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Research Article

Applications Of Remote Sensing For Protected Area Monitoring: A Bibliometric Study.

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Abstract

Monitoring and managing protected areas is greatly aided by advancements in science and technology, as well as the creation of sensors and remote sensing platforms. This study examines research articles from a bibliometric standpoint regarding the distantdetecting protected zones. The years 1991–2018 are the main focus of this analysis. The Web of Science database yielded a total of 4546 scholarly publications for use as data. Co-authorships between nations and institutions, as well as the co-occurrences of author keywords, were assessed using the VOSviewer software. The findings show that the number of yearly publications on remote sensing of protected areas is on the rise.This study identifies the primary theme areas, top nations, and most significant academic institutions worldwide that have produced pertinent research in scientific publications; it also identifies the journals with the greatest number of publications, and the cooperative trends pertaining to protected area remote sensing. Among the most widely used satellites and sensors are Landsat, MODIS, and LiDAR. The primary focus of protected area monitoring research is on change detection, biodiversity protection, and the effects of climate change. Researchers and academics can find future study directions and gain a deeper understanding of the field's intellectual structure with the aid of this analysis.

Keywords : *remote sensing; protected areas; bibliometric analysis; VOSviewer.*

INTRODUCTION

A protected area (PA) is described by the International Union for protection of Nature (IUCN) [1,2] as "a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated species."cultural values and ecosystem services. National parks, national forests, natural reserves, conservation areas, wilderness areas, marine protected areas (MPAs), and wildlife refuges and sanctuaries are examples of land or sea areas that are generally regarded as PAs. These areas are designated for the preservation of native biological diversity as well as natural and cultural heritage and significance [3].Both terrestrial and marine PAs have significantly expanded in number and coverage over the last century [4].As of July 2018, there were 238,563 classified PAs, which accounted for roughly 14.9% and 7.3% of the Earth's land and ocean surface areas, respectively, according to the World Database on Protected Areas [5]. Key environmental, social, cultural, and cultural factors make PAs essential to nature conservation initiatives.economic operations worldwide [3, 6]. Furthermore, PAs are crucial for maintaining ecological integrity and biodiversity [7–10].

The art, science, and technology of gathering Earth system data using nonphysical touch sensors or sensor systems installed on platforms in space, the air, and other environments, processing and interpreting data from automated and visual analysis, and information gathering are all referred to as remote sensing.generation through the use of traditional and digital mapping tools, and uses of the information and data produced to suit the needs and benefit society. Comprehensive geographic data for mapping and studying PAs at various geographical scales, such as high spatial resolution, can be obtained by remote sensing.and extensive coverage, distinct spectral characteristics (such as visible, near-infrared, or microwave), distinct temporal frequencies (such as daily, weekly, monthly, or annual observations), and distinct spatial contexts (such as the nearby PA areas versus a larger backdrop of land and water bases).Remote sensing has been essential in safeguarding biodiversity, ecosystems, and natural resources and is seen to be an affordable way to assist PAs' monitoring efforts [11,12].Due of its capacity for large-scale observation, remote sensing is increasingly being used to track the traits and evolution of PAs' land surface attributes [13]. For instance, remote sensing has been used to evaluate the illumination in and around buildings at night.

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worldwide terrestrial PAs and wilderness areas [14], ongoing Landsat-based monitoring of national park landscape dynamics [15–19], forest dynamics assessment within and surrounding Olympic National Park using time-series Landsat observations [20], and tracking changes in wildlife habitat in Kejimkujik National Park and the National Historic Site in southern Nova Scotia of the Canadian Atlantic Coastal Uplands Natural Region [21].One specific benefit that remote sensing may offer for protected area inventory and monitoring is data to better understand the current and historical conditions, as well as the changes that have taken place under various impacting elements and management techniques, the patterns of change relative to those in nearby regions, and the effects of changes on ecosystem functioning [22–24]. Since frontier lands are typically located in isolated, challenging-to-reach areas with vast coverage, remote sensing offers special benefits for monitoring these areas.Various forms of remote sensing data have been used to research frontier regions. For instance, hyperspectral and radar data have been used to monitor forests in the Amazon [25–30], Africa [31], and Siberia [32–35], as well as to detect hydrologic changes in the lake-rich Arctic area [36,37], in MPAs [42], and along the coast [38–41].

A number of reviews on PA monitoring with remote sensing have also been published. In their evaluation of remote sensing for conservation monitoring, for instance, Nagendra et al. [43] evaluated PAs, habitat extent, habitat condition, species diversity, and threats. Kachelriess and colleagues [44] examined managing MPAs with the use of remote sensing. Advances in spaceborne remote sensing of terrestrial PAs were evaluated by Gillespie et al. [45].A survey of the remote sensing change detection techniques used for the ecological monitoring of US PAs was given by Willis [11]. A certain kind of PA or the monitoring technique has been the primary focus of the reviews that are now available. There haven't been any bibliometric studies of remote sensing apps used for PA monitoring.A mathematical and statistical method for examining relevant literature and comprehending the worldwide research trends in a particular field, bibliometric analysis was first presented by Pritchard in 1969 [46, 47].

Bibliometric analysis techniques are often employed to offer numerical evaluations of scholarly literature [48], and have been used in a variety of fields, including ecology, soil science, food safety, environmental engineering and science, and the use of new energy. Finding research gaps and directions in a particular field is aided by bibliometric analysis [49]. This approach has been used in recent years to assess remote sensing research trends and applications across various scientific domains [50–52].As an example, Zhang et al.[53] examined the worldwide research trends in remote sensing studies by combining the novel indicator (geographical impact factor) with conventional bibliometric techniques. A bibliometric analysis was conducted by Viana et al. [54] to evaluate the publishing, research trends, and features.about the use of data from remote sensing for human health. The research status and trends in China's remote sensing of agricultural growth monitoring were examined by Wang et al. using the bibliometric approach [55]. Nevertheless, no effort has been made to use bibliometric analysis techniques to assess the monitoring and inventory of PAs in the literature. Publications on the remote sensing monitoring of PAs have been growing in quantity in recent years.As a result, a summary of the state and direction of development in this sector is required. Researchers can have a better understanding of the current number of publications and the journals in which these papers are published by using bibliometric methodologies.in, which nations and organizations are most prominent in this subject, how this discipline's research orientation is evolving, etc.

This research examines the pertinent literature that focuses on remote sensing applications in PAs using a bibliometric methodology. (1) Summarizing the differences in document types, overall publication output, subject categories, and source journals is the goal of this work.(2) examine the output of publications and international cooperation by nations, organizations, and writers; and (3) use a keyword analysis to identify the common research subjects of PA monitoring studies.In addition to identifying pertinent research and application paths, this study can assist us in understanding the advancements made in this subject.

METHODOLOGY AND DATA COLLECTION

Numerous publications, subject categories, source journals, nations, and institutions are among the bibliometric indicators examined in this study; all of these were sourced directly from the Web of Science. Several statistics on retrieved papers are available in the Web of Science database, including the language, institution, author, group author, series name, conference name, country/region, document type, editor, fund financing institution, authorization number, publication year, research direction, source publication name, and Web of Science category. "Create a Citation Report" is another feature of Web of Science that can directly provide the average number of times a document has been cited, the total quoted frequency of the recovered documents, the total quoted frequency of the deleted self-cited documents, the quoted documents, the quoted documents of the removed self-cited documents, and the The H-index for every item.

This study also examined co-authorship between nations and institutions. Co-authorship primarily examines the authors' co-signatures in the published work. The writers are seen as having a cooperative relationship if they sign their names together in the paper. Right now, co-authorshipAnalysis

encompasses not only a study of scholars but also a study of international and institutional collaboration. Regarding the co-authorship analysis, the total link strength shows the overall strength of a country or institution's co-authorship links with other countries and institutions, while the link strength between countries and institutions shows the number of publications that two affiliated countries and institutions have co-authored.The number of articles in which two keywords occur together is also indicated by the link strength between the author keywords in the co-occurrence analysis. To look into the development From the findings of the co-occurrence keywords, we identified the keywords associated with sate lite, sensor, and remote sensing monitoring technique in the context of protection area monitoring.

The VOSviewer program was used in this study to generate a term co-occurrence analysis and show the co-authorship collaboration networks of nations and institutions. VOSviewer, which was created by Van Eck and Waltman of Leiden University in the Netherlands, is open source.mining program to analyze trends in the scientific literature and create bibliometric maps [56].VOSviewer's powerful graphic presentation capability is its best feature and makes it ideal for examining vast amounts of sample data. Compared to other comparable analysis tools, this visualization impact is superior, and the analysis function is more extensive. VOSviewer is a powerful tool that use clustering techniques and features according to how strongly items are connected to facilitate the network's analysis. [57]. The VOSviewer software depicts an element with a circle and label; circles of the same hue belong to the same cluster, and the circle size indicates the element's relevance.

VOSviewer is used to build bibliometric maps. Countries, institutions, and author keywords from the current study are all included in these maps. A link is the relationship or connection that exists between two items. The number of articles that two countries have in common is indicated by the strength of the link. The number of publications where two author keywords appear together in the case of co-occurrence linkages, or the number of institutions that have co-authored in the case of co-authorship links [46,58]. There are two ways to determine link strength in the VOSviewer: fractional counting and complete counting. When a co-authored article is counted with a full weight of one for each co-author, this is known as full counting, and it suggests that the total weight of a publication is equal to the number of writers. A co-authored publication is assigned fractionally when fractional counting is used.with the publication's total weight being equal to one for each coauthor. A fractional counting strategy is better than full counting, according to Perianes-Rodriguez et al. (2016)'s analysis [59].As a result, we decided to compute the link strength using fractional counting.The literature network is clustered by VOSviewer using a clustering approach that is comparable to Modularity's network clustering technique, namely the maximization formula:where γ is the clustering resolution and ci is the element I cluster. Its size can be changed to produce varied resolution clusters. More clustering will result from a greater γ, and the

The classification will be more precise.The "choose threshold" option in VOSviewer determines how many clusters are present. The threshold for a co-authorship analysis is the bare minimum of a nation's or institution's documents. The threshold in co-occurrence analysis refers to the bare minimum of times a keyword appears. The threshold can be chosen based on our own requirements.Numerous fields have made extensive use of the VOSviewer program for bibliometric analysis. For instance, Santos et al. mapped knowledge networks on female entrepreneurship using VOSviewer [60]. The co-citation network of writers and journals on the foundations of hospitality was mapped by Sainaghi et al. research on performance measurement with VOSviewer [61]. Map-based bibliometric indicators for the worldwide research output on antibiotic resistance in urinary pathogens were visualized by Sweileh et al. using VOSviewer [62].The pertinent papers were obtained from Thomson Reuters' multidisciplinary Web of Science database's Science Citation Index Expanded (SCI-Expanded) and Social Science Citation Index (SSCI) [63]. All of the archived documents were searched using the following keywords:"protected area*," "natural reserve*," "conservation area*," "national park*," "national forest*," "marine protected area*," "wilderness area*," "frontier land*," "natural monument*," "biodiversity conservation," and "remote sensing" are examples of TS (Topic). Included were the articles that used any of those keywords or their variants (with*) in their keyword lists, abstracts, or titles [48].The abstract, keywords, referenced references, authors, title, and institution were all downloaded. Given that there were a lot more articles in professional journals and publications about remote sensing applications in PAs and related studies after 1991, we chose 1991 as the study's start year. Figure 1 depicts this. The date of the data collection was November 16, 2019. For this investigation, a total of 4546 records were obtained up till 2018. Of these records, 552 papers dealt with MPAs, and 3994 papers concentrated on the remote sensing monitoring of terrestrial PAs.

RESULTS

General Characteristics And Trends Of Publication Outputs

sshows the trend for publications between 1991 and 2018. With minor variations from year to year, the number of publications has generally been trending upward over time. The development of the published article output can be separated into three phases based on the dates.phases. The

first stage, which has a somewhat modest growth period, runs from 1991 to 2003. From 2004 to 2011, there is a period of consistent growth in the second stage. The third stage, which runs from 2012 to 2018, is one of rapid expansion.

A total of 108 subject categories were covered by the sample documents. Numerous issues and disciplines were covered within the research domain. Figure 2 shows the top 10 subject areas with over 200 papers. According to the findings, environmental sciences came in first with 1524 publications, followed by 1062 publications in remote sensing, 946 articles in ecology, and 652 publications in image science and photography technology. Other pertinent topic areas included water resources, forestry, biodiversity conservation, physical geography, multidisciplinary geosciences, and meteorological and atmospheric sciences.

Regarding the source journals, articles about remote sensing for PA monitoring were published in 739 distinct journals. The top 20 journals by total number of pertinent publications are displayed in Table 1. First place went to Remote Sensing of the Environment, which accounted for 256 papers or 5.63% of all publications. Sensing remotely came in second place with 174 articles (3.83%), followed by the International Journal of Remote Sensing in third place with 153 articles (3.37%). The International Journal of Applied Earth Observation and Geoinformation, Forest Ecology and Management, and the ISPRS Journal of Photogrammetry and Remote Sensing (ranked fourth, fifth, and sixth, respectively) contributed 2.02%, 2.11%, and 2.38%.

Countries, Institutions, And International Collaboration

The publications covered 153 different countries (or territories, referred to as "countries" for simplicity's sake) in total, according to the results that were obtained. Figure 3 displays the geographic distribution of the top 20 producing nations over the course of the study. First place went to the USA with a dominating output of 1655 papers, or 36.41% of the total. China ranked second with 619 papers (13.62%) and the UK ranked third with 479 papers (10.54%). Germany (7.92%), India (7.90%), Australia (7.11%), Canada (6.64%), and Italy (5.65%) are the other top-ranked nations. Figure 4 shows the network of the major nations that was the subject of the co-authorship analysis.More than 60 papers were published by these nations. The network was divided into four major clusters (Table 2). The UK displayed 14,335 citations, while the USA displayed 62,644 citations with a link strength of 634.had a link strength of 241, whereas China outperformed all other clusters with 12,906 citations and a link strength of 265. With a link strength of 151.93, the USA and China had the greatest relationship, followed by the USA and Canada at 64.89, the USA and the UK at 58.69, and the USA and Germany at 49.93. Brazil and the USA have a 43.59 link strength, while the USA and Australia have a 46.48 connection strength.

The findings show that 4451 institutions contributed to the articles under analysis. In Table 3, the top 15 research institutes with the most documents are given. With 296 publications, the Chinese Academy of Sciences was by far the most productive organization in China. The University of Maryland, with 118 publications, came in second. In terms of citations, the Chinese Academy of Sciences came in first, followed by the U.S. Forest Service, NASA, and the University of Maryland.Figure 5 shows an institutional cooperation network for creating scientific maps that is based on the VOSviewer software. The four collaboration clusters among the productive institutions with 35 or more publications are shown in this figure. There are nine in the largest cluster (red). establishments. The United States owns every institution in the red cluster. There are five institutions in each of the blue and green clusters. The remaining three institutions in the green cluster are from Australia, the United Kingdom, and the United States, while two are from the Netherlands. Two American institutions and three Chinese institutions make up the blue cluster. Three Canadian institutions are included in the fourth cluster (yellow). It is evident that the majority of institutional collaboration takes place within the same nation or its neighbors.

Common Interests In Research Topics

A fundamental component of papers, keywords provide a highly condensed version of the substance of a work. The selection of keywords in pertinent studies must be rigorously examined in order to comprehend the focal areas and development trends of one discipline [64]. Table 4 displays the top 20 most commonly used Research on PA monitoring that focuses on deforestation and biodiversity conservation uses author keywords from 1991 to 2018, such as "remote sensing," "GIS," "Landsat," "deforestation," "LiDAR," "conservation," and "biodiversity." In order to compare the changes in common research subjects and the evolution of PA monitoring studies, it is helpful to statistically analyze the changes in author keywords between stages [19,65,66]. The evolution of PA monitoring research is divided into 1991–2003, 2004–2011, and 2012–2018 are the three phases. The most popular author keywords were "Landsat" and "Remote sensing," which were in the top 20 during all three times. From 1991 to 2011, the frequency of presence of the keywords "MODIS" and "LiDAR" grew, and from 2012 to 2018, they climbed even more, suggesting that the platform was crucial to PA monitoring.The rankings of the keywords varied significantly between the three periods. From 2012 to 2018, the term "climate change" started to rank among the top 10, indicating that PA research was beginning to pay greater attention to this issue. Each stage's research focus is as follows.Early study focuses on human disturbance and ecological changes in landscapes. The detection of changes

in land cover and land use brought on by deforestation is the main objective of the middle stage. The influence of climate change on PAs is the main topic of the latter stage.

The most often chosen keywords pertaining to satellites and sensors were tallied in order to track the trend of the remote sensing data used in PAs research. The top 10 are Sentinel (Sentinel-1 and Sentinel-2), Landsat, MODIS, LiDAR, SPOT, AVHRR, ASTER, IKONOS, PALSAR, and WorldView.using sensors with low, moderate, or high resolution. Figure 6 displays the top 10 satellites and sensors' yearly publications. With 1078 publications, Landsat was the most often utilized satellite and sensor type in terms of quantity. MODIS and LiDAR came in second and third, respectively, with 439 and 370 papers. Furthermore, as remote sensing technology continues to advance, new platforms and satellites have surfaced and been used to monitor PAs in recent years. For instance, between 2001 and 2008, there were 26 studies on small satellites and 35 papers on UAV monitoring of PA.Table 5 also includes the remote sensing monitoring techniques based on the co-occurrence analysis. Classification, time-series analysis, model methods, object-oriented methods, visual analysis, direct comparisons, and hybrid methods are the primary techniques used in remote sensing monitoring [67,68].With 526 papers and 11.57% of all publications, the classification approach is in first place. Time-series analysis comes in second (288, 6.34%) and the model method comes in third (159, 3.50%).To determine the research front in terms of subject trends for PA monitoring, Figure 7 displays a co-occurrence network analysis of the keywords. According to our research, a keyword must appear at least thirty times in titles and abstracts across all publications. The subject of the study of PA monitoring was divided into six colored clusters, which underwent the following analysis."Land cover" is at the top of the red cluster with the most keywords (12); Furthermore, "land use," "hyperspectral," "monitoring," "mapping," and "classification" are also this cluster's primary buzzwords. Studies on the classification of land use and land cover using hyperspectral remote sensing data are linked to the majority of the keywords in this cluster. With eleven keywords, the blue cluster has Its primary connected terms are "Landsat," "MODIS," "NDVI," "climate change," "change detection," and "wetland," which show up in the pertinent studies on the mapping of PA habitats, the detection of changes, and the effects of climate change. The terms "deforestation," "LiDAR," "REDD," "biomass," "forest inventory," "tropical forest," "forest management," and "carbon" are the main emphasis of the green cluster (11 keywords). This cluster's keywords are closely associated with using LiDAR data to estimate forest biomass and carbon storage in PAs.Out of the ten keywords in the yellow cluster, "remote sensing" and "conservation" are the most commonly used; biodiversity, "protected areas," and "fragmentation" rank third through fifth, respectively. The majority of this cluster's keywords are related to the application of remote sensing to PAs to aid in biodiversity conservation. The purple cluster contains four keywords: "land-use change," "land-cover change," "ecosystem service," and "landscape metrics." This cluster pertains to the examination of changes in land use and cover and assessment of ecosystem services using landscape measurements and remote sensing. There are just three terms in the orange cluster. There are 387 instances of the keyword "GIS," which is the most common."Soil erosion" and "RUSLE (The Revised Soil Loss Equation)" are the other two keywords. Using the GIS analysis method, this cluster is associated with keywords pertaining to the investigation of soil erosion and its spatial distribution in PAs.

DISCUSSION

In this work, we uncovered buried knowledge beneath this important body of research by recovering the pertinent literature on remote sensing monitoring protected areas. The number of publications indicates a trend of steady increase, indicating that an increasing number of academics have taken notice.to this area of study. Remote sensing monitoring of PAs is a field intimately related to environmental science, remote sensing, and ecology, as evidenced by the fact that environmental sciences scored first among subject categories, followed by remote sensing and ecology. The International Journal of Remote Sensing, the ISPRS Journal of Photogrammetry and Remote Sensing, and Remote Sensing of the Environment are the top three renowned journals in the subject of remote sensing. The long-term development of remote sensing monitoring for PAs is not aided by the relatively close interaction among national research organizations and the very low level of international cooperation. Institutions and nations should icrease their expertise.exchanges and collaboration to host pertinent academic forums and conferences in order to more successfully debate research trends and status in the field The United States is the top country of origin. Furthermore, the majority of the top 20 nations are in Europe. The Chinese Academy of Sciences published the most publications when institutions were taken into account. There are more research institutes in the US than any other country.the top 15, which makes up over half of them. The USA was identified as the focal point of international cooperation by this study's co-authorship analysis of nations and organizations.

According to the analysis's findings, research has mostly focused on terrestrial PAs, with comparatively little literature on MPA monitoring. In order to create a long-term, scientific, and systematic monitoring system, future research should fully utilize new monitoring technologies and methodologies. system and so offer a framework based on evidence for

assessing MPA efficacy. It is evident from the shifts in keywords that the primary goals of remote sensing monitoring of PAs were biodiversity preservation, vegetation classification, landscape pattern analysis, and tracking changes in PAs. The effect of climate change on PAs will be the main focus of future research directions.

When taking temporal variation into account, there is a noticeable upward and downward trend in the utilization of Landsat, MODIS, and LiDAR. In recent years, the usage of LiDAR and SAR for landscape monitoring and assessment has grown. These days, several satellites and sensors are used in various domains and at distinct PA scales. Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI) are a few examples of Landsat products that can be used to track vegetation dynamics and evaluate changes in land-cover and land-use. MODIS sensors, on the other hand, can give high temporal resolution time series data at the landscape, regional, and global spatial scales and are better suited for monitoring forest fires and vegetation phenology.In vast regions of the planet, LiDAR enables the estimation of tree height, biomass, and leaf area index [69, 70]. At small and medium scales, SAR makes it easier to estimate tree height and forest biomass [71]. Additionally, SPOT or Species or particular vegetation change monitoring can be done with QuickBird [72–74]. The primary purpose of AVHRR sensors is to examine how vegetation coverage in PAs is affected by climate change. Land-cover/land-use change in PAs can also be studied using ASTER's high spatial resolution [75]. IKONOS and WorldView are two more high-resolution satellites that concentrate on mapping vegetation types or habitat linked to endangered animals [76,77].With the quick advancement of satellites, sensors, and methodologies in recent years, remote sensing applications have become widely used in PA management and monitoring. The pertinent study findings for raising the standard of monitoring in PAs, creating distinct regional Policies for safeguarding and directing sustainable development are crucial. This bibliometric study indicates that the inventory and classification of vegetation, change detection, habitat degradation, the effects of climate change, and biodiversity protection have been the primary areas of research on the remote sensing monitoring of PAs. The most popular approaches for PA monitoring were those involving classification, time series analysis, and modeling. There will likely be more innovative ways to keep an eye on PAs in the near future. For instance, big data techniques are being used to handle massive volumes of data from remote sensing [78–80].

This study still has several limitations. First off, not all scientific journals and topic books are indexed by the one database we used, which may leave out some pertinent articles. For instance, there is some gray literature on this subject from non-profits, government organizations, and nature conservancies. may have been left out. Reducing omissions in the study can be achieved by broadening the search over several databases, including Scopus and Google Scholar. Second, some older studies can be missed if 1991 is chosen as the beginning year. However, starting in 1991, the majority of papers pertinent to PAs' use of remote sensing were published in scholarly publications. As a result, we think that 1991 is still a suitable and representative beginning point. Thirdly, the program VOSviewer has some functional limitations. It should be noted that in the future, VOSviewer may be used in conjunction with other bibliometric analysis tools, such Citespace, to cover the published research on PA remote sensing ingreater detail. By restricting the search to "remote sensing" alone, we accept that it is very difficult to cover all remote sensing applications for PAs. Additional phrases and explanations like "land-cover monitoring," "landscape configuration," and

Among other instances, "composition," "habitat analysis," "biodiversity conservation," and "bathymetry assessment" may be highly pertinent to research in protected areas using remote sensing applications, but they might be overlooked in the analysis. This is especially valid for tracking shifting terrestrial and marine ecosystems that are impacted by both man-made and natural disturbances in protected areas. This problem may be remedied when bibliometric analysis searches can incorporate the entire contents of published papers utilizing advanced technologies like artificial intelligence and big data, rather than relying just on a restricted number of carefully chosen keywords.

CONCLUSIONS

This study examined worldwide research and publishing patterns in the field of PA remote sensing monitoring between 1991 and 2018. Document types, publishing output, subject categories, source journals, nations, organizations, and keywords were the eight primary components of this analysis. The findings revealed that the number of articles has been rising regularly and quickly since 2004. The greatest topic area was environmental sciences. The two journals on remote sensing and remote sensing of the environment published the most papers. The greatest number of publications on the use of remote sensing technology in PA monitoring came from the USA. In these kinds of investigations, American-affiliated institutions have a vast quantity of publications and a strong worldwide partnership.The most widely utilized sensors and satellites are LiDAR, MODIS, and Landsat. The majority of the research was devoted to model approaches, time-series analysis, and classification. The chosen keywords show that "Landsat,"Deforestation," "LiDAR," "conservation," and "biodiversity" are some of the most frequently observed topics in PA remote sensing. The primary goals of research on PA monitoring with remote sensing are change detection,

biodiversity preservation, and the effects of climate change. We should keep an eye on the hot places and development patterns for PA remote sensing monitoring in the future. International research cooperation should be aggressively promoted and the interchange of ideas should be strengthened by researchers from all nations.

Author Contributions

P.D. planned the study, gathered information, examined the findings, and penned the initial manuscript.The research was conceived and the manuscript was reviewed by Y.W. The data was analyzed and visualized by P.Y. The published version of the manuscript has been read and approved by all authors.

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Conflicts of Interest

No conflicts of interest are disclosed by the writers.

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