BIBLIOMETRIC INDICATORS OF BIODIVERSITY MONITORING USING RS/GIS IN WESTERN HIMALAYA

S. Bisht and S. Chaudhry*

Institute of Environmental Studies, Kurukshetra University, Kurukshetra, Haryana, India

*For Correspondence: smitachaudhry11@gmail.com

ABSTRACT

A bibliometric analysis of published biodiversity monitoring studies using remote sensing and geographic information system was carried out to quantitatively evaluate scientific research on various categories in a long span of 19 years between 1996–2015, in the western Himalayan states of India. The common remote sensing platform/sensors and scientific production of RS/GIS papers in any journal of all subject categories were studied. Studies related to geospatial modeling, invasive species, land use dynamics, phenology, forest fire and fragmentation, biodiversity assessment and mitigation as main subject categories in biodiversity research were analyzed. In the western Himalayan region, land use dynamics was the most important subject category followed by geospatial modelling. Medium to high spatial resolution sensors (e.g. Landsat, IRS, SPOT, ASTER) were used in studying all the subject categories. The published output analysis showed that RS/GIS research concerning biodiversity steadily increased over the past 19 years and the paper production in 2011-2015 was about 21 times 1996-2000 production outputs. The growth of article outputs has increased tremendously since 2011. Journal of the Indian Society of Remote Sensing and Current Science were most active journals in this field. Uttarakhand was the largest contributor in the region's biodiversity studies followed by Himachal Pradesh. The study revealed use of different sensors, and pattern in scientific outputs and subject categories highlighting the topics for further research advancements.

Keywords: Bibliometry, Western Himalaya, RS/GIS, Biodiversity.

INTRODUCTION

Biodiversity monitoring, by evaluating spatial (e.g. range), temporal (e.g. phenology) and self (e.g. physiology) trends is valuable to infer causes of biodiversity changes. Observational data and model simulations by the use of highly advanced computer software, multimedia and virtual reality technologies as well as global positioning systems, multi-source spatio-temporal data (weather stations, seismometers, gauges etc. and society) has literally opened up new areas of ecological research and analysis. Global coverage by data from Satellite Remote Sensing (SRS) such as, geostationary and polar orbiting satellites at a variety of resolutions enable decision makers to use these technologies for developing prevention, mitigation and adaptation measures to solve the questions relevant to environmental issues (Fischer-Kowalski; Haberl 2007). Mountains are particularly rich in biodiversity, providing various ecosystem services, but are being highly vulnerable to degradation, due to increased socio-economic progression and high sensitivity to climate within short distances (Shrestha 2007). Western Himalayan region of India covers three states of India viz. Jammu and Kashmir, Himachal Pradesh...
and Uttarakhand. The region is structurally complex with elevations ranging from 300 to over 6000m. In response to variations in climate and geology, diversity of ecosystems range from alluvial grasslands, subtropical broadleaved forests to dominance of conifers in the temperate zone to alpine meadows above the tree line. High-altitude cold desert ecosystems encompass a significant area of the region. Recently, there have been some reports on temperature rise at a rate of 1.6 °C during the last century in the western Himalaya (Bhutiyani et al., 2007). In this paper, a bibliometric analysis of published research of RS/GIS techniques in biodiversity monitoring for the period of 1996–2015 has been carried out.

DATA AND METHODS

Bibliometric method as an effective tool is used to evaluate the research trends in various science fields (Pritchar, 1969; Li et al., 2011). In this paper the bibliometric analysis using the publication output of journals, subject categories, and states, and the temporal evolution of research patterns has been done. Further the scope of sensors in various subject categories of RS/GIS techniques in biodiversity monitoring and conservation has been studied. The searched terms, including “biodiversity and climate change,” “habitat types,” “species distribution,” “species distribution and modeling,” “ecological effects,” “forest ecosystems and climate change,” “land cover dynamics,” “phenology,” “forest fires,” “forest fragmentation,” “invasive species,” “insects,” “biodiversity assessment,” “plant introduction,” “REDD/REDD+” were used to distinguish publications in “western Himalayan region” using “remote sensing” and “geographic information system” in journals that contained these words in publications’ titles, abstracts, keyword lists or texts. When gathering reference material, formal searches, using Thomson Reuters Web of Science database and the Google Scholar search engine, with the experience of individual co-authors were combined to compile relevant and pertinent literature.

RESULTS AND DISCUSSION

Publications and Journals

The earliest article that directly related to use of RS/GIS technique in western Himalaya was published in 1996. From 1996 to 2015 mid, the article number increases from 2 in 1996-2000 to 41 in 2011-2015 (Fig. 1), year 2015 showed a decrease due to an uncompleted statistical analysis in the latest year. An evident increase occurs from 2011-2015 (59%) due to increasing concerns on this concept. The 70 publications are published in 34 journals. Journal of the Indian Society of Remote Sensing ranked first in the number of published articles (12, 17%), followed by Current Science (11, 16%), and International Journal of Remote Sensing (5, 7%). Results identify that 10 journals are responsible for more than 66% of the 70 articles. A comparison of growth trend of publications among the top ten productive journals is presented in Fig. 1.

1. Remote Sensing Sensors and Subject Categories to Monitor Biodiversity

Remote sensing datasets are increasingly being used by researchers to monitor changes in biodiversity at various scales. The publications were grouped into major seven categories in monitoring biodiversity in the climate change scenarios using RS/GIS techniques. In the western Himalayan region, a vast majority of RS/GIS studies on biodiversity focus on the land cover changes (30%) followed by use of models to study species distribution (19%) and forest fire and fragmentation (17%) (Fig. 2). Medium to low resolution satellite data (e.g., MODIS, AVHRR) facilitates a large spatial extent of mapping. In the western Himalaya studies have demonstrated the usefulness of MODIS data for assessing land cover (Li et al., 2014), phenological patterns of vegetation (Mishra and Chaudhuri 2015), forest fire monitoring (Chand et al. 2007) on regional scales. Advanced Very High Resolution Radiometer (AVHRR) vegetation data representing NDVI was used to study invasive species (Lantana camara). In this study the species spatial distribution was predicted using various
algorithms (Priyanka and Joshi 2013). These datasets are particularly successful for habitat evaluation, degradation and biodiversity assessment at the regional scales.

![Figure 1](image.png)

**Fig. 1.** Publication Outputs in Biodiversity Studies using RS/GIS in different Journals

In many cases, the use of high to moderate (≈ 1 0 – 3 Qn) spatial resolution data, such as provided by the Landsat, Indian Remote Sensing Satellite (IRS), SPOT and the ASTER is used to capture the broad extent and spatial patterns of habitats, such as, land-use change (Ghosh et al., 1996; Tsarouchi et al., 2014), deforestation (Munsi et al., 2010a; Munsi et al., 2010b), habitat suitability (Kushwaha et al., 2000), alpine treeline shift (Singh et al., 2012), impact of projected climate change on forest ecosystems (Joshi et al., 2012), detection and discrimination of invasion (Padalia et al., 2013), forest fire risk zonation (Chavan et al., 2012), vegetation mapping on the basis of climatic zoning (Naithani and Mathur 2014), forest fragmentation (Sharma and Roy 2007), phyto-phenology (Joshi et al., 2001), factors determining forest types (Ashutosh et al., 2010), forest growing stock (Singh et al., 2004), forest density (Kumar et al., 2007), inventory approach in RED framework (Sharma et al., 2013), aboveground biomass and mitigation (Wani et al., 2015) and in estimating plant richness (Rashid et al., 2013). Although habitat mapping is much harder to undertake in the mountainous regions due to errors in interpretation of spectral signatures such as of shadows, clouds and slopes. These high resolution imagery (HR) such as Landsat, SPOT, ASTER and IRS etc. are often used even in complex fine-scale habitat mosaics due to the easy availability of these and being cost effective as compared to very high resolution (VHR) imageries such as IKONOS etc.. In the western Himalayan region, the IKONOS data were used specifically to obtain sample error matrices in the classifications such as dense and degraded classes (Prabhakar et al., 2006), Google earth for specificities on location etc. (Sharma et al., 2013), data linking techniques using both MODIS data and multi-temporal high spatial resolution imagery in Google Earth for detecting factors for change in vegetation trend (Mishra and Chaudhuri 2015) and sampling in aquatic vegetation survey (Romshoo and Rashid 2014). In addition, GDEM (e.g. SRTM) was also used for further refinements in classifications such as altitudinal stratifications (Jaryan et al., 2013; Li et al., 2014). Hyperspectral data although is technically challenging, however because of its narrow band combinations with contiguous spectral signature based on molecular absorption facilitate in discrimination and classification of different forest types for e.g., EO-1 Hyperion data was used to differentiate broadleaved evergreen and conifer forest tree species (George et al., 2014) and for best ranges for specific species and their functions in western Himalayan region (Singh et al., 2014). Active remote sensing data, such as LiDAR was used in western India to study the forest vertical structure, based on three-dimensional (3D) structure, and using secondary data for error estimations (Tripathi and Behera 2013). In a duration of 19 years from 1996-2015 use of RS/GIS in phenological studies (6%) and invasive species (9%) and mitigation (9%) are very less. This may be because of lack of long term data required for phenological studies and the limited available data available to study the new range of invasive species, and for mitigation measures (Fig. 2). Although in the three western Himalayan states, these seven categories showed varied fluctuations in their percentage growth from the duration of 1996-2011 to 2011-2015, these however suggested that the research focus in biodiversity monitoring shift among
Table 1. Use of Remote Sensing Sensors and Different Techniques in Biodiversity Monitoring and Assessment in the Western Himalaya

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Geospatial Modelling</th>
<th>Land Use Dynamics</th>
<th>Habitat Degradation</th>
<th>Biodiversity Assessment</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habitat Evaluation</td>
<td>Tree line shifts</td>
<td>Plant Richness</td>
<td>Climate Projections on Forests</td>
<td>Invasive Species</td>
</tr>
<tr>
<td>Coarse spatial resolution (e.g., MODIS, AVHRR)</td>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
<td>Modeling spatial distribution of Lantana cumara (Priyanka and Joshi, 2013)</td>
</tr>
<tr>
<td>Medium to high spatial resolution (e.g., Landsat, IRS, SPOT, ASTER)</td>
<td>Habitat suitability (Kushwaha et al., 2000; Kushwaha et al., 2004; Singh et al., 2009; Padalia et al., 2010; Saran et al., 2010; Yang et al., 2013)</td>
<td>Vulnerability of the eco-development zone (Nandy et al., 2015)</td>
<td>Environmental niche (Singh et al., 2013); Alpine treeline shift (Singh et al., 2012)</td>
<td>Biodiversity characterization (Rashid et al., 2013)</td>
<td>Impact of projected climate change on forest ecosystems (Joshi et al., 2012); Spatiotemporal change patterns of forest cover (Muniy et al., 2012)</td>
</tr>
</tbody>
</table>


ENVIS Centre on Himalayan Ecology
<table>
<thead>
<tr>
<th>Data Source</th>
<th>Methodology</th>
<th>Application Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high spatial resolution (e.g., Google Earth or IKONOS)</td>
<td>Determination of distribution of broadleaved, evergreen, and conifer forest tree species (Chauvet et al., 2014)</td>
<td>Not used</td>
</tr>
<tr>
<td>Hyper spectral (e.g., Landsat)</td>
<td>Not used</td>
<td>Forest health assessment (Ghosh et al., 2014)</td>
</tr>
<tr>
<td>Forest and land use mapping (Rai, 2015)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Himalayan forests degradation (Prabhakar et al., 2007)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Vegetation distribution (Sharma et al., 2012); Spatial patterns of wildfire (Li et al., 2014)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Vegetation distribution (Sharma et al., 2012); Spatial patterns of wildfire (Li et al., 2014)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Distribution characteristics of invasive in three sites (KNP, WH)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Active remote sensing data (e.g., LiDAR)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Plant height profiling (Golchin et al., 2013)</td>
<td>Not used</td>
<td>Not used</td>
</tr>
</tbody>
</table>

**Sources:**
- Prabhakar, C. et al. (2007).
- Sharma, A. et al. (2012).
- Li, J. et al. (2014).
different subject categories in the recent years. In Uttarakhand, studies are more equal in all the subject categories as compared to other states. Publications in the land use changes showed maximum decrease (10.86%) followed by invasive species (2.29%). In the state research articles in biodiversity assessment showed highest increase (8%) followed by studies in phenology (4%). In Himachal Pradesh, research publications in phenological studies showed maximum decrease (50%) followed by mitigation (17%). Forest fire and fragmentation (42%) showed maximum increase followed by geospatial modeling, invasive species and land use dynamics with increase in each by 8% respectively. In Jammu and Kashmir, biodiversity assessment showed maximum decrease (50%) followed by phenological studies (25%). Publications in mitigation measures showed maximum increase (33%) followed by geospatial modeling (17%) and invasive species (17%).

**Fig. 2.** Percentage of publications in biodiversity studies using RS/GIS Techniques (1996–2015)

**Fig. 3.** Percentage change in publications in climate Change-Biodiversity Studies in the Three Western Himalayan States

**CONCLUSIONS**

In conclusion, while very high resolution imageries e.g., IKONOS are considered being the ideal option for plant richness, biodiversity assessment and fine scale mapping of habitats with high spatial heterogeneity, high resolution imagery such as Landsat, SPOT, IRS and ASTER are often sufficient for these purposes over large areas, even in complex fine-scale habitat mosaics. Researchers along with extensive field data, use the free available very high resolution imagery provided by Google Earth in the selection of field sampling location, as training samples for classification and comparing of results. Based on 70 publications obtained from Thomson Reuters Web of Science database and the Google Scholar search engine, the findings on bibliometric study suggested that among the various subject categories in use of RS/GIS in biodiversity monitoring studies, land use changes remained an important topic in the western Himalaya followed by geospatial modeling. Our study suggested that there has been tremendous growth in the scientific outputs in the use RS/GIS in monitoring biodiversity in recent years particularly after 2011. Among the 34 journals responsible for publishing articles in various subject categories, 66% contribution are by Journal of Indian the Society of Remote Sensing and Current Science which comes out as the major consistent journal in the publication of research in this area of study. At the regional level, Uttarakhand attained a dominant position in biodiversity monitoring research by contributing the largest number of articles. Different research categories are identified in the three states of the western Himalayan region, which may direct the research needs in future.

**REFERENCES**


للأسف، ليس هناك نص يمكن قراءته بشكل طبيعي من الصورة المقدمة. إذا كنت بحاجة إلى مساعدة أخرى أو إذا كان لديك أي أسئلة أخرى، فسأكون سعيدًا بمساعدتك.