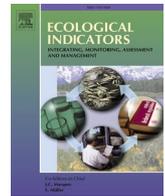




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Review

Ecosystem services research trends in the water tower of Asia: A bibliometric analysis from the Hindu Kush Himalaya

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ABSTRACT

The study presents the first comprehensive overview of ecosystem services (ES) research from the Hindu Kush Himalaya (HKH), a region often referred to as the 'water tower of Asia'. Through a systematic literature search, we consolidated 439 peer-reviewed journal articles related to ecosystem services in the HKH. A bibliometric analysis was carried out to examine the temporal trend, geographical distribution, journal coverage, keywords used, authorship patterns, and collaboration networks in ES research on the region. The results showed an increasing trend in the publication of ecosystem services research on the HKH, with nearly 62 per cent of the journal articles being published in just the last five years. Most of the research has been carried out in China, followed by Nepal and India. Among the 166 scholarly journals publishing ecosystem services research on the HKH, *Ecosystem Services* and *Sustainability* are the most-used, followed by *Science of the Total Environment*. The keywords analysis identified a total of 1,460 keywords used in the articles on ES. Among them, 'ecosystem services' is the most commonly used, followed by 'China', 'Nepal', 'conservation', and 'biodiversity.' The authorship analysis revealed that of the total of 1,386 authors, 1,000 co-authored ES publications. The top publishing authors are from the region; however, they are either affiliated with an international organization or based in developed countries. Research institutions from 56 countries have networked to conduct collaborative ES research in the HKH, so far. Although China has the highest number of publications, Nepal was identified as a principal collaborator with the widest country network. The existing research focuses on biophysical elements of ecosystem services, with very few published studies covering its social and political aspects and the management of ecosystem services. As the HKH is a contiguous ecosystem shared by eight countries, there is a need for regional analyses of ecosystem services. Our study concludes that ecosystem services being a multidisciplinary concept, research into it requires regional collaboration between multiple actors from varied disciplines, with a greater emphasis on social and political science, together with the biophysical sciences, for a more holistic understanding. Furthermore, it is important that ES research include the local context and issues to avoid the dominance of international perspectives and the marginalization of local concerns.

1. Introduction

Ecosystem services (ES) is now a well-defined and established field of science, and is an important part of the global discourse on environmental management (Chaudhary et al., 2015; Costanza and Kubiszewski, 2012; Wood et al., 2018). The concept 'ecosystem services' gained momentum after the comprehensive assessment of global ecosystems through the Millennium Ecosystem Assessment (MEA, 2005). Later, in 2010, ES became an important indicator for measuring human well-being (Kumar, 2010), and was included in the Convention on

Biological Diversity (CBD) as part of the Aichi Targets (CBD, 2010). Subsequently, the concept gained global recognition through the establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and inclusion in the Sustainable Development Goals (SDGs) (Chaudhary et al., 2015; Kull et al., 2015; Wood et al., 2018). The rationale for this development was the strong interdependence between human well-being and the health of ecosystems (Daily, 1997; Díaz et al., 2018; IPBES, 2019; Pascual et al., 2017).

There is a growing appreciation of the value of ecosystem services

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due to the fact that global economic prosperity and well-being are underpinned by them (Kumar, 2010). An increasing number of studies addressed the functioning, assessment, and management of ES at regional and global levels (Aznar-Sánchez et al., 2018; Chaudhary et al., 2015; Pauna et al., 2018). Efforts are continuously being made to integrate the concept into everyday planning, policies, and decision-making processes (Fisher and Brown, 2014; Wood et al., 2018). However, the deteriorating condition of ecosystems along with an alarming loss of biodiversity at a global scale is putting human well-being at risk due to decline in ES (IPBES, 2019; Kubiszewski et al., 2017). This is particularly important for mountain ecosystems, which are key sources of a wide range of ecosystem services (Grêt-Regamey et al., 2012; Schirpke et al., 2019; Walz et al., 2016) and are already fragile and highly susceptible to various drivers of change, including climate change (Egan and Price, 2017; Moos et al., 2018; Sharma et al., 2019).

One such ecosystem is the Hindu Kush Himalaya (HKH), a unique mountain ecosystem and the highest in the world, which extends over 3,500 km from east to west and covers an area of 4.3 million sq. km. Often referred to as ‘the Third Pole’ and ‘the water tower of Asia’, the HKH is a storehouse of biodiversity and ecosystem services (Chettri et al., 2008; Sharma et al., 2010; Xu et al., 2019). The ecosystem services that are provided by the HKH in terms of agricultural diversity, water, and nutrients to vast arable lands in downstream basins such as the Indus, Ganges, Brahmaputra, and others, are extremely important for food and energy security, and economic development in the region (Aryal et al., 2018; Chaudhary et al., 2016; Kandel et al., 2018; Karki et al., 2018; Sharma et al., 2015; Upreti et al., 2016). For instance, ecosystems here support 240 million people living in the upland and lowland areas of the HKH. Around 1.9 billion people reside in the 10 major river basins of this vast region, and around 3 billion people – or little less than half of humanity – depend on the food produced in these river basins (Molden et al., 2016; Sharma et al., 2019). However, even as it is a rich source of ecosystem services for more than one-third of the world’s humanity, the HKH faces multiple challenges, including land use and land cover change, climate change, and infestation by invasive species, leading to species loss and ecosystem degradation, all of which is adversely impacting its fragile ecosystems and people (Chettri and Sharma, 2016; Sharma et al., 2019; Xu et al., 2019).

In order to protect the rich biodiversity and ES of the HKH through informed policy-making, the primary step would be to understand the knowledge base of ES here. Although many scholars from the region have studied ES in the HKH (for example, Chaudhary et al., 2016; Kandel et al., 2018; Karki et al., 2018; Paudyal et al., 2015) and there is an increasing trend of collaborative research through a network of scholars from within and outside the HKH (Adhikari et al., 2018; Baral et al., 2017; Dorji et al., 2018; Sears et al., 2018), the existing knowledge is still limited and its generation sporadic. As a result, investments to protect the biodiversity and ES of the region are limited and skewed towards certain countries and ecosystems.

A holistic, landscape-level understanding of the state-of-the-art regarding ES studies in the HKH would help in identifying emerging themes and gaps and in providing directions for future ES research projects and investments in the HKH. This study aims to fill the knowledge gaps by consolidating the existing literature on ES from the HKH and examining regional trends, spatial distribution, authorship analysis, and scholarly networks through a bibliometric analysis. Bibliometric analysis has been evolving as a robust method to evaluate both spatial and temporal research trends and scholarly networks in different research disciplines, including ES (for example, McDonough, et al., 2017; Pauna et al., 2018; Suominen et al., 2018). However, so far, most of the analysis of the research on ES has been confined to western or developed countries with very limited focus on the HKH region (Chaudhary et al., 2015; Zhang et al., 2019). To the best of our knowledge, this is the first bibliometric analysis that provides a comprehensive overview of ES research in the HKH. The study would help to understand the status of ES research, identify the research priorities, and provide a

strong rationale for mainstreaming ES in policy and practice in the region.

2. Methods

2.1. Designing the review

This review was inspired by the fact that mountain ecosystems are an important source of ES, globally recognized as nature’s contribution to people living in the mountains as well as downstream (Díaz et al., 2018; Locatelli et al., 2017; Mengist et al., 2020; Schirpke et al., 2019). However, the contribution of mountain ecosystems to ES is not adequately understood, documented, and recognised within the global discourse on ES (Egan and Price, 2017; Martín-López et al., 2019). Considering the vast area to be covered, its diverse ecosystems, and the varying research priorities in countries of the HKH, three broad research questions to guide the analysis were developed.

- (i) What are the temporal and spatial trends in ES research in the HKH?
- (ii) Which priority aspects of ES has the research focused on and what are the gaps?
- (iii) How the research trend in the HKH compared to the global discourses and where are the gaps?

These questions were then answered through the following three steps: designing the study, collating the research articles on ES, and analysing them. (Fig. 1).

Based on these objectives, we identified the parameters to be considered in the search. As the objective was to look for spatial and temporal trends in the research on ES in the HKH along with priority areas and enabling conditions and gaps, we opted to have a database of references with defined search terms, including details regarding the year of publication, name of the journal, study area, keywords used, the number of authors, and their affiliations and collaborations. After following the above search criteria, a bibliometric analysis of the scientific literature on ES was carried out.

2.2. Data collection and management

The data collection was carried out through Scopus, an online search database commonly used for bibliometric analysis. One could use other databases based on the study’s objectives (Aznar-Sánchez et al., 2019), but we opted for Scopus as it is considered to be the largest database of peer-reviewed literature, containing more indexed journals than Web of Science (Mongeon and Paul-Hus, 2016). Also, the subject ES in particular is represented more comprehensively in Scopus than in other databases such as Web of Science and CAB Abstracts (McDonough et al., 2017). Furthermore, Scopus has smart features to help track, analyse, and visualise research, which makes it a useful tool for literature review work (Scopus, 2019).

In Scopus, we first used the search terms ‘ecosystem services’, ‘ecological services’, or ‘environmental services’ along with ‘Hindu Kush Himalaya’. However, this search retrieved only four articles. Therefore the names of individual countries in the HKH were added, along with the names of administrative boundaries within. For example, we used the search terms ‘ecosystem services’, ‘ecological services’, or ‘environmental services’ along with the country name ‘India’ and state name ‘Sikkim’ or other such names of provinces, states, or districts in other countries. This systematic search was carried out to cover the literature published until July 2020. It resulted in a total of 565 publications, which included journal articles, books, book chapters, conference papers, errata, and letters. A further screening was done and duplicates removed. Publications other than English-language, peer-reviewed journal articles were also removed. Only journal articles were included because of their assured quality through the peer-review process and the

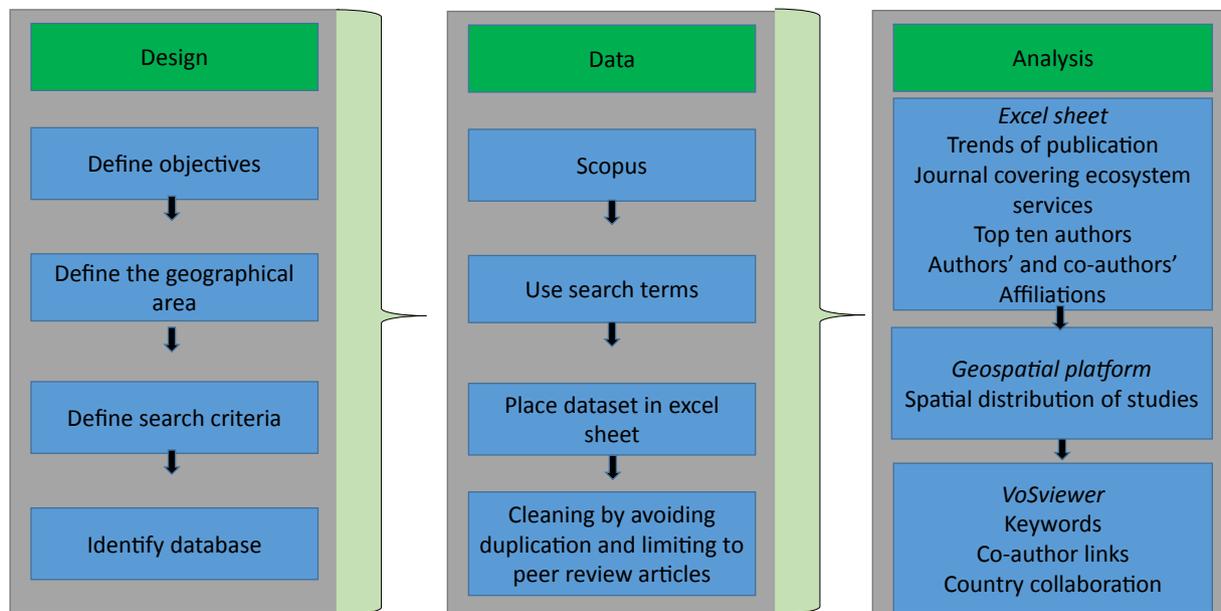


Fig. 1. Schematic flow of the methodology used for the review.

access through search options. This left a total of 439 articles for the analysis. The list of articles used for this study is provided as [Supplementary data 1](#).

2.3. Data analysis

A review of the scientific literature on ES was conducted through a bibliometric analysis. As in other bibliometric analyses (Chaudhary et al., 2015; Liu et al., 2011; McDonough et al., 2017; Paudyal et al., 2017a), a non-statistical *meta*-analysis was carried out to track and analyse the nature and volume of ES research. The articles were analysed from the following perspectives: (i) the temporal pattern of the publications, keeping in view the date of publication; (ii) geographical distribution of the research based on the name of the study area, province, or district of the country in the HKH; (iii) names of the journals; (iv) keywords; (v) authorship and affiliation; and (vi) collaborations among countries. For the analysis relating to the geographical distribution, the state or province of each of the study areas was identified and coded with the presence or absence of studies. The cumulative numbers were then included in maps using a geospatial platform.

For the bibliometric analysis relating to the formation of networks for keywords, authors, and countries, we used VOSviewer (version 1.6.7, Leiden University, Leiden, The Netherlands). VOSviewer is a social network tool widely used for creating scholarly network maps in similar kind of studies (Aznar-Sánchez et al., 2019; Pauna et al., 2018; Velasco-Muñoz et al., 2018). The maps created in VOSviewer consist of one type of item (country names, keywords, or author names) connected to each other by lines or links. Each link has a strength, represented by a positive numerical value. The strength of a link may, for example, indicate the number of publications two researchers have co-authored (in the case of co-authorship links), the number of publications in which two keywords have occurred together (in the case of keyword co-occurrence), or the number of publications in which two countries have collaborated (in the case of country co-authorship). A closely-linked set of items forms a cluster, which is linked to other clusters that further constitute a network. The size of each item in a network is weighted by the number of documents, citations, or the strength of the link between two items. The colour of an item is determined by the cluster to which it belongs (Van Eck and Waltman, 2013). We used number of documents as a weight for calculating the size of the items in mapping keywords, authors, and country networks for ES research in the HKH.

3. Results

3.1. Temporal trends in ES research

An exponential growth in ES research on the HKH was observed, with only two articles published in 2002, rising to not less than 30 articles each year over the period 2014–2020. In all, a total of 439 articles on ES were published until July 2020, over a span of 18 years (Fig. 2).

Four specific periods can be observed in the overall temporal trend: (i) before 2005 (a period before the release of the MEA), when only five articles were recorded; (ii) 2006–2012, with a total of 51 articles, at an average of 7.3 articles per year; (iii) 2013–2015 (a three-year period with a total of 111 articles), when research reached a peak with 50 papers published in 2015; and (iv) 2016–2020 (a period of 4.5 years with 272 articles), with a peak of 79 articles in 2019, and at an average of 60.4 articles per year.

3.2. Spatial trends in ecosystem services research on the HKH

ES studies were found to be unevenly distributed across the HKH. The highest volume of research was on China, especially on the provinces of Yunnan, Sichuan, and the Tibetan Plateau (49%, $n = 214$), followed by Nepal (21%, $n = 93$), and India (20%, $n = 88$). However, very few studies on ecosystem services in Pakistan were observed (2%, $n = 10$). There was only one study in Myanmar and no country-specific study on ecosystem services in Afghanistan during that period (Fig. 3).

3.3. Journal coverage patterns

A total of 166 journals were found to publish ES research on the HKH. The highest number of articles were published in journals *Ecosystem Services* and *Sustainability* (5% of the total number of articles, $n = 23$ in each journal). They were followed by *Science of the Total Environment* (3.5%, $n = 15$) (Fig. 4). Other leading journals include *Environmental Monitoring and Assessment*, *Forests*, *Ecological Indicators*, and *Land Use Policy*. The top fifteen journals were found to publish 39% of the total number of articles. The top fifteen journals with their total publications and citations are shown in Fig. 4. The journal *Ecosystem Services* has the highest number of citations ($n = 254$), followed by *Environmental Monitoring and Assessment* ($n = 185$), and *Science of the Total Environment* ($n = 157$), and others.

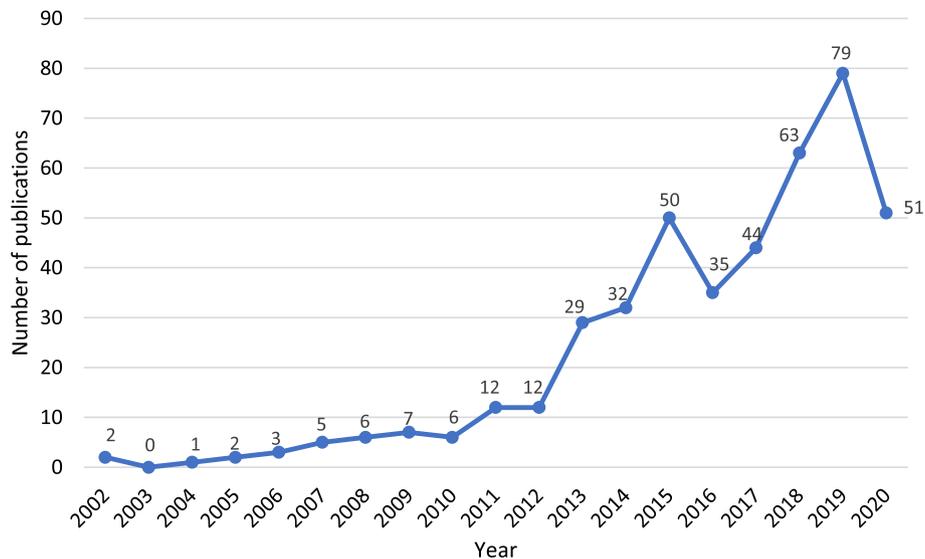


Fig 2. Temporal trends in ecosystem services research on the Hindu Kush Himalaya, 2002–2020.

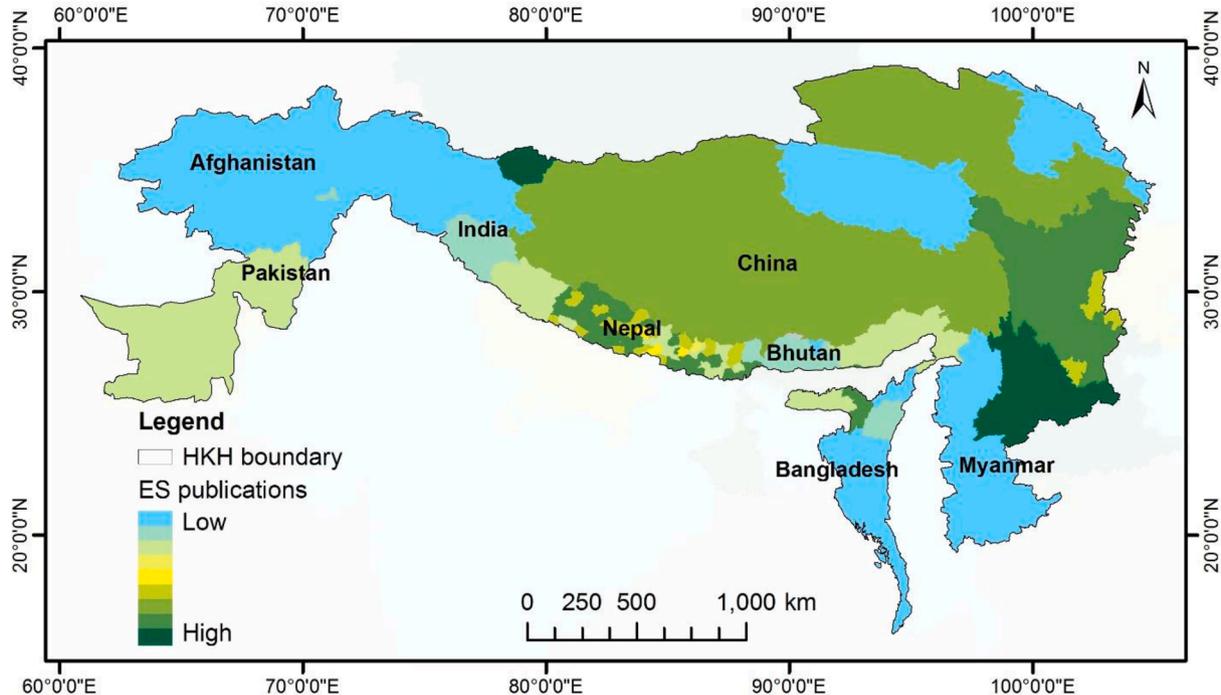


Fig. 3. Spatial pattern of articles related to ecosystem services research on the Hindu Kush Himalaya.

3.4. Keywords use patterns

A total of 1,460 keywords were found in the dataset of ecosystem services research across the HKH. Of the total, approximately 1,203 keywords were used once. 'Biogeography', 'air pollution', 'choice experiment', 'cultural values', 'governance', and 'tree lines' are some examples of keywords that appear only once. Expectedly, 'ecosystem services' is the most-used keyword; it appears in 26 per cent of the total publications, followed by 'land use' in 10 per cent of the articles. 'Biodiversity', 'conservation', 'climate change', 'remote sensing', and 'payment for ecosystem services' are others among the 122 keywords used by at least three papers in the published articles (Fig. 5).

3.5. Authors and co-authorship patterns

The ecosystem services research in the HKH shows diverse collaborations of co-authorships. A total of 1,386 authors were registered in the dataset and among them, 1,000 worked as co-authors on ES research. Keeping the threshold at the minimum of two authors and one citation, the results showed that 288 authors collaborated on research on ES in the HKH among 17 clusters (Fig. 6). The highest number of articles (20%, $n = 90$) had three authors, followed by four authors in 17% ($n = 73$), and five authors in 15% ($n = 57$) of the total number of articles. About 4% of the total number of articles ($n = 18$) were written by single authors. About 3% ($n = 14$) of the articles had more than 10 authors. The dataset contains an article with 36 authors (Rumbaer et al., 2015), which is the highest number, followed by Peh et al. (2016), which has 18

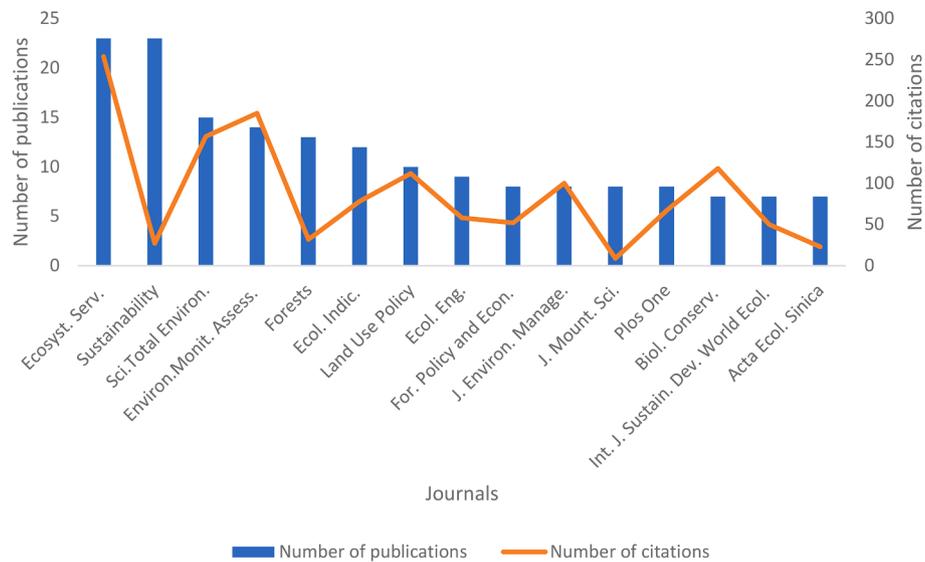


Fig. 4. Top fifteen journals publishing articles on ecosystem services in the Hindu Kush Himalaya, 2002–2020.

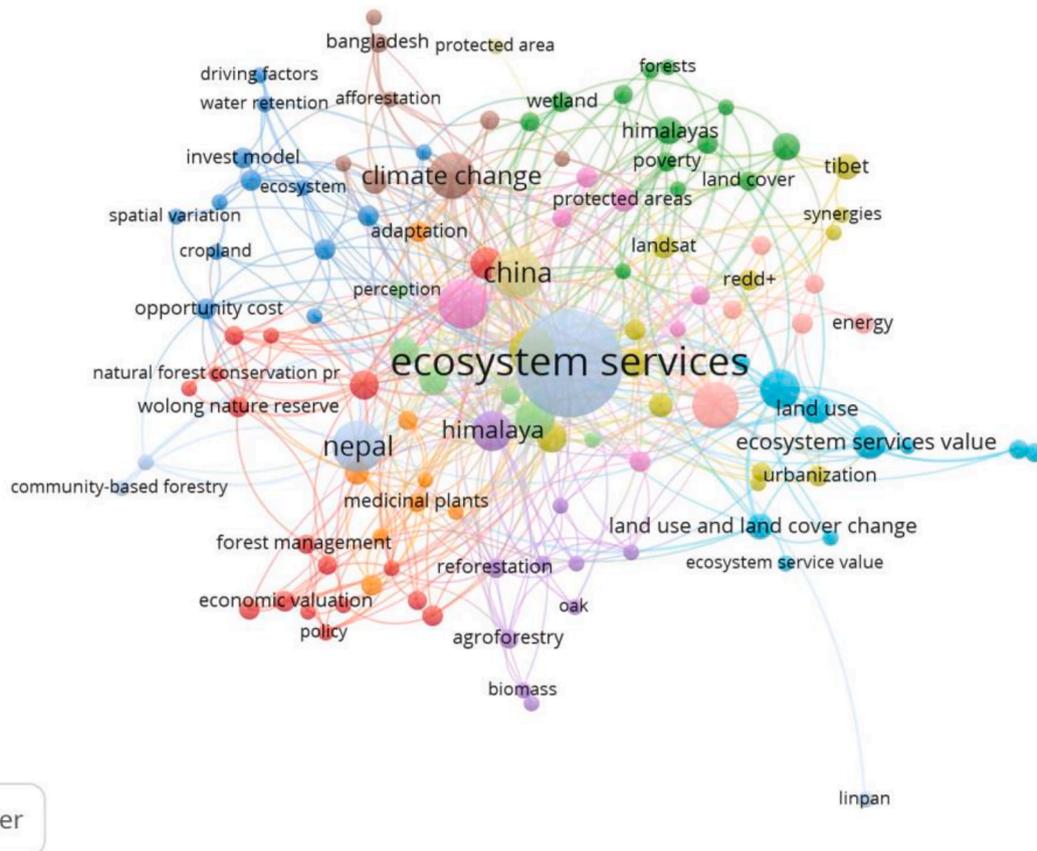


Fig. 5. Keywords co-occurrence network for ecosystem services research on the Hindu Kush Himalaya.

authors.

The study also analysed the highest contributors to research on ES in the region. Baral, H., Liu, J., and Liu, Y were found to have the highest number of contributions; they (co)authored 3.5 per cent of the total number of articles each (Table 1). The academics with the next-highest number of published articles were Xu, J., Zhang, Y., and Li, X. Considering the total number of articles, co-authorship and collaboration, altogether, the ten authors listed in the table contributed to 30 per cent of the total number of articles on the region.

3.6. Networks of collaboration

Research on ecosystem services in the HKH region has diverse collaborating networks. Our study identified a total of 56 countries collaborating on ES research in the region. Among them, institutions from 32 countries are collaborating with more than one country (Fig. 7). The highest number of countries are from Asia (22), followed by Europe (21), and the rest from the Americas, Africa, Oceania, and Australia. The result on a network illustrating the international collaboration between

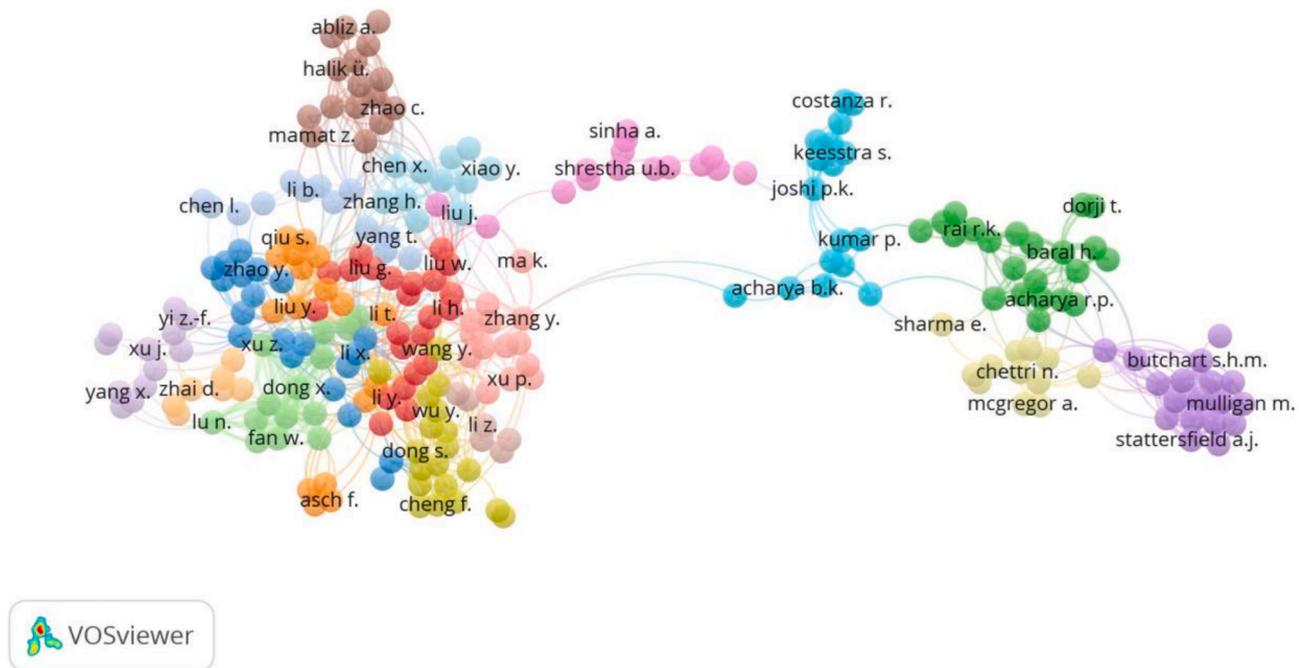


Fig. 6. Co-authorship network of authors publishing on ecosystem services in the Hindu Kush Himalaya.

the principal publishing countries shows 28 distinct clusters. The size of the circle is indicative of the number of articles published by authors from each country. This is led by China, which has strong collaborative links to the main Asian countries, Australia, the United States, and the United Kingdom. The second-most dominant cluster is led by the United States, followed by India, Nepal, Australia, and Germany. Interestingly, there were network links between Indonesia and Australia, the United States, and even Brazil.

Nepal was identified as the principal collaborator, holding a central position in the network (Fig. 7). It was found to collaborate extensively with other countries, including Australia, Canada, Germany, the United Kingdom, and the United States. China was the second-biggest collaborator, after Nepal, followed by the United States. However, it is to be noted that China has collaborated in the highest number of articles (47%), followed by the United States (22%), with India (19%) and Nepal (15%) in third and fourth place, respectively (Table 2).

4. Discussion

This study explores the status of the scientific literature on ecosystem services in the HKH published over the last 18 years, to advance our knowledge of ES science on the region. This is important as the HKH is regarded as a data-deficit region, with very limited data on ecosystem science (Xu et al., 2019). This review fills this gap by showing the temporal trends, the geographical distribution, and authorial, institutional, and topical patterns in ES research.

The bibliometric analysis showed an increasing trend of ES research on the HKH, consistent with the general trends in ES research at the global level (Chaudhary et al., 2015; McDonough et al., 2017), on mountain ecosystems (Martín-López et al., 2019), and at regional scales (Malinauskaite et al., 2019). The temporal trend showed that the number of publications grew remarkably after the publication of the Millennium Ecosystem Assessment in 2005, with a particularly sharp increase from 2012 on, after the establishment of the IPBES (Chaudhary et al., 2015; Martín-López et al., 2019). This trend has been directly and indirectly influenced by important global conservation science and policy discourses. The Convention on Biological Diversity (CBD), a global conservation agreement signed by 196 parties, emphasised the importance of raising awareness about ecosystem services and their

valuation in its Aichi targets (CBD, 2010). This has influenced parties to the CBD to directly or indirectly adopt ES as a part of national policy and practice. For instance, Nepal has already integrated the concept of ES in its environmental policies (Chaudhary and McGregor, 2018). Similarly, the establishment of the IPBES has been significant in bridging ES science and global policy discourse (Chaudhary et al., 2015). The science-policy integration in the discourse around ES, such as The Economics of Ecosystems and Biodiversity (TEEB), also influenced ES research on the HKH (TEEB, 2014).

This review shows the geographical distribution of ES research on the region, with the highest concentration in China, in consonance with prevailing trends (Aznar-Sánchez et al., 2018; McDonough et al., 2017). The trend is obvious with a higher concentration of ES research in developed or developing nations (Zhang et al., 2019) or regions (Malinauskaite et al., 2019). Yet, ES science in the HKH is at a lower priority than in developed countries (Zhang et al., 2019), such as those of Europe (Ruijs et al., 2013) and Latin America (Pulido and Lara, 2018). Although the region is highly interdependent in terms of regional ES flows (Schirpke et al., 2019), research at the regional scale, covering trans-national ecosystem flows, is negligible (Rai et al., 2018). This analysis revealed that there have been very few contributions from Myanmar and Pakistan, and no country-specific records from Afghanistan, which reflect the limited interest and investment in ES discourses in these countries, a lack also noted by Martín-López et al. (2019). One of the main reasons for the relatively higher research carried out in China and India compared to other countries of the HKH could be the investment capacities and priority given to ES research in these countries (Katsnelson, 2016), or the higher ecosystem diversity in the Eastern Himalaya (Gorenflo et al., 2012). Interestingly, Nepal has been identified as one among the thirty-biggest investor countries in ES science, mainly due to external collaborations (Katsnelson, 2016). Nevertheless, the existing gaps reveal avenues for future research in these data-deficit regions.

The journal coverage analysis showed that, so far, 166 journals have published ES research on the region (Fig. 4). This indicates that research on ES has the potential to reach out to a broad array of varied science communities and ecosystem management readers and practitioners. However, all the top journals focus on biophysical research, indicating the dominance of the biophysical sciences and the marginalization of other disciplines. This has potentially adverse implications, as research

Table 1
Top thirteen authors of ES research on the HKH.

Authors	Number of articles	Number of collaborating authors	First author article	Co-authored articles	Affiliation
Baral, H.	15	42	0	15	Centre for International Forestry Research (CIFOR), Indonesia
Liu, J.	15	38	2	13	Michigan State University, United States
Liu, Y.	15	45	4	11	Institute of Arid Ecology and Environment, Xinjiang University, China
Xu, J.	11	41	1	10	Chinese Academy of Sciences, China
Zhang, Y.	10	41	0	10	Beijing Normal University, China
Li, X.	9	39	1	8	University of Western Australia, Australia
Bhatta, L.D.	8	24	4	4	International Centre for Integrated Mountain Development (ICIMOD), Nepal
Chen, X.	8	22	3	5	University of North Carolina, United States
Chettri, N.	8	20	1	7	International Centre for Integrated Mountain Development (ICIMOD), Nepal
Li, Y.	8	35	2	6	School of Environment, Beijing Normal University, China

on intangible benefits such as spirituality, sense of place, and attachment to nature, which require social science methods for their study, could be marginalized (Chaudhary et al., 2019). This is in line with the keywords pattern, which shows ES science in the HKH is mainly focused on ecological compensation, land use change, biodiversity, conservation, and payment for ecosystem services (see Fig. 5). While ES research globally is gradually becoming more interdisciplinary (Costanza et al., 2017; Droste et al., 2018), ES research on the HKH is still more focused to biophysical sciences and less on social and political science, as seen elsewhere (Aznar-Sánchez et al., 2018; Martin-López et al., 2019; Paudyal et al., 2017b). And although identified as a hotspot for climate change (Sharma et al., 2019), the impacts of climate change on ES and damage such as water-induced disasters are still not a priority area of research in the HKH.

The keywords analysis showed that the most common keywords are similar to those reported in other ES review papers (Pauna et al., 2018). However, specific terms such as 'provision', 'regulation', 'cultural', etc. did not appear in the top 100 keywords. The link to multi-dimensional drivers, including land cover change, land use change, and climate change featured prominently, indicating increasing focus in the science

of ES (Xu et al., 2019). Likewise, the keywords pattern also reflected the use of ES valuation and mapping tools such as Integrated Valuation of Ecosystem Services and Trade-offs (InVEST), remote sensing, and Landsat. The indication of trade-offs (conservation versus ES), incentives in terms of payment for ES, InVEST, Reduced Emissions from Deforestation and Forest Degradation (REDD +), China's Grain to Green programme, and protected areas and species (such as the giant panda) all suggest that the studies are evolving by looking at social dimension due to the realisation on nature's contribution to people required for reaching the sustainable development goals (Martin-Lopez et al., 2019; Tang et al., 2018). Such a social-ecological approach could bring new opportunities in conserving fragile ecosystems and developing the region sustainably. As such, this study provides a strong rationale to advance ES research further and to mainstream an ES approach in the policy on, and practice of conservation and sustainable development.

The authorship analysis showed that among the 1,386 authors registered, 1,000 of them co-authored ES publications on the HKH. It is worth noting that most authors with the highest number of publications are from the region (China, Nepal, and India), but affiliated with international organizations, or associated with institutions in developed countries, indicative of the international influence on ES research in the HKH. This trend is quite similar to that reported by Pauna et al. (2018), who highlighted the major contributions by Chinese scholars in global ES research.

The collaboration network analysis showed that 57 countries collaborated in ES research on the HKH, suggesting an advancement of research networks among the HKH countries and interest in the region from outside. Chaudhary et al. (2018) also noted a similar pattern. China, India, and Nepal were found to collaborate intensely with the United States, Germany, the United Kingdom, Australia, and other countries, as has also been reported by Zhang et al. (2019). This kind of multinational collaboration on the one hand provides opportunities for innovations in research (Suominen et al., 2018) and, on the other, intensifies the risk of greater influence by international actors and institutions, marginalizing local contexts and issues (Chaudhary et al., 2019). In addition, the support from international conservation aid institutions alone is often regarded as insufficient in addressing national issues (Bare et al., 2015). Therefore, ES research has to be high on national research priorities in order to highlight the importance of local contexts and issues, as has also been recommended by other studies (Chaudhary et al., 2018; Paudyal et al., 2018).

5. Conclusion

This study aims to analyse the status and advancement of ecosystem services research in the Hindu Kush Himalaya. A bibliometric analysis was performed to examine the regional trends and scholarly networks. The analysis showed the temporal trends, geographical distribution, journal coverage, keywords usage patterns, authorship, and patterns of collaboration in ES research. The results showed that the research on ecosystem services in the HKH has advanced rapidly in less than two decades, indicating the influence of global discourses, which have followed a similar trend. However, the geographical representation is skewed towards a few countries, with a lower priority in the western part of the HKH. The top journals covering ES research from the region include *Ecosystem Services, Sustainability* (Switzerland), and *Science of the Total Environment*.

The most common keywords are 'ecosystem services', 'China', 'Nepal', 'conservation', 'biodiversity', and 'climate change'. This reveals the dominance of the biophysical sciences in ES research, suggesting the need to integrate other disciplines, including social and political science. International scholars and institutions were also found to be influential, suggesting the likely dominance of their interpretations, and the consequent marginalization of the local context and issues, including intangibles such as spiritual values prevalent in the region.

Moreover, despite the HKH being a contiguous and shared ecosystem

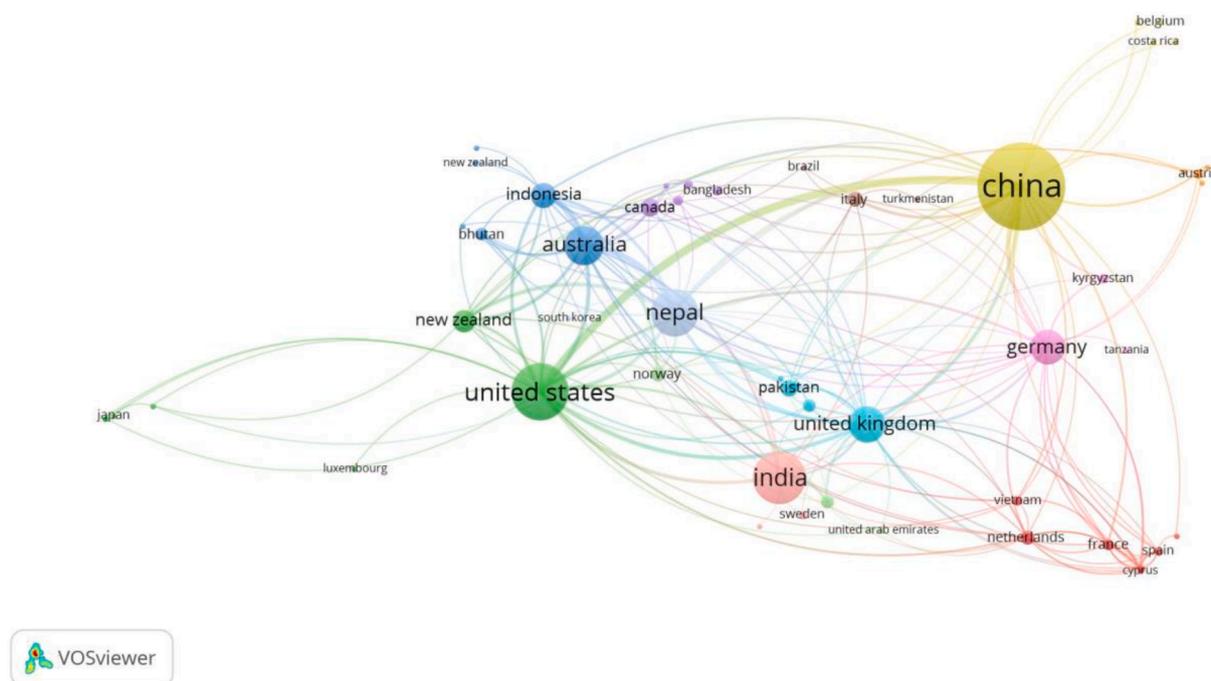


Fig. 7. Co-authorship collaboration country networks of ecosystem services research on the Hindu Kush Himalaya.

Table 2

Top ten collaborating countries based on authors' affiliations and their number of publications and citations.

Country	Number of publications	Citations
China	207	1808
United States	95	931
India	83	419
Nepal	66	605
Australia	48	395
United Kingdom	41	556
Germany	39	581
Indonesia	22	269
New Zealand	18	145
Canada	12	97

among the eight member countries, and prone to much damage including natural and anthropogenic disasters and the impacts of climate change, regional-level analysis showing interdependence and the need for regional cooperation is still limited. We therefore argue that ecosystem services research be made multi-disciplinary and geographically representative, with a focus on the local, national, and regional issues and interpretations in ES discourse. This is especially important for the HKH as the drivers of change in the region are multidimensional, requiring a holistic and multidisciplinary approach for better ecosystem management and governance.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Disclaimer.

The views and interpretations in this publication are those of the authors and should not be ascribed to their respective institutions.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ecolind.2020.107152>.

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