Lhuntse	Agriculture crops, forest, pastureland	Common plant
126	*Spergula arvensis* L.	Corn spurry (Eng.)	Disturbed area, roadsides, farmlands, forest	Bumthang, Haa, Punakha, Trashigang, Trashiyangtse, Thimphu, Wangdue (Mainly above 1000 m).	Agriculture crops, native plants	Semi-dominant
127	*Stellaria media* (L.) Vill.	Common chickweed (Eng.)	Cultivated fields, gardens, pasture,	Chhukha, Mongar, Punakha, Samtse,	Agriculture crops, native	Invasive

Sl.No.	Species	Common /Local name	Habitat	Distribution	Threats	Bio Status
			lawn, roadsides, wasteland	Trashigang, Thimphu, Wangdue (Mainly at high altitudes but also down to 600 m).	plants	
128	*Striga asiatica* (L.) Kuntze	Witch weed (Eng.)	Grasslands, cultivated field	Punakha, Wangdue.	Agriculture crops	Less common
129	*Syzygium cumini* (L.) Skeels	Black plum (Eng.)	Moist riverine area, riverbanks		Native plants	
130	*Tagetes minuta*L.	Stinging Roger (Eng.)	Pasturelands, roadsides, stream and river sides	Thimphu, Paro (1000-1500m)	Agriculture crops Native plants	Invasive
131	*Thlaspi arvense* L.	Field penny cress (Eng.)	Cultivated field, wasteland	Bumthang, Chukkha, Mongar, Trashigang, Punakha, Thimphu (mainly above 1800m).	Agriculture crops	Common
132	*Tithonia diversifolia* (Hemsl.) A. Gray	Mexican sunflower (Eng.)	Roadsides, disturbed areas	Chukha, Samtse, Sarpang, SamdrupJongkhar (350-1500m).	Native plants	Major invasive
133	*Trifolium repens* L.	White clover (Eng.)	Roadsides, agriculture lands, pastureland	All districts (2000-2700m).	Native plants	Major invasive
134	*Urochloa panicoides* P. Beauv.	Liver seed grass (Eng.)	Pastureland, grasslands, cultivated fallows		Agriculture crops, poisonous to cattle	
135	*Verbascum thapsus* L.	Common mullein (Eng.)	Roadsides, forest clearing, meadows, pastures, open disturbed area		Native plants	
136	*Xanthium strumarium* L.	Common cocklebur (Eng.)	Roadsides, field edges, wastelands, cultivated area, fallows	Chhukha, Lhuntshi, Mongar, Trashigang, Thimphu, Trongsa, Wangdue.	Agriculture crops, native plants	Occasionally dominant

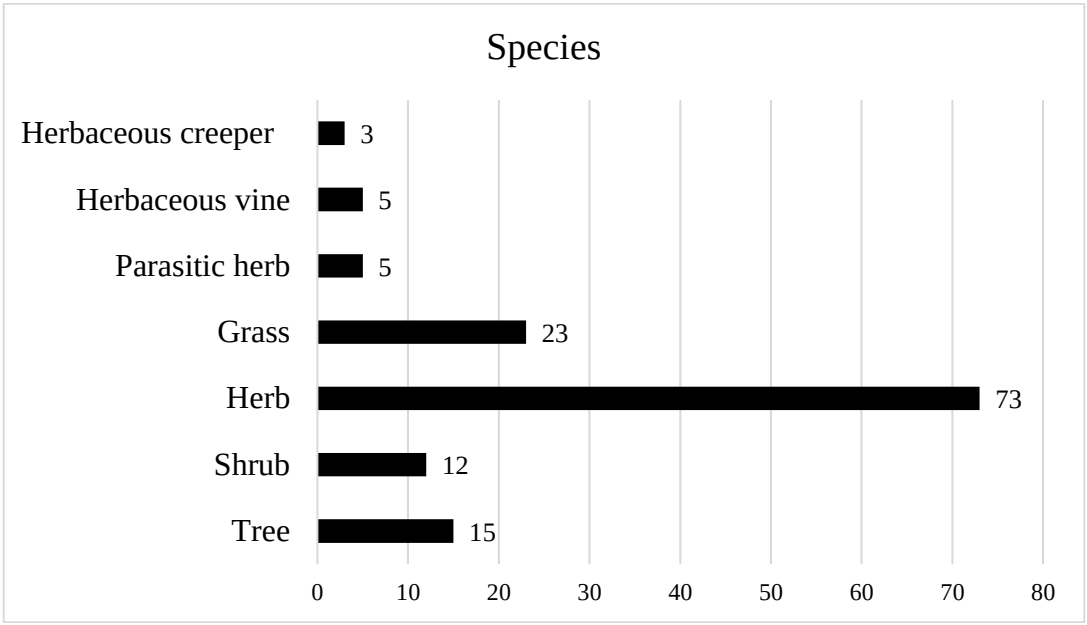

Fig. 2. Different lifeforms of the IAPS recorded in Bhutan

IAPS has posed threat to natural environments, forest and wetland ecosystems, grasslands and pasturelands, native plants and native animals. Besides, it has adverse impact on agriculture yield, as a serious and compitive weeds of the crops. Some are even considered as hazadrous to animal and human health. However, the country still lacks the comprehensive study on impacts of all the IAPS and its invasive status in the country. Furthermore, the geographical distribution of all IAPS in the country could not be well documented due to lack of proper documentations of IAPS and its current distributiion in the country. Therefore, geographical IAPS will expand with its invasiveness in near future. IAPS in the country consitutute maximun for Fabcaeae (24), followed by Poaceae (20) and Astercaee (19) species, similar to finding of Dorji, (2014). Most of IAPS in the country are annual or perennial herbaceous plants.

6. CONTROL AND MANAGEMENT STRATEGIES OF IAPS

The management and control of IAPS causes huge economic losses once it is established or naturalized in the area (Richardson & Pyšek, 2007). However, prevention of IAPS is environment friendly and economically sound. Therefore, prevention of introducing IAPS is vital in IAPS management strategies (U.S. Department of Interior, 2021). Broadly, management of IAPS are categorized into two phases; preventive measures before introduction of IAPS and control or eradication measures after establishment IAPS in the particular area (CABI, 2021).

A. Preventive measures:

Some of the important preventive measures are as follows:

- Create mass awarness and sensitizaion programs on negative impacts of IAPS on environment and agriculture.
- Follow strict plant quarantine and plant sanitation regulations during plant imports.
- Early detection of IAPS in the country: conduct surveys, documentations, research and assessment of potential risk of plant invasion in the area.

B. Control and management strategies:

- **Initial assessment and prioritization:** assess invasive status and impact of IAPS and proiritize major invasive plants with adverse effect for management.
- **Eradication and containment**: scientifically based eradication and population conatinment methods must be followed to ensure its longterm succes.
- **Follow control measures**: IAPS popluations are controlled by mechanical methods (Slashing, uprooting, clearing and

burning), chemical methods (application of approved weedicides and herbicides) and biological control (identifying and introducing natural enemies like herbivores, insects and native plants).

- **Habitat management:** traditionally practiced environment management strategies like prescribed burning and agriculture practices must be continued to favor suitable habitat for native plants.

7. CONCLUSION

Invasive alien plant species (IAPS) threaten natural environments, including forests, wetlands, grasslands, and native biodiversity. There is an urgent need for comprehensive documentation of IAPS, including their status, ecological impacts, and geographical distribution within the country. Future studies on the economic impacts of IAPS on local communities and the health risks they pose can also be evaluated. Furthermore, systematic surveys to assess IAPS distribution and impacts can be conducted, fostering interdisciplinary research for integrated management strategies, and raising public awareness about the risks associated with invasive species.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We hereby declare that no generative ai technologies such as large language models (Chatgpt, Copilot, etc.) And text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

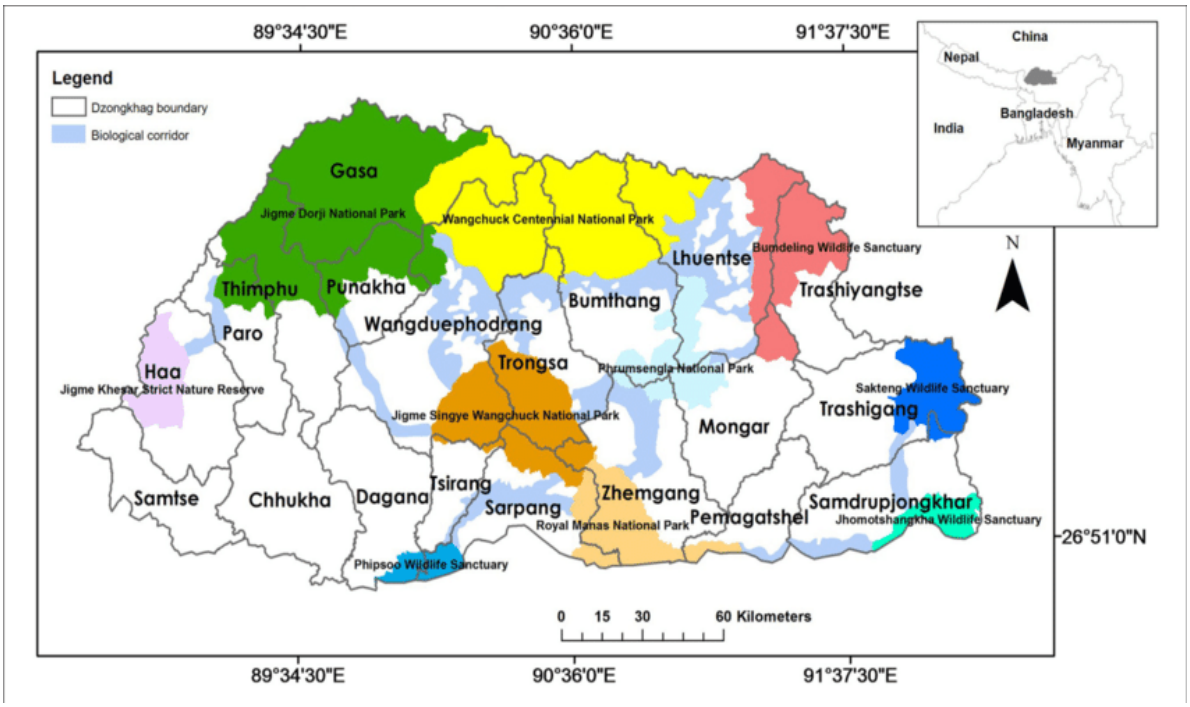

Fig. 3. Protected areas of Bhutan. (Thinley et al., 2021).

- *Jigme Dorji National Park (JDNP): Gasa, Paro, Punakha, Thimphu, Wangdue Phodrang.*
- *Jigme Singye Wangchuk National Park (JSWNP): Sarpang, Tsirang, Trongsa, Wangdue Phodrang, Zhemgang.*
- *Thrumshingla National Park (TNP): Bumthang, Lhuntse, Mongar, Zhemgang.*
- *Wangchuck Centennial National Park (WCNP): Bumthang, Gasa, Lhuntse, Trongsa, Wangdue Phodrang.*
- *Royal Manas National Parks (RMNP): Pemagatshel, Sarpang, Zhemgang.*
- *Bumdeling Wildlife Sanctuary (BWS): Lhuntse, Mongar, Trashiyangtse.*
- *Phibsoo Wildlife Sanctuary (PWS): Dagana, Sarpang.*
- *Sakteng Wildlife Sanctuary (SWS): Trashigang, SamdrupJongkhar.*
- *Jomotsangkha Wildlife Sanctuary (JWS): SamdrupJongkhar.*
- *Jigme Khesar Strict National Reserve (JKSNR): Haa district*

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The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/129110