ORIGINAL RESEARCH

Plant Invasion Research in Nepal: A Review of Recent National Trends

Mohan Pandey[1], Khum Bahadur Thapa-Magar[2], Buddhi Sagar Poudel[3], Thomas Seth Davis[2], Bharat Babu Shrestha[4, *]

[1] KTK-BELT, Inc., Kathmandu, Nepal,

[2] Department of Forest and Rangeland Stewardship, Warner College of Natural Resources, Colorado State University, Fort Collins, USA.

[3] REDD Implementation Centre, Ministry of Forests and Environment, Kathmandu, Nepal

[4] Central Department of Botany, Tribhuvan University, Kathmandu, Nepal

Corresponding Author E-mail: shresthabb@gmail.com

Received: 31 May 2020

Accepted for publication: 28 September 2020

Published: 30 December 2020

Abstract

Research interests in Invasive Alien Plant Species (IAPS) have expanded globally, and nationally in Nepal, over the last few decades. Here we provide a systematic compilation and analysis of the scientific literature to explore research trends and identify research gaps in plant invasion biology in Nepal. We compiled and examined journal publications retrieved from Web of Science (WOS) and other databases (NepJOL, Google Scholar, and other bibliographies) using specific search keywords. The search yielded 86 research studies on IAPS, published between 1958 and 2020 (up to August 2020) that met our pre-determined criteria.

The number of publications in national journals that focused on IAPS increased, starting in 2000, but this increase was not notable in international journals, until 2010. Nearly 91 % of the studies that appeared in international journals were published after 2010. A majority of the studies focus on biology, ecology, and ecological impact studies of a few selected IAPS, especially mile-a-minute (*Mikania micrantha* Kunth), parthenium weed (*Parthenium hysterophorus* L.), and crofton weed (*Ageratina adenophora* (Spreng.) R.M. King & H.Rob.), mostly in Nepal's forest ecosystems. Eighty-four percent (84%) of field-based studies have been conducted in the central region of Nepal (Bagmati and Gandaki provinces together). Tribhuvan University, a Government-funded, National University of Nepal, was the largest contributor to IAPS related research and our analysis revealed that international grants were the primary funding sources for this research.

We conclude that future regional research should be prioritized on thematic areas focusing on: (a) understudied phytogeographic regions, (b) impacts on protected areas, (c) under-studied invasive and naturalized species, (d) IAP dispersal mechanisms, and (e) economic impacts. Additional research in these priority areas will help to focus our understanding of IAPS in Nepal and will be important for mitigating ecological and economic damages from IAPS. Also, funding from government agencies for research, and incentives for graduate students to publish their theses, may improve the knowledge-sharing aspects related to the above themes and reduce biases in areas that we identified in this review.

Keywords*:* Invasive Alien Plant Species, IAPS, Web of Science, research trends, research gaps

Introduction

Biological invasions are one of the five major impacts of anthropogenic activities on the global environment (IPBES, 2019). Invasive alien species are a serious threat to native species biodiversity (Blackburn et al., 2019), ecosystem function (Ehrenfeld, 2010), and ecosystem services (Vila and Hulme, 2017). Invasions by alien species can ultimately damage the economy and livelihoods of people (Reid et al., 2005; Pimentel et al., 2005) at both local and global scales (Bellard et al., 2016; Doherty et al., 2016).

Systematic reviews are often used in invasion ecology research to understand the spatial, temporal, and subject-based research trends and identify key knowledge gaps (Kettenring and Adams, 2011; Lowry et al., 2013). In recent years, several global systematic review papers on invasive plant ecology have focused on specific invasive species (Yu et al., 2016; Maharjan et al., 2019a), taxonomic groups (Thomaz et al., 2014), environmental impacts (Nelson et al., 2017), dispersal pathways and mechanisms (Ansong and Pickering, 2013), and management options (Esler et al., 2010).

Biological invasions in Nepal has been identified as one of the emerging threats to biodiversity and ecosystem services (Shrestha, 2019) and is one of the major underlying causes of habitat degradation in Nepal, along with unsustainable harvesting practices, environmental pollution, overgrazing, and infrastructure developments (Chaudhary et al., 2016). The number of invasive alien plant species (IAPS) in Nepal has increased over time (Shrestha, 2019) and the range of climatically suitable areas for most of the IAPS of Nepal is likely to expand and shift upslope under climate change scenarios in the future (Shrestha and Shrestha, 2019).

These current and future scenarios suggest that issues surrounding biological invasions are likely to escalate. Current management and policy responses to these problems are inadequate in Nepal (Shrestha, 2019), although considerable efforts have been made by researchers to generate new knowledge, related to biology and ecology of individual IAPS (Maharjan et al., 2014), their diversity (Bhattarai et al., 2014), distribution (Shrestha et al., 2019a; Maharjan et al., 2019b), impacts (Murphy et al., 2013; Bhatta et al., 2020; Thapa et al., 2020), management and control (Shrestha et al., 2011; Rai et al., 2012), and socioeconomic aspects (Rai and Scarborough, 2013; Shrestha et al., 2019b).

Despite the increasing number of research publications on IAPS of Nepal, there is a need to critically review regional research on IAPS in order to identify priority areas for future work and provide direction to managers concerned with mitigating the effects on IAPS.

Thus, we aimed to conduct a comprehensive, systematic review of studies related to the IAPS of Nepal to answer the following questions: (1) How has the rate of publication in IAPS research in Nepal changed over time? (2) Are different regions of Nepal reasonably represented in ecological sampling? (3) How wide is the difference between basic and applied research in terms of research effort? (4) Which species and habitats have been prioritized for IAPS research? and (5) Who is studying IAPS of Nepal and who funds this research?

The information compiled here creates a knowledge-base to identify current research trends and gaps for future research of IAPS in Nepal. Our hope is that this information would influence invasive alien species policies, funding priorities, and management options, across the country.

Methods

Literature searches were conducted from the following sources: (a) Institute for Scientific Information (ISI) Web of Science Database (WOS), an international database; (b) Google Scholar; (c) a bibliography of invasive species in Nepal (DFRS, 2011); and (d) NepJOL, a Nepalese journal database, following standard procedures for a systematic review (Pullin and Stewart, 2006). In ISI WOS, we identified papers on August 19, 2020, using search keys: Topic: 'Nepa*' OR 'Nepal hima*' AND 'inva*' OR 'alien' OR 'exotic' OR 'naturalized' AND 'plant' OR' weed' followed by the 'refine' function to eliminate non-biological topics.

We searched literature from Google scholar and NepJOL up to August 20, 2020, using search keys: 'IPS Nepal', 'Invasive species Nepal', 'invasive plants Nepal', the scientific, common, and local name of each IAPS (e.g. Lahare Banmara for *Mikania micrantha*, Kalo Banmara for *Ageratina adenophora*, Seto Banmara for *Chromolaena odorata*, Jalkumbhi for *Eichhornia crassipes*, etc.). Studies published in some bulletins (e.g. Bulletin of Department of Plant Resources) were also included.

After the literature search from multiple resources, we collated the results, and an additional screening step was performed that included reading the title and abstract of each paper. From the screening process papers were further filtered and papers were excluded on the basis of: (1) studies of irrelevant topics (e.g. invasive fauna, native weeds), (2) unrelated locations (i.e. outside Nepal), and/or (3) duplicate publications and publications other than journal research articles (e.g. newsletter, proceeding, global systematic review articles, theses, books, and book chapters) (See Supplement 1 for diagram showing article filtering process).

After exclusion, we extracted the following information from the remaining papers: (1) first two author's names, (2) types of databases, (3) publication year, (4) institution of main and corresponding author/s, (5) research theme, (6) funding source, (7) types of research, (8) focus species, (9) habitat, and (10) study location (see Supplement 2 for details).

A distribution map of IAPS field studies was constructed using the coordinates of the study area in R software using package "sf" (Pebesma, 2018). The required GIS layers (district boundary, road system, physiographic region) were extracted from the regional database system of the International Centre for Integrated Mountain Development (ICIMOD) (https://rds.icimod.org/). For studies that did not have geographic data, we used Google Maps (https://www.google.com/maps) to specify the boundary according to the textual description of the study area and extracted latitude and longitude using mid-point of delineated boundaries. The elevation of the respective locations was extracted from the Digital Elevation Model of Nepal (USGS, 2000).

Results

We retrieved 267 publications, of which 102 were from WOS and 165 from other databases (NepJOL, Google scholar, bibliography, and others). After refining 3 biological studies in WOS, we reduced the record to 99. We did not use any refine function to publications retrieved from other sources but removed non-relevant publications manually.

A total 181 studies (75 from WOS and 106 from other databases) were excluded that were unrelated to the topics of our interest after reading the titles, abstracts, and full texts (if needed), duplicate papers (17), and publications which could not be accessed for data compilation (1). Eventually, we included 27 and 59 papers for the systematic review, which met our criteria from WOS and other databases, respectively (see Supplement 1). The list of the selected 86 papers has been provided as Supplementary Information (see Supplement 3).

Sources and year of IAPS publications

About one-third (27) of total studies (86) were retrieved from WOS while the remaining two-thirds (59) retrieved from other databases. The WOS extracted the papers that were published in international journals after 2000. The trend of publication in a national journal (n=40) showed an increase in research effort beginning in 2000s, while research effort published in international journals (n=46) abruptly increased after 2010.

Locations of research study areas

Field studies (N = 59 sites) have been undertaken in Tarai (n = 12), Siwalik (21), Middle Mountain regions (24), and High Mountains (2) but there were no studies related to IAPS in the High Himalaya ecoregion. More than four-fifths (84%) of the studies were conducted in Bagmati (e.g. Chitwan, Kathmandu, Nuwakot districts) and Gandaki Provinces (e.g. Kaski, Tanahu districts) which are located in central Nepal (approximate region: 83° to 86.5° E longitude) (Figure 2).

Nearly half (49%) of the study sites were inside the protected areas, with 62% of them focused to Chitwan National Park. There was no study reported from Karnali and Sudurpaschim Provinces.

Research themes, type of research, focus species and habitats

The highest proportion of studies were investigations of the ecological impacts of IAPS, followed by studies on the biology and ecology of IAPS (Figure 3A). These two research themes accounted for 55% of all studies, while studies related to socio-economic aspects were the least abundant. About 85% studies were observational (Figure 3B) and within this category, two-thirds were observational field studies.

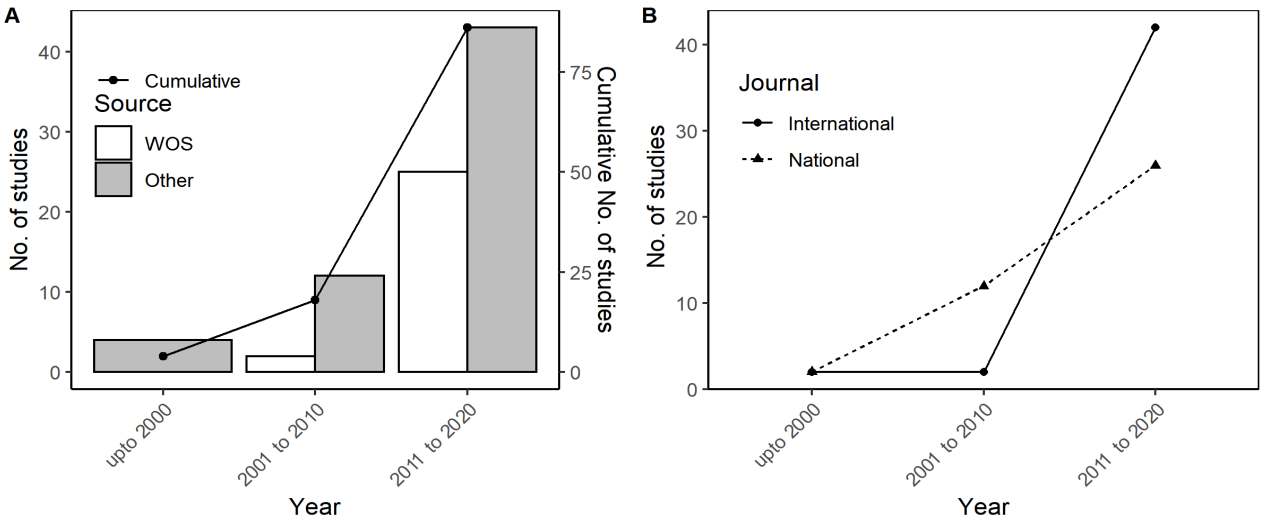


Figure 1. Number of studies, over time (N=86). A. Studies extracted from WOS and other sources. B. Studies published in national and international journals. In 2020, studies published until August 2020 were included.

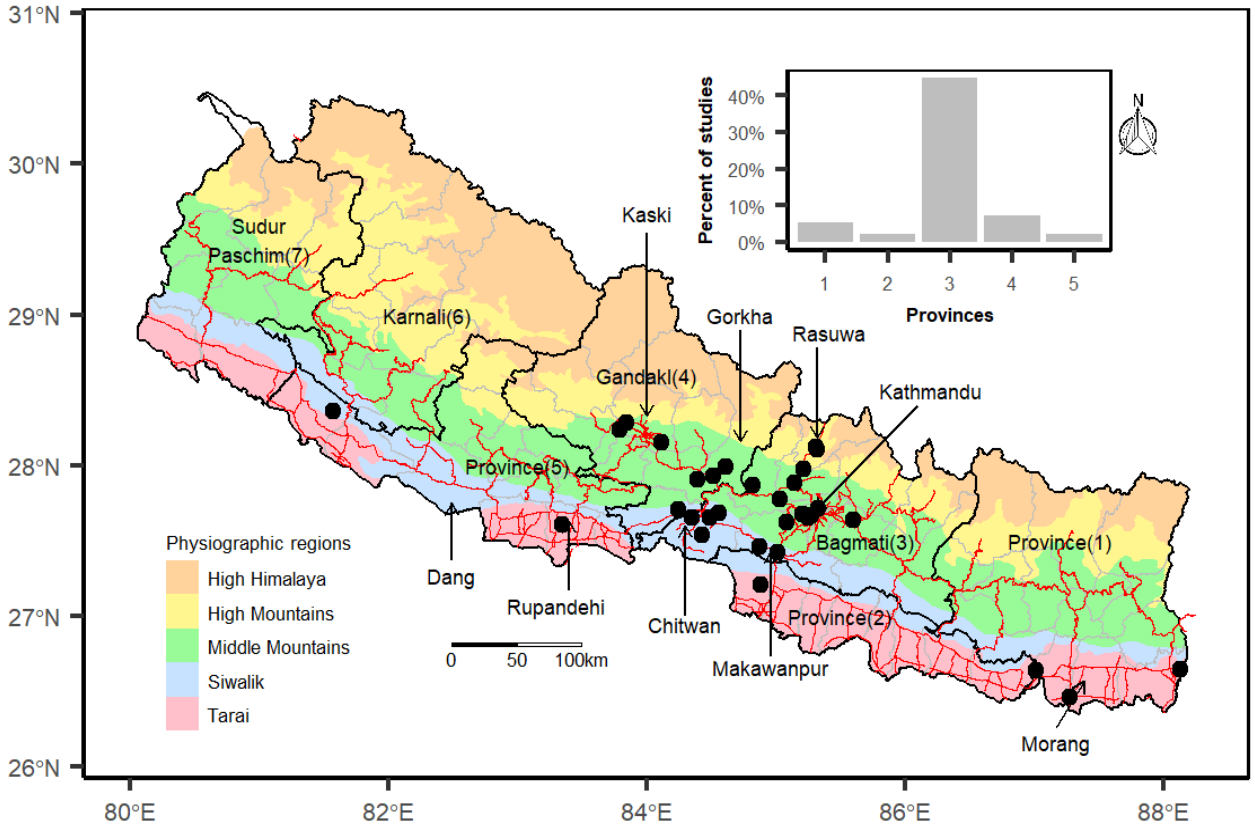


Figure 2. Location of study areas in publications based on field studies (N=59, denoted by black dots; the smaller number in the map is because of overlap). Black, grey, and red lines in the map represent province boundary, district boundary, and primary road systems (including highways), respectively.

Out of 27 IAPS reported from Nepal, 11 species were the subject of at least one study, suggesting that there is no existing research on ~59% of IAPS in Nepal. Among these species, mile-a-minute (*Mikania micrantha* Kunth), crofton weed (*Ageratina adenophora* (Spreng.) R. King & H. Rob.), and parthenium weed (*Parthenium hysterophorus* L.) were commonly studied (Figure 3C). These three IAPS represented nearly three-fifth of the total studies that we evaluated. Out of 43 field studies that had identifiable habitat types, about half of the studies were conducted in forest ecosystems (Figure 3D). By comparison, relatively few studies were from grasslands, wetlands, or roadside areas.

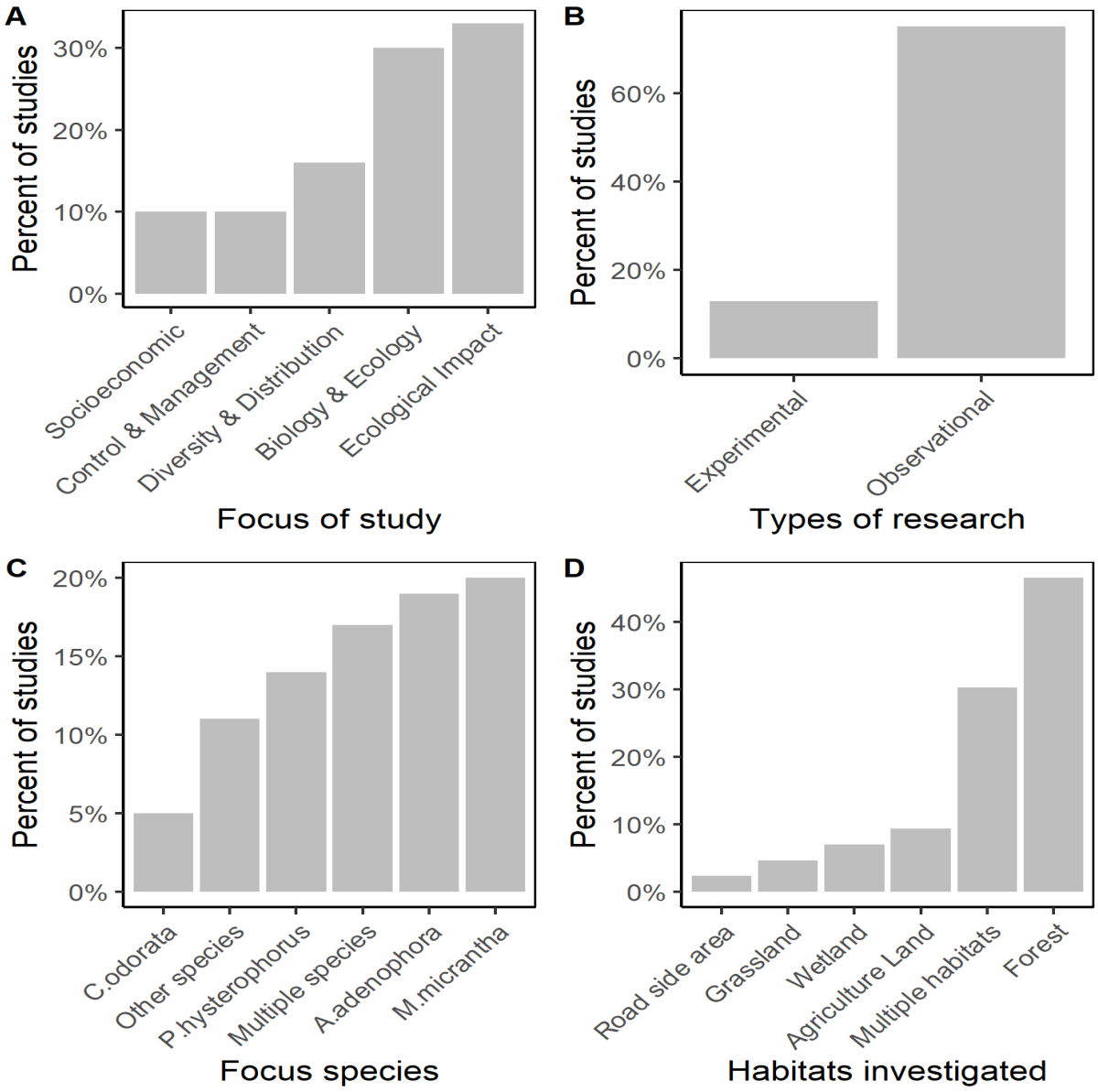


Figure 3. Number of studies on invasive alien plant species of Nepal (N = 86). A) Theme of study, B) Types of research, C) Focus species (*Chromolaena odorata*, *Ageratina adenophora*, *Parthenium hysterophorus*, *Mikania micrantha*; 'other species' included *Ageratum houstonianum*, *Alternanthera philoxeroides*, *Amaranthus spinosus*, *Lantana camara*, *Mimosa pudica*, *Eichhornia crassipes*, and *Mimosa diplotricha*), and D) Habitats investigated (N=43).

Contributing institutions and funding sources

Universities were found contributing two-third of total publications in which Tribhuvan University (a national university of Nepal) alone represented 41% of all authors (Figure 4A). Nearly one-fourth (24%) of the total authors were affiliated to foreign universities while 15% were Nepal Government officials.

Forty-seven studies (54% of total) mentioned the funding sources in their publications; of these, 38% of studies were funded from international grants while the Nepal Government funded only 19% of studies (Figure 4B).

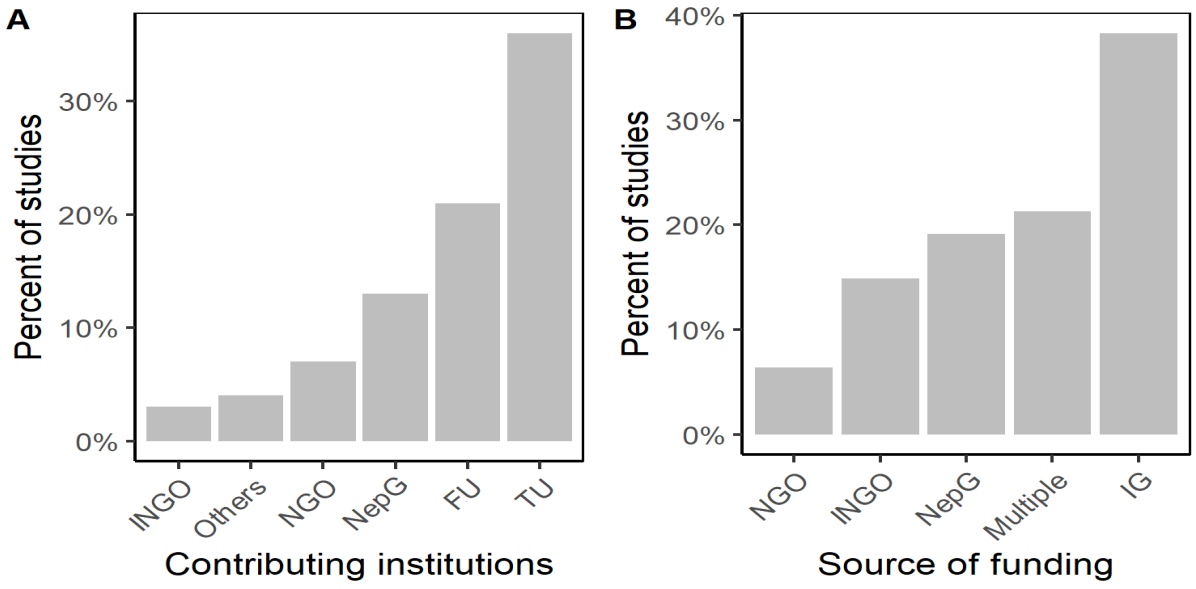


Figure 4. Number of studies according to the author's institutions and funding sources. A) Categories of institutions to which authors were affiliated (N=86), and B) Categories of funding institutions (N=47). Abbreviations: FU- Foreign universities, IG - International grants including funding from foreign universities, INGO - International Non-governmental Organizations, NepG - Nepal Government, NGO- Non-governmental Organizations, TU - Tribhuvan University

Discussion

How has the rate of publication in IAP research in Nepal changed over time?

The trend of IAPS related publications from Nepal differs from global trends of biological invasions related publications and suggests that IAPS in Nepal has only recently become a subject of considerable research interest. Globally, rapid increase in publications related to biological invasions was observable in the 1990s (Lowry et al., 2013), but this was not the case in Nepal until approximately 2010. The global rise of biological invasions publications is attributed to a SCOPE (Scientific Committee on Problems of the Environment) Program on the Ecology of Biological Invasions, which produced a series of publications during the late-1980s and early-1990s (Simberloff, 2011). Similarly, the reported post-2010 increase in IAPS publications in Nepal is concomitant with the timing of a national assessment and publication, reporting 21 IAPS by IUCN Nepal (Tiwari et al., 2005). Other contributing factors might be linked to (1) Nepal National Biodiversity Strategy and Action Plan (MFSC, 2014) and National Wetlands Policy (2003), which identified IAPS as a major threat to biodiversity; (2) increased funding on IAPS research after 2005; and (3) an increase in research activities at national universities such as Tribhuvan University (TU), where research has become a mandatory requirement for graduate students of botany, environmental science, forestry, and agriculture in recent decades. Some of these dissertation research have led to publications (e.g. Timsina et al., 2011; Bhatta et al., 2020), while others have not.

The WOS, as a large international database, was not able to extract the research studies that were published in national journals as *Scientific World* (Ministry of Education, Science and Technology), *Botanica Orientalis* (Tribhuvan University), *Banako Janakari* (Forest Research and Training Center of the Ministry of Forest and Environment), etc. which are published by government agencies and universities in Nepal.

Previous studies have also revealed that the WOS and other big databases are biased in terms of language, national, and subjective matters of data storage (Mongeon and Paul-Hus, 2016) and therefore insufficient to generalize research findings (Yu et al., 2016). Therefore, we note that systematic reviews relying only on data compilation from big international databases could be a significant limitation and may not reflect the state of knowledge generation at the national level, particularly in underdeveloped regions.

Are different regions of Nepal appropriately represented in ecological sampling?

There was a clear geographical bias on IAPS studies, with greater overall research effort in the Siwalik and the Middle Mountain regions of central Nepal. This difference is likely attributable to a higher diversity and abundance of IAPS and general habitat suitability in these regions as compared with the High Mountains and High Himalaya (Shrestha, 2016; Shrestha and Shrestha, 2019). Further, there was an observable effect of proximity to the capital city (Kathmandu), where most researchers and research institutions are concentrated.

We also report a higher number of studies in the Chitwan National Park and Buffer Zone (CNPBZ) areas, in Central Nepal. As most research funding awards for Nepali scientists are small, researchers often strategically choose to focus their efforts on species that are distributed in nearby areas to reduce fieldwork and travel expenses (Wilson et al., 2007). Such geographical biases in biological invasion studies have been reported previously in Nepal (Poudel and Thapa, 2012), and also in other countries, such as Brazil (de Andrade Frehse et al., 2016), as well as globally (Pysek et al., 2008).

These biases in research may have at least two critical management implications at local levels: (1) there is a risk of extrapolating results of a relatively few studies to a broader context by ignoring context-specific phenomena of biological invasions, and (2) bias in research focus could delay study of control methods for some IAPS at early stages of invasion in vulnerable habitats (Bellard and Jeschke, 2016).

Prioritization of future research in eastern and western Nepal will reduce existing geographic biases of IAPS relevant knowledge and provide balanced scientific information for policy and management decisions.

Which research theme, species and habitats are prioritized for IAPS research?

In recent years, research priorities have been expanding from observational and ecological impact studies to topics including distribution mapping (e.g. Shrestha et al., 2019a) and projection of future species' distribution under climate change (e.g. Shrestha and Shrestha, 2019), control of IAPS (e.g. Rai et al., 2012), and socioeconomic effects of IAPS invasions (e.g. Rai and Scarborough, 2013; Shrestha et al., 2019b).

About 95% of the studies were focused on basic research that includes studies reporting distribution, biology, ecology, impacts, etc. with very less prioritization on applied aspects such as reporting of control and management. This is in line with global literature (Esler et al., 2010) whereas it is in contrast to the findings in Mexico (Espinosa-Garcia and Villasenor, 2017). In our view, this wide research gap, due to lack of adequate knowledge generation in management and control, may critically affect the timely preparation of national level IAPS management protocols for Nepal and prompt implementation of the protocols at the local scale.

Mostly studies have prioritized widespread species that pose a substantial threat to biodiversity and agricultural livelihoods (Reid et al., 2005; Pysek et al., 2008) and rarely emphasize co-occurring, but still potentially problematic, invasive species (Kuebbing et al., 2013).

We found that the IAPS research in Nepal was primarily focused on some widespread and economically injurious species, such as mile-a-minute, parthenium weed and crofton weed. Among the three most studied species, mile-a-minute is one of the world's worst invasive species (Lowe et al., 2000). In Nepal, recent national inventories rank mile-a-minute and crofton weed as posing 'high-risk' and 'medium risk', respectively, to native ecosystems (Tiwari et al., 2005). As a species, mile-a-minute has significant negative impacts on wildlife forage by covering and out-competing palatable forage plants in broadleaf ecosystems in Chitwan National Park

(Murphy et al., 2013), whereas crofton weed often colonizes forest edges and shrublands, where it may be ingested by livestock.

Similarly, parthenium weed is rapidly expanding from peri-urban grasslands and roadside verges to agro-ecosystems and natural habitats including protected areas (Shrestha et al., 2015; Shrestha et al., 2019a). Several other invasive species such as lantana (*Lantana camara* L.*),* Siam weed (*Chromolaena odorata* (L.) R. King & H. Rob.), and water hyacinth (*Eichhornia crassipes* (Mart.) Solms), which are globally infamous (Lowe et al., 2000) and high risk posing IAPS in Nepal (Tiwari et al., 2005), are relatively less studied by comparison.

Non-invasive but naturalized species have not been an object of research from the perspective of biological invasions. Forest ecosystems were reported as the most studied habitats in a systematic review of crofton weed and Siam weed using the WOS database (Yu et al., 2016). A similar result in the present analysis may be related to the institutional and policy framework of Nepal that prioritizes forests over other ecosystems (BB Shrestha and BS Poudel, *personal observations*).

More frequent IAPS studies in forests are also linked to the colonization of degraded forests and forest edges with mile-a-minute and crofton weed, the two most heavily researched IAPS in Nepal (Tiwari et al., 2005; Shrestha, 2019).

Although agriculture is also a dominant regional land cover type (Uddin et al., 2015) that is highly vulnerable ecosystem to IAPS infestation (Paini et al., 2016), we did find 37% fewer studies in agroecosystems represented in the literature than in forests. Yet, several IAPS including bluemink (*Ageratum houstonianum* Mill.) and water lettuce (*Pistia stratiotes* L.) are considered by farmers as highly problematic in agroecosystems in Nepal (Shrestha et al., 2019b). These species may also pose serious challenges for cropping systems by having an impact on the herbicide application rates.

Identification of IAPS as an emerging threat to the agriculture sector by Nepal Government (PQPMC, 2019) can help promote IAPS research in the agricultural sector and ensure food security.

Who is studying IAPS of Nepal and who funds this research?

Tribhuvan University (TU) is a major contributor to the existing scientific literature on plant biological invasions in Nepal, partly because graduate students in the biological sciences at TU and affiliated institutions must complete and report on original research to meet degree requirements. Several of these graduate research projects have been conducted without financial supports (e.g. Balami et al., 2019). However, the number of publications from funded-research increased since 2015 (e.g. Shrestha et al., 2019a) while studies conducted by international universities notably increased following 2012, indicating recent collaborative research efforts in this sector.

Although there are various research-based institutions and environmental departments in Nepal, government funding for IAPS research remains low and is erratic in comparison to international funding sources such as international grants. The government generally places low funding priority on the environmental sector, with an estimated allocation of only about 1% of the total annual budget (GoN, 2019). Globally, recent data also show that developing countries tend to spend less on research and innovation (UNESCO, 2020).

However, the large number of self-funded studies from university students (e.g. Balami et al., 2019) suggests that scientists continue to conduct research independently despite limited available government funding. This trend indicates a growing public interest in academics and a grassroots commitment to improving the management of IAPS in Nepal. Nevertheless, gross domestic expenditure on research and development as a percentage of GDP is increasing in Nepal (Katsnelson, 2016), which is promising for the future IAPS research funding needed to cover broad geographic regions, understudied species, and ecosystems, and elucidate the socioeconomic impacts of IAPS in Nepal on public and private stakeholders.

Despite the low national funding for research in universities of Nepal, TU continues to be the largest academic institution publishing IAPS research in Nepal. We excluded graduate theses from our analysis but Poudel and Thapa (2012) reported that graduate theses accounted for 60% of all kinds of biological invasion related literature in Nepal.

We are aware that many M.Sc. graduate theses end up without publication. For example, 32% of 54 M.Sc. graduate theses, supervised by one of the authors (BB Shrestha) between 2003 and 2018 have not yet been published in peer-reviewed journals. It could, at least partly, be attributed to personal lack of motivation, as most of the students after graduation obtain some employment which leads to a lack of motivation to publish. Any incentive from universities, whether monetary reward or certificate of merit, may also encourage graduate students to publish their

theses. Publications of graduate thesis in standard journals, rather than predatory ones, not only showcase the academic excellence of the graduates but also enrich essential knowledge base, such as of IAPS and improve research impacts of universities with the potential of attracting additional funding from various sources.

Conclusions and future directions for IAPS research in Nepal

Our review not only highlights geographic, taxonomic, and habitat biases in IAPS research in Nepal, but also documents a recent increase in research output despite limited available governmental funding. Accordingly, we recommend that future regional IAPS research should be prioritized to under-studied phytogeographic regions, such as eastern and western Nepal.

As most previous studies have focused on only a few species, new research should focus on other widespread but under-studied species such as lantana, water hyacinth, bluemink, and others including invasive and non-invasive naturalized species. Research on IAPS ecology in wetland, grassland, and agroecosystem habitats are also comparatively underrepresented in the literature and studies in these systems could inform new weed management practices. Although protected areas were the context for slightly less than half of the identified field studies, they were mostly confined to the Chitwan National Park and not broadly representative of conservation efforts in Nepal. Future research incorporating additional protected areas is essential to understand the extent and severity of IAPS problems and should be considered in ecosystem management plans of protected areas at the national level.

Some of the key information essential for effective policy and management responses are also missing in the IAPS literature that we reviewed. For example, identifying dispersal mechanisms and pathways (both internationally as well as within-country) and movement vectors is indispensable for the management of invasive alien species (Hulme, 2009) but none of the literature we identified examined these crucial issues. Similarly, economic impacts in terms of direct damage and cost of management have never been quantified in Nepal, although such quantification is available for other countries (e.g. Pimentel et al., 2005; Xu et al., 2006) as well as at regional (e.g. Nghiem et al., 2013) and global scales (Pimentel et al., 2001).

Economic valuation of IAPS-related impacts provides the most compelling justification for policy and management responses and can help to clarify the economic rationality of various management applications. Furthermore, knowledge generated from applied research on the effectiveness of different control strategies for IAPS requires more consistent outreach to agriculturalists and land managers in order to enhance general applicability and integration of effective methods.

Acknowledgements

We would like to acknowledge the assistance provided by Dr. Nimal Chandrasena, the Editor-in-Chief of the 'Weeds' journal. His insights, critical comments and editing of the early drafts of the manuscript are highly appreciated. Authors are also thankful to other anonymous reviewers for their comments and suggestion on the manuscript.

References

Ansong, M. and Pickering, C. (2013). Are weeds hitchhiking a ride on your car? A systematic review of seed dispersal on cars. *PLOS ONE*, 8 (11): 1–11.

Balami, S., Thapa, L. B. and Jha, S. K. (2019). Effects of invasive *Ageratina adenophora* on mycelial growth of some important soil fungi. *Songklanakarin Journal of Science and Technology*, 41 (2): 464–469.

Bellard, C., Cassey, P. and Blackburn, T. M. (2016). Alien species as a driver of recent extinctions. *Biology Letters*, 12 (4).

Bellard, C. and Jeschke, J. M. (2016). A spatial mismatch between invader impacts and research publications. *Conservation Biology,* 30 (1): 230-232.

Bhatta, S., Joshi, L.R. and Shrestha, B.B. (2020). Distribution and impact of invasive alien plant species in Bardia National Park, western Nepal. *Environmental Conservation*, 47 (3): 197-205.

Bhattarai, K. R., Måren, I. E. and Subedi, S. C. (2014). Biodiversity and invasibility: Distribution patterns of invasive plant species in the Himalayas, Nepal. *Journal of Mountain Science*, 11 (3): 688-696.

Blackburn, T. M., Bellard, C. and Ricciardi, A. (2019). Alien versus native species as drivers of recent extinctions. *Frontiers in Ecology and the Environment*, 17 (4): 203-207.

Chaudhary, R. P., Uprety, Y. and Rimal, S. K. (2016). Deforestation in Nepal: Causes, consequences, and responses. In: Shroder, J.F., Sivanpillai, R. (Eds.), Biological and Environmental Hazards, Risks, and Disasters. Elsevier, San Diego, United States. pp. 335–372.

de Andrade Frehse, F., Braga, R. R., Nocera, G. A. and Vitule, J. R. S. (2016). Non-native species and invasion biology in a megadiverse country: scientometric analysis and ecological interactions in Brazil. *Biological Invasions*, 18 (12): 3713-3725.

DFRS. (2011). A Bibliography of the Invasive Alien Species in Nepal. Department of Forest Research and Survey (DFRS), Kathmandu, Nepal. 15 p.

Doherty, T. S., Glen, A. S., Nimmo, D. G., Ritchie, E. G. and Dickman, C. R. (2016). Invasive predators and global biodiversity loss. *Proceedings of the National Academy of Sciences of the USA*, 113(40): 11261-11265.

Ehrenfeld, J. G. (2010). Ecosystem consequences of biological invasions. *Annual Review of Ecology, Evolution, and Systematics*, 41: 59-80.

Esler, K. J., Prozesky, H., Sharma, G. P. and McGeoch, M. (2010). How wide is the "knowing-doing" gap in invasion biology? *Biological Invasions*, 12 (12): 4065-4075.

Espinosa-García, F. J. and Villaseñor, J. L. (2017). Biodiversity, distribution, ecology and management of non-native weeds in Mexico: a review. *Revista Mexicana de Biodiversidad*, 88: 76-96.

GoN. (2019). Budget Speech of Fiscal Year 2019/20. Government of Nepal (GoN), Ministry of Finance, Singha Durbar, Kathmandu (Available at: https://mof.gov.np/uploads/document/file/budget_speech_website_20190619052055.pdf)

Hulme, P. E. (2009). Trade, transport and trouble: Managing invasive species pathways in an era of globalization. *Journal of Applied Ecology*, 46 (1):10–18.

Katsnelson, A. (2016). Big science spenders. *Nature*, 537 (7618), S2-S3.

Kettenring, K. M. and Adams, C. R. (2011). Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. *Journal of Applied Ecology*, 48 (4): 970-979.

Kuebbing, S. E., Nuñez, M. A. and Simberloff, D. (2013). Current mismatch between research and conservation efforts: The need to study co-occurring invasive plant species. *Biological Conservation*, 160: 121–129.

IPBES (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, et al. (Eds.). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) secretariat, Bonn, Germany. 56 p.

Lowe, S., Browne, M., Boudjelas, S. and De Poorter, M. (2000). 100 of the world's worst invasive alien species: a selection from the global invasive species database (Vol. 12). Auckland, New Zealand: Invasive Species Specialist Group. 11 p.

Lowry, E., et al. (2013). Biological invasions: a field synopsis, systematic review, and database of the literature. *Ecology and Evolution*, 3 (1): 182-196.

Maharjan, S., Joshi, S., Shrestha, B. B., Devkota, A. and Jha, P. K. (2014). Life History Traits and Invasion Success of *Parthenium hysterophorus* L. in Kathmandu Valley, Nepal. *Nepal Journal of Science and Technology*, 15 (1): 31-38.

Maharjan, S., Shrestha, B. B., Devkota, A., Muniappan, R. and Jha, P. K. (2019a). Temporal and spatial patterns of research on a globally significant invasive weed *Parthenium hysterophorus* L.: A bibliographic review. *Crop Protection,*135: 104832.

Maharjan, S., et al. (2019b). Predicting suitable habitat of an invasive weed *Parthenium hysterophorus* under future climate scenarios in Chitwan Annapurna Landscape, Nepal. *Journal of Mountain Science*, 16 (10): 2243–2256.

MFSC. (2014). Nepal National Biodiversity Strategy and Action Plan 2014-2020. Ministry of Forest and Soil Conservation (MFSC), Government of Nepal, Kathmandu. 200 p.

Mongeon, P. and Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 106 (1): 213–228.

Murphy, S. T., et al. (2013). Invasive mikania in Chitwan National Park, Nepal: the threat to the greater one-horned rhinoceros *Rhinoceros unicornis* and factors driving the invasion. *Oryx*, 47 (3): 361-368.

Nelson, S. B., et al. (2017). Patterns and mechanisms of invasive plant impacts on North American birds: a systematic review. *Biological Invasions*, 19 (5): 1547–1563.

Nghiem, L. T., et al. (2013). Economic and environmental impacts of harmful non-indigenous species in Southeast Asia. *PLoS ONE*, 8(8): e71255.

Paini, D. R., et al. (2016). Global threat to agriculture from invasive species. *Proceedings of the National Academy of Sciences of the USA*, 113(27): 7575-7579.

Pebesma, E. (2018). Simple Features for R: Standardized Support for Spatial Vector Data. *The R Journal*, 10 (1): 439–446.

Pimentel, D., et al. (2001). Economic and environmental threats of alien plant, animal, and microbe invasions. *Agriculture, Ecosystems and Environment,* 84 (1): 1-20.

Pimentel, D., Zuniga, R. and 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.

Poudel, B. S. and Thapa, H. B. (2012). An assessment of existing studies on invasive alien plant species of Nepal. *Banko Janakari*, 22 (1): 28-36.

PQPMC. (2019). Invasive Alien Species: An emerging threat to agriculture and biodiversity in Nepal. Plant Quarantine and Pesticide Management Center (PQPMC), Ministry of Agriculture and Livestock Development, Nepal. 52 p.

Pullin, A. S. and Stewart, G. B. (2006). Guidelines for systematic review in conservation and environmental management. *Conservation Biology*, 20 (6): 1647–1656.

Pysek, P., et al. (2008). Geographical and taxonomic biases in invasion ecology. *Trends in Ecology and Evolution*, 23 (5): 237-244.

Rai, R. K., Sandilya, M. and Subedi, R. (2012). Controlling *Mikania micrantha* HBK: How effective manual cutting is? *Journal of Ecology and Environment*, 35 (3): 235-242.

Rai, R. K. and Scarborough, H. (2013). Economic value of mitigation of plant invaders in a subsistence economy: incorporating labour as a mode of payment. *Environment and Development Economics*, 18 (2): 225-244.

Reid, W. V., et al. (2005). Ecosystems and human well-being-Synthesis: A report of the Millennium Ecosystem Assessment. Island Press, Washington, DC. 137 p.

Shrestha, B. B., Shabbir, A. and Adkins, S. W. (2015). *Parthenium hysterophorus* in Nepal: A review of its weed status and possibilities for management. *Weed Research*, 55(2):132–144.

Shrestha, B. B. (2016). Invasive Alien Plant Species in Nepal. In: P.K. Jha, M. Siwakoti and S. Rajbhandary (Eds.), Frontiers of Botany. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal. pp. 269–284.

Shrestha, B. B. (2019). Management of invasive alien plant species in Nepal: current practices and future prospects. In: S.C. Garkoti, S. van Bloem, P.Z. Fule and R.L. Semwal (Eds.), *Tropical Ecosystems: Structure, Functions and Global Change*. Springer Nature Singapore. pp. 45-68.

Shrestha, B. B., et al. (2019a). Distribution of *Parthenium hysterophorus* and one of its biological control agents (Coleoptera: *Zygogramma bicolorata*) in Nepal. *Weed Research*, 59 (6): 467-478.

Shrestha, B. B., et al. (2019b). Community perception and prioritization of invasive alien plants in Chitwan-Annapurna Landscape, Nepal. *Journal of Environmental Management*, 229: 38–47.

Shrestha, B. B., Thapa-Magar, K. B., Paudel, A., & Shrestha, U. B. (2011). Beetle on the battle: Defoliation of *Parthenium hysterophorus* by *Zygogramma bicolorata* in Kathmandu valley, Nepal. *Botanica Orientalis: Journal of Plant Science*, 8: 100-104.

Shrestha, U. B. and Shrestha, B. B. (2019). Climate change amplifies plant invasion hotspots in Nepal. *Diversity and Distributions*, 25(10): 1599–1612.

Simberloff, D. (2011). Charles Elton: neither founder nor siren, but prophet. In: D.M. Richardson (Eds.), Fifty years of invasion ecology: The Legacy of Charles Elton, Wiley-Blackwell Publications, UK. pp. 11-24.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. and Sridith, K. (2020). "Soaked in rainwater" effect of *Ageratina adenophora* on seedling growth and development of native tree species in Nepal. *Flora: Morphology, Distribution, Functional Ecology of Plants*, 263: 151554.

Thomaz, S. M., Kovalenko, K. E., Havel, J. E. and Kats, L. B. (2014). Aquatic invasive species: general trends in the literature and introduction to the special issue. *Hydrobiologia*, 746 (1): 1–12.

Timsina, B., Shrestha, B. B., Rokaya, M. B. and Münzbergová, Z. (2011). Impact of *Parthenium hysterophorus* L. invasion on plant species composition and soil properties of grassland communities in Nepal. *Flora-Morphology, Distribution, Functional Ecology of Plants*, 206 (3): 233-240.

Tiwari, S., Siwakoti, M., Adhakari, B. and Subedi, K. (2005). An inventory and assessment of invasive alien plant species of Nepal. IUCN Nepal. 115 p.

Uddin, K., et al. (2015). Development of 2010 national land cover database for Nepal. *Journal of Environmental Management*, 148: 82-90.

UNESCO. (2020, May 9). How much does your country invest in R&D? (Retrieved from http://uis.unesco.org/apps/visualisations/research-and-development-spending/)

USGS. (2000). Nepal Digital Model Elevation (DEM). US Geological Survey.

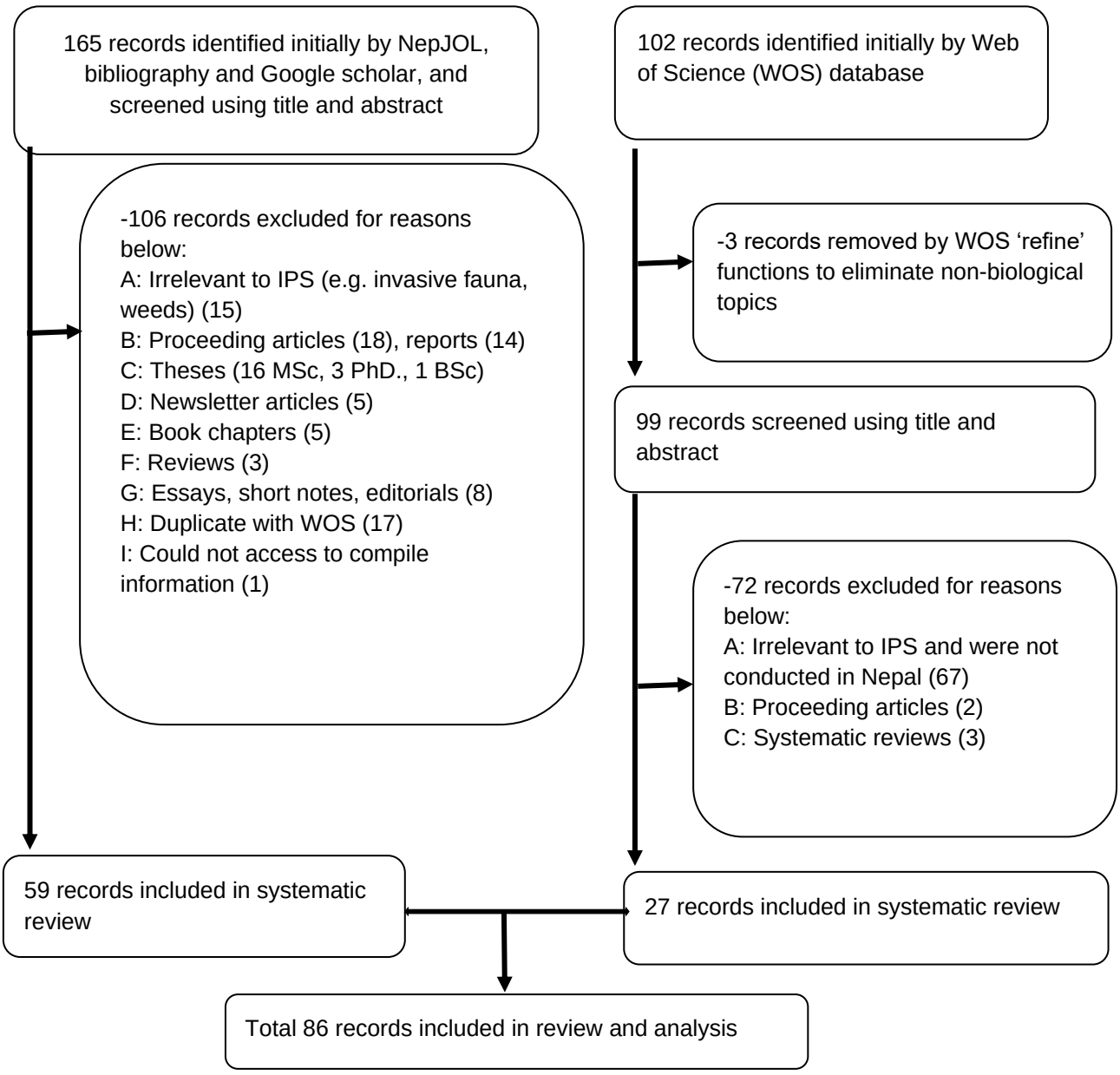
Vilà, M. and Hulme, P. E. (Eds.). (2017).*Impact of biological invasions on ecosystem services* (Vol. 12). Cham: Springer. 354 p.

Wilson, J. R., Procheş, Ş., Braschler, B., Dixon, E. S. and Richardson, D. M. (2007). The (bio) diversity of science reflects the interests of society. *Frontiers in Ecology and the Environment*, 5 (8): 409-414.

Xu, H., et al. (2006). The distribution and economic losses of alien species invasion to China. *Biological Invasions*, 8(7): 1495-1500.

Yu, F., Akin-Fajiye, M., Thapa Magar, K., Ren, J. and Gurevitch, J. (2016). A global systematic review of ecological field studies on two major invasive plant species, *Ageratina adenophora* and *Chromolaena odorata*. *Diversity and Distributions*, 22 (11): 1174–1185.

Supplement 1. Diagram showing article filtering process



Supplement 2. Selected publication attributes with categories and description

Attributes	Categories	Description
Authors institution	1) First author 2) Corresponding author	Corresponding author over the first author for analysis in case they differed from each other
Types of databases	1) WOS 2) Other sources	Other sources (e.g. Google scholar, NepJOL, bibliography published by DFRS 2011).
Research Theme	1) Diversity and Distribution 2) Biology and Ecology 3) Socioeconomic Aspect 4) Ecological Impact 5) Management and Control	1) Studies on species diversity, distribution, abundance, modelling, reviews 2) Studies on trait characteristics (morphological, anatomical, biological, and chemical features; adaptation for environmental gradients); phytochemical screening 3) Perception of local people, impact on local economy and livelihood 4) Studies related to impact on biology and ecology of other species - species distribution, regeneration, occurrence; habitat alteration due to invasion; allelopathy; effect on ecosystem and habitat attributes 5) Studies on management aspects; policy and institutions
Research types	1) Observational 2) Experimental	1) Studies that do not have control over the factors and distribution modelling studies are considered as observational. 3) Studies that have been done by controlling the environmental factors with the experimental design is considered as experimental studies.
Funding resources for research	1) Nepal government 2) Non-Governmental Organizations 3) International Non-Governmental Organizations 4) International Grants 5) Multiple funding sources	1) Organizations/Departments governed by Nepal government. 2) Non-profit citizen-based national organizations registered in Nepal. 3) International non-profit organizations 4) International charitable trusts, governments, and foreign universities. 5) Studies with more than one funding sources
Contributing institution	1) Nepal government 2) Tribhuvan University 3)Non-Governmental Organizations 4) International Non-Governmental Organizations 5) Foreign University 6) Others	2) Tribhuvan University and its constituent institutions. 5) Universities outside Nepal 6) Any organizations/institutions other than mentioned above
Study locations	1) Protected areas 2) Outside protected areas	1) Buffer zone and core areas of national park, wildlife reserve, conservation area; Ramsar sites; protected forests; world heritage sites 2) All other areas other than protected areas

Supplement 3. List of publications selected for inclusion in analysis

Balami, S. and Thapa, L. B. (2017). Herbivory damage in native *Alnus nepalensis* and invasive *Ageratina adenophora*. *Botanica Orientalis: Journal of Plant Science*, 11:7–11.

Balami, S., Thapa, L. B. and Jha, S. K. (2017). Effect of invasive *Ageratina adenophora* on species richness and composition of saprotrophic and pathogenic soil fungi. *BIOTROPIA-The Southeast Asian Journal of Tropical Biology*, 24(3):212-219.

Balami, S., Thapa, L. B. and Jha, S. K. (2019). Effects of invasive *Ageratina adenophora* on mycelial growth of some important soil fungi. *Songklanakarin Journal of Science and Technology*, 41(2):464–469.

Banerji, M. L. (1958). Invasion of *Eupatorium glandulosum* HB & K. in East Nepal. *Bulletin of Botanical Society*, 10(1/2): 14-18.

Baral, B. and Maharjan, B. L. (2011). Antagonistic characteristics and phytochemical screening of invasive alien species of Nepal Himalaya. *International Journal of Pharmaceutical & Biological Archives*, 2(5): 1444–1450.

Baral, B. and Vaidya, G. S. (2011). Biological and chemical assessment of water hyacinth (*Eichhornia crassipes* (mart.) Solms.) of Phewa Lake, Nepal. *Scientific World*, 9(9):57-62.

Baral, B., Bhattarai, N. and Vaidya, G. S. (2011). Pharmacological and Antagonistic Potentials of *Mikania micrantha*. *Nepal Journal of Science and Technology*, 12:75–84.

Baral, B., Vaidya, G. S. and Bhattarai, N. (2011). Bioactivity and biochemical analysis of water hyacinth (*Eichhornia crassipes*). *Botanica Orientalis: Journal of Plant Science*, 8:33–39.

Baral, S., et al. (2017). Invasion of alien plant species and their impact on different ecosystems of Panchase Area, Nepal. *Banko Janakari*, 27(1):31–42.

Basnet, S., Chand, D. B., Wagle, B. H. and Rayamajhi, B. (2016). Plant diversity and stand structure comparison of *Mikania micrantha* invaded and non-invaded tropical *Shorea robusta* forest. *Banko Janakari*, 26(1):78-81.

Bhargava, D., Mondal, C. K., Shivapuri, J. N., Mondal, S. and Kar, S. (2013). Antioxidant properties of the leaves of *Chromolaena odorata* Linn. *Journal of Institute of Medicine*, 35(1):53-57.

Bhatta, S., Joshi, L. R. and Shrestha, B. B. (2020). Distribution and impact of invasive alien plant species in Bardia National Park, western Nepal. *Environmental Conservation*, 47(3):197-205.

Bhattarai, K. R., Måren, I. E. and Subedi, S. C. (2014). Biodiversity and invasibility: Distribution patterns of invasive plant species in the Himalayas, Nepal. *Journal of Mountain Science*, 11(3):688–696.

Bhattarai, N. and Shrestha, G. (2009). Antibacterial and Antifungal Effect of *Eupatorium adenophorum* Spreng against Bacterial and Fungal Isolates. *Nepal Journal of Science and Technology*, 10:91–95.

Chaudhary, R., Shrestha, B. B., Thapa, H. and Siwakoti, M. (2020). Status and impacts of invasive alien plant species in Parsa National Park, central Nepal. *Banko Janakari*, 30(1):21-31.

Dai, J., et al. (2020). Mapping understory invasive plant species with field and remotely sensed data in Chitwan, Nepal. *Remote Sensing of Environment*, 250:1-12.

Devkota, A. and Sahu, A. (2018). Antimicrobial activities and phytochemical screening of leaf extract of Mikania micrantha H.B.K. *Journal of Natural History Museum*, 30:274–286.

Dhakal, S., Shrestha, B. B. and Siwakoti, M. (2018). Comparisons of Invasive Alien Plant Species Richness between Tarai and Siwalik Regions of Central Nepal. *Journal of Plant Resources*, 16(1):119–123.

Dyola, N., et al. (2020). Growth pattern of *Pinus roxburghii* under different regimes of invasive species in Panchase, Nepal Himalayas. *Pakistan Journal of Botany*, 52(1):261-270.

Everard, M., et al. (2018). Can control of invasive vegetation improve water and rural livelihood security in Nepal? *Ecosystem Services*, 32:125–133.

Gaudel, G., Hui, Z. W., Hung, D. Q. and Hien, L. T. (2016). Assessment of Invasive Alien Plant Species : Impact on Carbon Sequestration. *Imperial Journal of Interdisciplinary Research,* 2(10):51-65.

Gautam, D. and Pathak, A. (2020). Status and Impact of Invasive Alien Plant Species in Jyamire Bufferzone Community Forest of Parsa National Park, Nepal. *International Journal of Forestry and Horticulture*, 6(1):2454–9487.

Gurung, H. B., Shrestha, N. P., Chemjong, P. B., Neopnae, S. P. and Aryal, I. K. (1996). Effect of feeding banmara (*Eupatorium adenophorum*) [*Eupatorium trapezoideumon*] on the reproductive performance of goats in the eastern hills of Nepal. *Veterinary Review (Kathmandu)*, 11(2):48-50.

Joshi, C., van Andel, J., Skidmore, A., De Leeuw, J. and Duren, I. V. (2011). Morphological plasticity of corms in enhancing invasion of *Chromolaena odorata*. *Banko Janakari*, 21(2):3–12.

Joshi, C., et al. (2006). Indirect remote sensing of a cryptic forest understorey invasive species. *Forest Ecology and Management*, 225(1–3):245–256.

Sharma, K. C. and GK, K. C. (1977). Reports on studies on the biological control of *Eupatorium adenophorum* [by the gallfly *Ecidochares utilis*, in Nepal]. *Nepalese Journal of Agriculture*, 12:135-58.

K.C., U. and Shrestha, B. (2019). Invasion of *Parthenium hysterophorus L .* across land use types in Kirtipur Municipality. *International Journal of Human Capitals on Urban Management*, 4(4):259–268.

Kafle, M. R., Kafle, G., Balla, M. K. and Dhakal, L. (2009). Results of an Experiment of Preparing Compost from Invasive Water hyacinth (*Eichhornia crassipes*) in Rupa Lake Area, Nepal. *Journal of Wetlands Ecology*, *2*:17–19.

Khadka, A. (2017). Assessment of the perceived effects and management challenges of *Mikania micrantha* invasion in Chitwan National Park buffer zone community forest, Nepal. *Heliyon*, 3(4):1-14.

Khanal, D. P., Raut, B. and Dangol, K. S. (2015). Phytochemical Screening, Pharmacognostic Evaluation and Biological Activity of *Amaranthus spinosus* L. *Journal of Manmohan Memorial Institute of Health Sciences*, 1(4):29–34.

Khaniya, L. and Shrestha, B. B. (2020). Forest regrowth reduces richness and abundance of invasive alien plant species in community managed *Shorea robusta* forests of central Nepal. *Journal of Ecology and Environment*, 44(1):1-8.

Lamsal, A., Devkota, M. P., Shrestha, D. S., Joshi, S. and Shrestha, A. (2019). Seed germination ecology of *Ageratum houstonianum*: A major invasive weed in Nepal. *PLoS ONE*, 14(11):1–14.

Maharjan, R. B. S. and Ming, C. L. (2012). The Potential Role of Water Hyacinth in Wastewater Treatment in Nepal. *Hydro Nepal: Journal of Water, Energy and Environment*, 10(10):36–41.

Maharjan, S., Joshi, S., Shrestha, B. B., Devkota, A. and Jha, P. K. (2014). Life History Traits and Invasion Success of *Parthenium hysterophorus* L. in Kathmandu Valley, Nepal. *Nepal Journal of Science and Technology*, 15 (1):31–38.

Maharjan, S., Shrestha, B. B. and Jha, P. K. (2007). Allelopathic Effects of Aqueous Extract of Leaves of *Parthenium Hysterophorus* L. on Seed Germination and Seedling Growth of Some Cultivated and Wild Herbaceous Species. *Scientific World*, 5 (5):33–39.

Maharjan, S., et al. (2019). Predicting suitable habitat of an invasive weed *Parthenium hysterophorus* under future climate scenarios in Chitwan Annapurna Landscape, Nepal. *Journal of Mountain Science*, 16(10):2243–2256.

Maharjan, S., Shrestha, B.B., Devkota, A., Muniappan, R. and Jha P.K. (2020). Seed biology of summer and winter generations of *Parthenium hysterophorus* L. *Journal of Environment Science*, 6:112-118.

Mishra, K. K. (1991). Parthenium hysterophorus LINN.-a new record for Nepal. *Journal of the Bombay Natural History Society*,88 (3):466-467.

Murphy, S. T., et al. (2013). Invasive mikania in Chitwan National Park, Nepal: The threat to the greater one-horned rhinoceros *Rhinoceros unicornis* and factors driving the invasion. *Oryx*, 47(3):361–368.

Niroula, B. (2012). Phenology, biomass, and associated species of alligator weed at Biratnagar, Nepal. *Nepalese Journal of Biosciences*, 2:148–150.

Niroula, B., Parajuli, D. and Jha, S. (2009). Ecophysiology of *Mimosa pudica* L. at Biratnagar, Eastern Nepal. *Our Nature*, 7 (1):177–181.

Pandit, N. R., et al. (2018). Biochar improves maize growth by alleviation of nutrient stress in a moderately acidic low-input Nepalese soil. *Science of the Total Environment*, 625:1380–1389.

Pandit, N. R., Mulder, J., Hale, S. E., Schmidt, H. P. and Cornelissen, G. (2017). Biochar from “Kon Tiki” flame curtain and other kilns: Effects of nutrient enrichment and kiln type on crop yield and soil chemistry. *PLoS ONE*, 12 (4):1–18.

Paudel, V. R. and Gupta, V. N. P. (2008). Effect of some Essential Oils on Seed Germination and Seedling Length of *Parthenium hysterophorus* L. *Ecoprint: An International Journal of Ecology*, 15:69–73.

Paudel, V., Gupta, V. and Agarwal, V. (2009). Effect of Diffusates of *Parthenium hysterophorus* on Seed Germination of *Raphanus sativus* L. *Scientific World*, 7(7):29–32.

Rai, R. K. and Rai, R. (2013). Assessing the Temporal Variation in the Perceived Effects of Invasive Plant Species on Rural Livelihoods: A Case of *Mikania micrantha* Invasion in Nepal. *Conservation Science*, 1(1):13–18.

Rai, R. K. and Scarborough, H. (2013). Economic value of mitigation of plant invaders in a subsistence economy: Incorporating labour as a mode of payment. *Environment and Development Economics*, 18(2):225–244.

Rai, R. K. and Scarborough, H. (2015). Understanding the Effects of the Invasive Plants on Rural Forest-dependent Communities. *Small-Scale Forestry*, 14(1):59–72.

Rai, R. K., Sandilya, M. and Subedi, R. (2012). Controlling *Mikania micrantha* HBK: How effective manual cutting is? *Journal of Ecology and Field Biology*, 35(3):235–242.

Rai, R. K., Scarborough, H., Subedi, N. and Lamichhane, B. (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.

Rokaya, M. B., Khatri-Chettri, J., Ghimire, S. R. and Shrestha, B. B. (2020). Vegetation and soil seedbank dynamics in *Parthenium hysterophorus* L. invaded subtropical grassland in Nepal. *Tropical Ecology*, 61(2):238-247.

Rymer, C. (2008). The effect of wilting and soaking *Eupatorium adenophorum* on its digestibility in vitro and voluntary intake by goats. *Animal feed science and technology*, 141(1-2):49-60.

Sahu, A. and Devkota, A. (2013). Allelopathic Effects of Aqueous Extract of Leaves of *Mikania Micrantha* H.B.K. on Seed Germination and Seedling Growth of *Oryza Sativa* L. and *Raphanus Sativus* L. *Scientific World*, 11(11):91–93.

Sahu, A. and Devkota, A. (2016). Antimicrobial Activity of Leaf Extracts of Some Invasive Alien Plant Species of Aster Family against Clinical Bacteria. *Ecoprint: An International Journal of Ecology*, 23:1–12.

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

Schmidt, H., et al. (2015). Fourfold Increase in Pumpkin Yield in Response to Low-Dosage Root Zone Application of Urine-Enhanced Biochar to a Fertile Tropical Soil. *Agriculture*, 5(3):723–741.

Sharma, K. R. (2020). In-vitro antioxidant, antidiabetic, and toxic effect of *Ageratum houstonianum* from Chitwan district Nepal. *Journal of Balkumari College*, 9(1):48-54.

Sharma, L. N., Adhikari, B., Bist, M. R. and Shrestha, B. B. *Mimosa diplotricha* (Fabaceae): A New Report of Invasive Weed from Eastern Tarai of Nepal. *Journal of Plant Resources*, 18(1): 1-5.

Sharma, M. and Devkota, A. (2018). Allelopathic Influences of *Artemisia dubia* Wall. Ex. Besser on Seed Germination and Seedling Vigor of *Parthenium hysterophorus* L. *Journal of Institute of Science and Technology*, 22 (2):117–128.

Sharma Poudel, A., Shrestha, B. B., Jha, P. K., Baniya, C. B. and Muniappan, R. (2020). Stem galling of *Ageratina adenophora* (Asterales: Asteraceae) by a biocontrol agent *Procecidochares utilis* (Diptera: Tephritidae) is elevation dependent in central Nepal. *Biocontrol Science and Technology*, 30 (7):611-627.

Shrestha, B. B., et al. (2019). Distribution of *Parthenium hysterophorus* and one of its biological control agents (Coleoptera: *Zygogramma bicolorata*) in Nepal. *Weed Research*, 59(6):467–478.

Shrestha, B. B., et al. (2010). Fortuitous biological control of *Parthenium hysterophorus* by *Zygogramma bicolorata* in Nepal. *Journal of Natural History Museum*, 25:332-337.

Shrestha, B. B., et al. (2019). Community perception and prioritization of invasive alien plants in Chitwan-Annapurna Landscape, Nepal. *Journal of Environmental Management*, 229:38–47.

Shrestha, B. B., Thapa-Magar, K. B., Paudel, A. and Shrestha, U. B. (2011). Beetle on the battle: Defoliation of *Parthenium hysterophorus* by *Zygogramma bicolorata* in Kathmandu valley, Nepal. *Botanica Orientalis: Journal of Plant Science*, 8:100–104.

Shrestha, B. K. and Dangol, D. R. (2014). Impact of *Mikania micrantha* H.B.K. Invasion on Diversity and Abundance of Plant Species of Chitwan National Park, Nepal. *Journal of Institute of Science and Technology*, 19(2):30–36.

Shrestha, K., Wilson, E. and Gay, H. (2008). Ecological and Environmental Study of *Eupatorium adenophorum* Sprengel (Banmara) with Reference to its Gall Formation in Gorkha-Langtang Route, Nepal. *Journal of Natural History Museum*, 23:108–124.

Shrestha, S. (2019). Distribution, effect, and utilization of Mikania micrantha on livelihood: Case study of Janakauli buffer zone community forest of Chitwan National Park. *Journal of Agriculture and Natural Resources*, 2(1):95–108.

Shrestha, U. B. and Shrestha, B. B. (2019). Climate change amplifies plant invasion hotspots in Nepal. *Diversity and Distributions*, 25(10):1599–1612.

Shrestha, U. B., Sharma, K. P., Devkota, A., Siwakoti, M. and Shrestha, B. B. (2018). Potential impact of climate change on the distribution of six invasive alien plants in Nepal. *Ecological Indicators*, 95:99–107.

Singh, A. G. and Sharma, A. (2014). Documentation of Invasive Alien Plants Species of Rupandehi District, Western Nepal. *International Journal of Applied Sciences and Biotechnology*, 2(2):168–175.

Singh, R. M. and Poudel, M. S. (2013). Briquette Fuel - An Option for Management of *Mikania micrantha*. *Nepal Journal of Science and Technology*, 14(1):109–114.

Siwakoti, M. (2007). Mikania Weed: A Challenge for Conservationists. *Our Nature*, 5(1):70–74.

Subba, B. and Kandel, R. C. (2012). Chemical Composition and Bioactivity of Essential Oil of *Ageratina adenophora* from Bhaktapur District of Nepal. *Journal of Nepal Chemical Society*, 30:78–86.

Sullivan, A., An, L. and York, A. (2018). Which perspective of institutional change best fits empirical data? An agent-based model comparison of rational choice and cultural diffusion in invasive plant management. *Journal of Artificial Societies and Social Simulation*, 21(1).

Sullivan, A., York, A. M., An, L., Yabiku, S. T. and Hall, S. J. (2017). How does perception at multiple levels influence collective action in the commons? The case of *Mikania micrantha* in Chitwan, Nepal. *Forest Policy and Economics*, 80:1–10.

Sullivan, A., York, A. M., White, D. D., Hall, S. J. and Yabiku, S. T. (2017). De jure versus de facto institutions: Trust, information, and collective efforts to manage the invasive mile-a-minute weed (*Mikania micrantha*). *International Journal of the Commons*, 11(1):171–199.

Suwal, M. M., Devkota, A. and Lekhak, H. (2010). Allelopathic Effects of *Chromolaena odorata* (L.) King & Robinson on Seed Germination and Seedlings Growth of Paddy and Barnyard Grass. *Scientific World*, 8 (8):73–75.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. T. and Sridith, K. (2016). Plant communities and *Ageratina adenophora* invasion in lower montane vegetation, central Nepal. *International Journal of Ecology and Development*, 31 (2):35-49.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. and Sridith, K. (2016). Plant invasiveness and target plant density: high densities of native *Schima wallichii* seedlings reduce negative effects of invasive Ageratina adenophora. *Weed Research*, 57(2):72–80.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. and Sridith, K. (2016). Impacts of invasive *Chromolaena odorata* on species richness, composition, and seedling recruitment of *Shorea robusta* in a tropical sal forest, Nepal. *Songklanakarin Journal of Science and Technology*, 38(6):683–689.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. and Sridith, K. (2020). “Soaked in rainwater” effect of Ageratina adenophora on seedling growth and development of native tree species in Nepal. *Flora: Morphology, Distribution, Functional Ecology of Plants*, 263-151554.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. and Sridith, K. (2020). Airborne and belowground phytotoxicity of invasive *Ageratina adenophora* on native species in Nepal. *Plant Ecology*, 221:883-892.

Thapa, S., Chitale, V., Rijal, S. J., Bisht, N. and Shrestha, B. B. (2018). Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya. *PLoS ONE*, 13(4):1–16.

Timsina, B., Shrestha, B. B., Rokaya, M. B. and Münzbergová, Z. (2011). Impact of *Parthenium hysterophorus* L. invasion on plant species composition and soil properties of grassland communities in Nepal. *Flora: Morphology, Distribution, Functional Ecology of Plants*, 206 (3):233–240.

Vaidya, G. S. and Bhattarai, N. (2009). Antagonistic study of *Lantana camara* (Linn) against with pathogenic bacteria. *Scientific world*, 7 (7):64-67.

Vaidya, G. S. and Bhattarai, N. (2014). Efficacy of invasive green manures and mycorrhiza on growth and yield of different legumes crops and study their antimicrobial properties. *Scientific World*,12 (12):65-69.