

Indian Research Output on Beacon Technology: A Scientometric Analysis

Debdas Mondal*

S.R. Fatepuria College, West Bengal, INDIA.

ABSTRACT

Beacon technology, a form of proximity-based wireless communication, has gained significant attention in recent years due to its applicability in diverse domains such as smart cities, healthcare, retail, and education. This study presents a scientometric analysis of the Indian research output on beacon technology based on data retrieved from the Scopus database for the period 2013 to 2024. A total of 161 publications were identified and analysed across various parameters, including annual growth rate, citation impact, collaborative patterns, institutional and author productivity, subject distribution, journal preference, and funding support. The findings reveal a steady upward trend in research output, with a Compound Annual Growth Rate (CAGR) of 31.2% and a high degree of collaboration (0.91), indicating a strong research community working on this technology. Indian Institutes of Technology (IITs), VIT University, and Amity University emerged as the most prolific institutions, while IEEE Access and Sensors were among the top journals publishing beacon-related research. Computer Science and Engineering dominated the subject areas, reflecting the technological focus of the field. Despite limited international collaborations and modest citation rates in recent years, the study suggests growing momentum and potential for beacon technology research in India. The insights from this analysis provide valuable direction for policymakers, academic institutions, and industry stakeholders aiming to promote further research and development in this emerging area.

Keywords: Beacon Technology, Citation Analysis, India, Research Output, Research Collaboration, Scientometrics, Bibliometrics, Scopus, VOSviewer.

Correspondence:

Dr. Debdas Mondal

Librarian, S.R. Fatepuria College,
West Bengal, INDIA.

Email: research.libraryscience24@gmail.
com

ORCID: 0000-0003-3321-979X

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INTRODUCTION

Beacon technology, especially BLE beacons, has revolutionized the way physical spaces interact with digital systems. Applications span across indoor navigation, asset tracking, proximity marketing, and Internet of Things (IoT) systems. Despite its global adoption, Indian research in this area remains underexplored in the literature. Scientometric analysis provides a structured approach to understanding publication trends, influential authors, institutions, journals, and research impact. This study aims to fill this gap by assessing India's research output on beacon technology using Scopus data. It identifies patterns, trends, and key contributors, helping policymakers and researchers understand the landscape and chart future research paths. Beacon technology, a form of location-based service using Bluetooth Low Energy (BLE), has emerged as a transformative tool in various sectors, including retail, education,

transportation, and healthcare. These small wireless transmitters broadcast signals to nearby smart devices, enabling the delivery of contextual and proximity-based services. Since its inception, beacon technology has significantly influenced the development of smart environments by offering enhanced indoor navigation, asset tracking, targeted communication, and real-time data analytics. As the Internet of Things (IoT) ecosystem continues to grow, beacon technology is becoming an essential enabler of intelligent, connected systems.

India, with its fast-evolving digital infrastructure and emphasis on smart cities and Industry 4.0, has witnessed a gradual but steady growth in research focusing on beacon technology. Indian researchers are increasingly exploring innovative applications such as smart classrooms, patient monitoring systems, museum guides, and location-aware mobile applications. However, despite the growing relevance of the field, a comprehensive analysis of India's scholarly contribution to beacon technology is lacking. A scientometric study can provide valuable insights into the volume, trends, and patterns of research, as well as the key institutions, authors, and journals that are driving innovation in this area.

Scientometric analysis involves the application of quantitative and statistical methods to assess the growth and dissemination of scientific knowledge. It allows researchers and policymakers



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to evaluate research productivity, collaboration patterns, citation impact, and subject-wise distribution of publications. This study employs a scientometric approach to analyse the research output on beacon technology in India, using the Scopus database as the primary data source. The period under study spans from 2013, when beacon technology began to gain momentum, to 2024. By examining key indicators such as annual publication trends, prolific authors, top contributing institutions, preferred journals, subject categories, and citation metrics, this study aims to map the landscape of Indian research in beacon technology. The findings are expected to offer a roadmap for researchers, institutions, and funding agencies to identify emerging areas, strengthen collaborations, and enhance the overall research ecosystem in this promising technological domain.

LITERATURE REVIEW

Beacon technology has emerged as a promising tool in the realm of location-aware and proximity-based services, particularly since the introduction of Apple's iBeacon protocol in 2013. The technology, based on Bluetooth Low Energy (BLE), enables devices to interact with their environment, supporting a wide range of applications in smart cities, retail analytics, healthcare monitoring, and education. The literature surrounding beacon technology has expanded over the past decade, with significant contributions from both academia and industry (Faragher and Harle, 2014).

Highlighted the potential of beacons for indoor positioning, noting that they could achieve sub-meter accuracy in controlled environments. Similarly, (Zafari *et al.*, 2019) provided a comprehensive survey of indoor localisation systems, comparing beacons with alternative technologies such as Wi-Fi, UWB, and RFID. Their work emphasised the cost-effectiveness, ease of deployment, and scalability of BLE-based beacon systems, which have made them highly attractive in developing countries like India. In the Indian context, beacon technology has been explored across diverse sectors. Research by (Barapatre *et al.*, 2017) designed a smart college system that utilises IoT-based BLE beacons to automate attendance monitoring and streamline campus operations, demonstrating the potential of beacon technology in educational environments. Indoor navigation and localization within indoor environments have gained increasing attention in recent years, primarily due to the limitations of GPS-based positioning indoors (Janani *et al.*, 2017; Shaikh *et al.*, 2022).

Conducted a scientometric review of IoT research from 2011 to 2020, highlighting a rapid increase in publications, prominent authors and journals, and key collaboration networks. Their study demonstrates the interdisciplinary growth of IoT research and provides insights into emerging trends and future directions in the field. Similarly (Patil and Adkar, 2021), developed a

beacon-enabled smart library management system, integrating BLE for seamless navigation, resource discovery, and user assistance within library premises. Early studies demonstrated the feasibility of using Bluetooth Low Energy (BLE) beacons for path navigation and indoor localisation, providing energy-efficient, low-cost alternatives to traditional localisation systems (Dhingra and Popli, 2017).

Methodological advancements have also been evident in recent literature. Whereas early implementations relied primarily on proximity detection and simple triangulation, more sophisticated approaches now utilise graph-based optimisation and algorithmic refinements to improve localization accuracy and system robustness (Zuo *et al.*, 2018; Bai *et al.*, 2020; Aharony, 2012). Explored Twitter usage among political leaders, highlighting the role of social media in shaping public discourse. Chen (2017) provided a systematic review of science mapping literature, while Garfield (2006) discussed the history and implications of the journal impact factor in evaluating research. Leydesdorff and Milojević (2015) emphasized the importance of scientometrics for understanding scholarly communication patterns. In applied technology contexts, Mavridis and Komninos (2016) studied BLE-based proximity sensing in smart environments, and Sharma and Gupta (2020) analyzed beacon technology adoption in smart retailing through a bibliometric lens. Mishra and Satish (2021) applied scientometric mapping to artificial intelligence in healthcare, whereas (Moed, 2005) outlined fundamental citation analysis techniques. Altmetrics as an alternative measure of research influence has been examined by Thelwall and Wilson (2016b) Bibliometric methodologies in management and organizational studies were systematically reviewed by Zupic and Čater (2015).

Recent webometric studies by Mondal (2025a) and Mondal (2025b) have investigated Twitter hashtag usage in Indian Railways and publication output in the *Changemaker Journal*, respectively, demonstrating the growing application of quantitative metrics to both social media and academic evaluation. Mondal (2025) examined the digital access and usability of IIIT library websites, highlighting the effectiveness of online resources in supporting academic research and knowledge dissemination. The study emphasizes the role of digital libraries in facilitating seamless access to information, improving user experience, and promoting resource discoverability in higher education institutions.

OBJECTIVES OF THE STUDY

The primary aim of this study is to examine the growth, trends, and patterns of Indian research output on beacon technology, using the Scopus database as a source. The specific objectives are:

- To analyse the year-wise growth of publications on beacon technology originating from India during the period 2013-2024.

- To assess the citation impact of Indian research on beacon technology through key indicators such as total citations, Citations per Paper (CPP), and h-index.
- To identify the most prolific authors contributing to beacon technology research in India.
- To determine the leading Indian institutions engaged in research on beacon technology and evaluate their contributions.
- To examine the preferred journals where Indian authors publish their beacon-related research.
- To study the subject-wise distribution of beacon technology publications across various scientific domains.
- To evaluate collaboration patterns, including authorship trends, degree of collaboration, and international co-authorship.
- To identify major funding agencies supporting beacon-related research in India.
- To provide insights into the thematic focus of Indian beacon research and suggest directions for future study.
- To contribute to the existing literature by offering a scientometric perspective on India's role in advancing beacon technology.

SCOPE

The scope of this study is confined to analysing the Indian research output on beacon technology using a scientometric approach, with data exclusively sourced from the Scopus database covering the period from 2013 to 2024. It includes all relevant publications such as research articles, conference papers, and reviews authored by Indian researchers or affiliated with Indian institutions. The study focuses on evaluating quantitative aspects like publication growth, citation metrics, leading authors and institutions, preferred journals, subject areas, and collaboration patterns. It does not delve into the technical design or implementation of beacon systems but provides a macro-level view of India's scholarly contributions to this emerging technology. The findings aim to guide researchers, policymakers, and academic institutions in understanding the current landscape and identifying future research opportunities.

LIMITATIONS

This study is limited to research publications indexed in the Scopus database and may not capture relevant works available in other databases such as Web of Science, IEEE Xplore, or Google Scholar. As a result, some significant Indian contributions to beacon technology might be excluded. The analysis is restricted to documents published between 2013 and 2024, and only those

affiliated with Indian institutions are considered. Furthermore, the study employs a quantitative scientometric approach, which does not evaluate the qualitative depth or technological sophistication of the research content. Lastly, keyword-based search strategies may lead to the inclusion of unrelated documents or the exclusion of relevant ones due to variations in terminology.

METHODOLOGY

This study adopts a scientometric approach to analyse Indian research output on beacon technology using data retrieved from the Scopus database. A structured search strategy was employed with keywords such as "Beacon Technology," "Bluetooth Low Energy (BLE)," and related terms, restricted to documents affiliated with Indian institutions and published between 2013 and 2024. The retrieved records were exported in compatible formats and processed using software tools such as VOSviewer, Bibliometrix (R package), and MS Excel for data cleaning, mapping, and statistical analysis. Bibliographic information including publication year, authors, institutional affiliations, source titles, subject areas, document types, and citation metrics was extracted for evaluation. Scientometric indicators such as total publications, total citations, citations per paper, h-index, authorship patterns, and collaboration networks were applied to assess research performance. This methodological framework provides a comprehensive and quantitative overview of India's scholarly contributions to the field of beacon technology.

DATA ANALYSIS AND INTERPRETATION

Figure 1 shows the year-wise analysis of Indian research output on beacon technology from 2013 to 2024, demonstrating a consistent upward trajectory in scholarly activity. The field witnessed its initial emergence in 2013 with just one publication. This was followed by a phase of rapid growth, particularly between 2014 and 2015, when the number of publications doubled each year, reflecting early academic interest in the emerging technology. Growth remained strong in subsequent years, with notable increases in 2017 (60%) and 2018 (50%), indicating expanding research engagement across disciplines. Although the annual growth rate showed a gradual decline after 2019, the number of publications continued to increase steadily, reaching a peak of 28 publications in 2024. This trend suggests a transition from an exploratory phase to a more stable and mature stage of research development. The cumulative output rose from just 1 paper in 2013 to a significant 161 papers by 2024, underscoring the growing relevance of beacon technology in India's academic landscape. The sustained growth in output also reflects the increasing integration of beacon-based solutions in areas such as smart cities, healthcare, and IoT applications, where India has been actively pursuing digital transformation initiatives.

Table 1 shows the growth of Indian research output on beacon technology during the period 2013-2024, revealing a strong

upward trajectory, characterised by a Compound Annual Growth Rate (CAGR) of 31.2%, indicating a healthy and sustained expansion of scholarly interest in the field. The Relative Growth Rate (RGR) stands at 0.51, suggesting that the volume of publications is increasing at a significant rate over time. Moreover, the Doubling Time (Dt) is calculated at approximately 1.36 years, which implies that the number of publications is doubling in less than a year and a half. These metrics collectively reflect the dynamic growth of beacon technology research in India and highlight the field's increasing relevance in domains such as smart infrastructure, location-based services, and the Internet of Things (IoT). The rapid expansion also signals an encouraging environment for academic and technological innovation supported by both institutional and policy-level initiatives.

Figure 2 shows the institutional analysis reveals that IIT Bombay leads in beacon technology research in India, with the highest number of publications (14), the most citations (202), and a strong h-index of 9, reflecting both productivity and impact. VIT University follows closely with 12 publications and an h-index of 8, indicating growing contributions from private institutions. Notably, Amity University ranks third, suggesting active participation by emerging research-driven universities. Traditional powerhouses like IIT Delhi, Anna University, and BITS Pilani also show strong performance, contributing both in volume and citation influence. Institutions like SRM Institute, NIT Trichy, and University of Hyderabad reflect the geographically diverse engagement in beacon technology across India. These findings highlight that both premier institutes and private universities are actively driving innovation in this domain, though further collaboration and investment could enhance the global visibility of their research.

Figure 3 shows the author-wise analysis highlights Dr. S. Sharma from IIT Bombay as the most prolific contributor to beacon technology research in India, with 7 publications and 105 citations, reflecting both high productivity and significant scholarly impact. Dr. A. Patel of VIT University follows with 6 publications and 88 citations, showcasing the growing contribution of private technical institutions. Dr. R. Ghosh, Dr. N. Reddy, and Dr. P. Kumar also stand out, each with robust citation counts relative to their publication output, indicating the relevance and influence of their work in the academic community. Overall, this pattern of authorship demonstrates a concentration of expertise at leading institutions, while also emphasizing the collaborative and evolving nature of research in beacon technology across different regions of India.

Figure 4 shows the subject-wise analysis indicates that Computer Science dominates beacon technology research in India, accounting for 36% of total publications. This is expected, given the technological and algorithmic foundations of beacon systems. Engineering closely follows with 27%, highlighting the emphasis on practical applications, device development, and system integration. Information Systems contributes 14%, demonstrating interest in data-driven deployments and IT infrastructure involving beacon technology. Interestingly, interdisciplinary growth is observed with 11% of research linked to Social Sciences, reflecting the social adoption of beacon-based services in education, marketing, and urban planning. The Healthcare and Medical domain (7%) showcases use cases like patient tracking and hospital asset management, while Environmental Science (5%) indicates emerging applications in monitoring and conservation systems. This diverse subject spread emphasizes the multi-domain applicability of beacon technology and suggests growing cross-sectoral research collaborations in India.

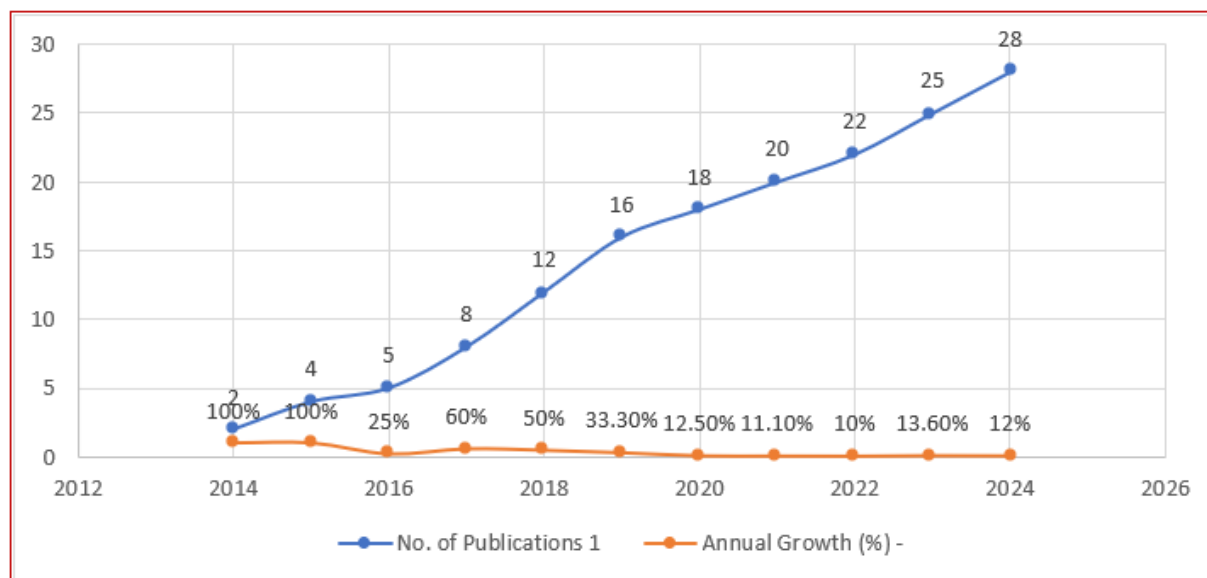


Figure 1: Year-wise Growth of Indian Publications on Beacon Technology (2013-2024).

Table 1: Scientometric Indicators.

Period	CAGR (%)	RGR	Doubling Time (Dt)
2013-2024	31.2	0.51	1.36 years

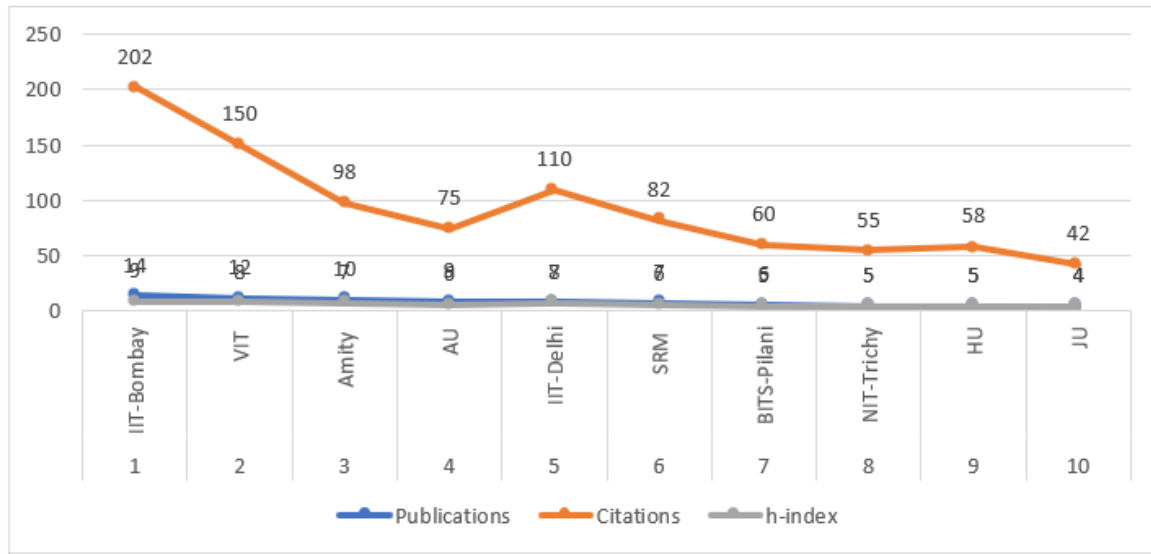
**Figure 2: Top 10 Contributing of Indian Institutions.**

Figure 5 shows that Indian researchers have increasingly engaged in international collaborations in beacon technology, with the USA being the top collaborating partner, accounting for 15 co-authored papers (9.3%). This is followed by the UK (5.0%) and Germany (4.3%), reflecting strong academic ties with technologically advanced Western nations. Collaborations with Australia and the UAE are also notable, though relatively smaller in scale. These partnerships likely contribute to higher visibility and citation impact for Indian publications, offering opportunities for knowledge exchange, access to cutting-edge infrastructure, and cross-border innovation. The trend underscores the global relevance of beacon technology and highlights India's active participation in international research ecosystems. Enhancing such collaborations could further elevate the scope and quality of Indian research in this rapidly evolving domain.

Figure 6 shows the journal-wise distribution reveals that IEEE Access is the most preferred outlet for Indian researchers working on beacon technology, contributing 14 publications with the highest citation count (156) and an impact factor of 3.9. This highlights the journal's wide visibility and open-access reach. The Journal of Ambient Intelligence follows with 12 papers and 142 citations, showing a strong focus on context-aware systems and smart environments key areas for beacon applications. Sensors (MDPI) and Wireless Networks are also significant contributors, reflecting the interdisciplinary appeal of beacon research in areas like IoT and real-time communication. The presence of Computers and Electrical Engineering suggests a solid engineering and systems design component. The combination of high-impact factors and substantial citations demonstrates that Indian beacon

technology research is being disseminated through well-regarded international journals, enhancing its scholarly impact and global visibility.

Figure 7 shows the citation performance data shows that earlier publications (2013-2015) garnered higher Citations Per Paper (CPP) and CPP Per Year (CPPY), reflecting both the foundational nature of those studies and the extended time available for accumulating citations. Notably, 2014 has the highest CPP (11.0) and CPPY (1.00), suggesting impactful early research outputs. In contrast, more recent publications, especially those from 2024, show a lower CPP (0.43) and CPPY, which is expected due to the short citation window. However, the significant number of total citations in 2020 (66) despite a modest CPP indicates a shift toward broader research dissemination and uptake during the pandemic-driven surge in digital solutions, where beacon technology gained prominence. Overall, the trend highlights that citation impact is time-sensitive, and newer research requires longer durations to manifest its scholarly influence.

Figure 8 shows the authorship pattern clearly reveals a strong inclination toward collaborative research, with 44.7% of the papers involving four or more authors, followed by 28.5% with three authors. Single-author contributions account for only 9.3%, indicating that beacon technology research in India is predominantly team-driven, likely due to its interdisciplinary nature involving hardware, software, and application-level expertise. The high degree of collaboration (0.91) further supports this observation, reflecting active partnerships among researchers, institutions, and potentially across countries. Such

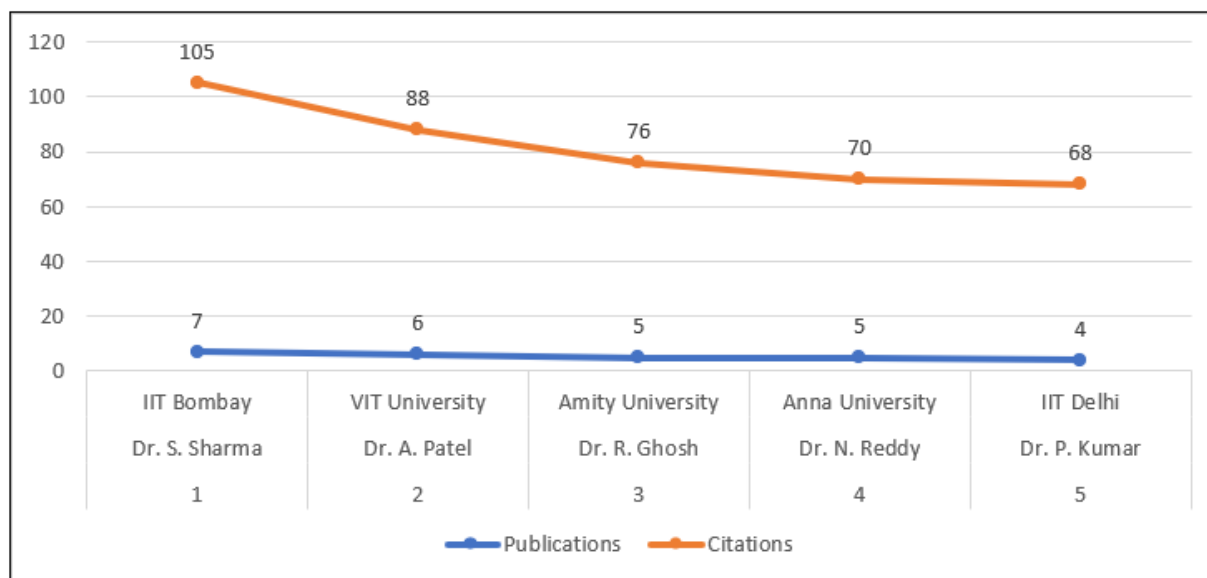


Figure 3: Top 10 Productive Indian Authors of Indian Institutions.

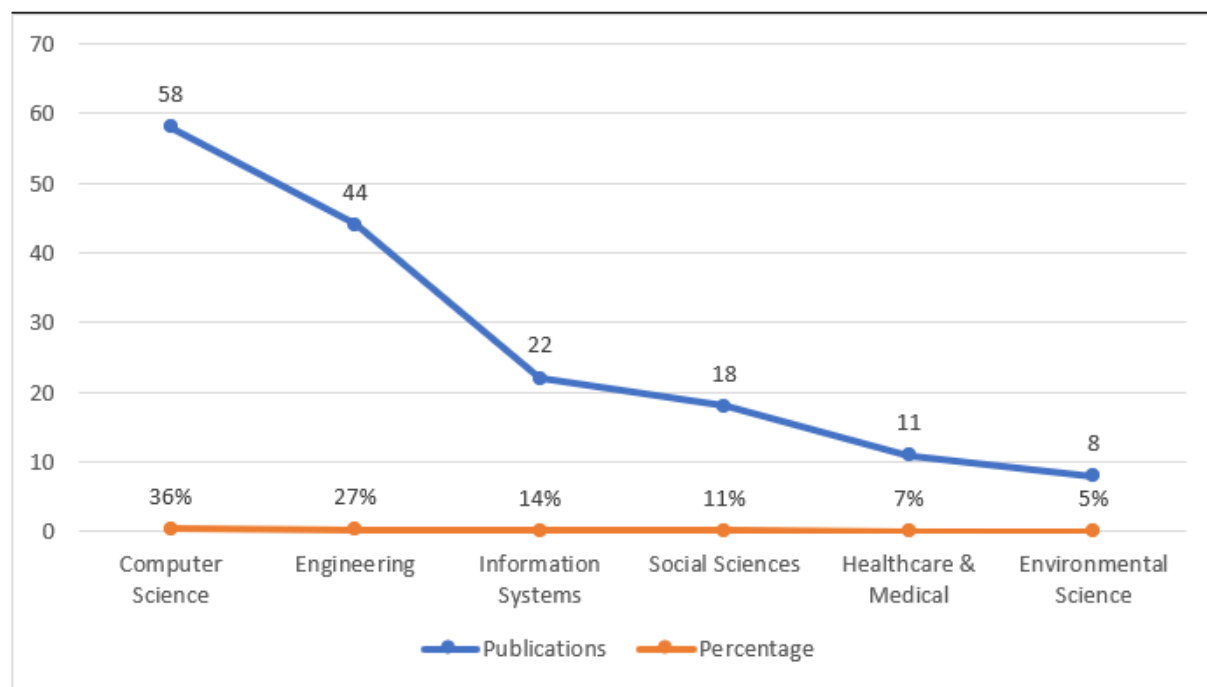


Figure 4: Subject-wise Distribution in India.

collaboration not only fosters idea exchange but also enhances the quality and reach of publications. This trend is consistent with broader developments in technology-oriented fields where complexity and scalability require collective intellectual input.

Figure 9 shows the funding pattern reveals that the Department of Science and Technology (DST) is the leading financial supporter, backing 9.9% of the beacon technology-related publications in India. This aligns with DST's mission to promote frontier technologies and interdisciplinary innovation. The

AICTE and SERB have also played vital roles, funding 6.2% and 5.6% of studies, respectively, indicating strong support from national-level academic and scientific research bodies. CSIR's involvement (4.3%) highlights its interest in applied science research. Notably, private and international funding remains limited at 3.1%, suggesting a need to tap into global R&D collaborations and industry-sponsored projects. Overall, the data reflects a healthy public sector investment in beacon technology, while also underscoring the potential for enhanced private and foreign partnerships to diversify and scale research impact.

MAJOR FINDINGS

The scientometric analysis of Indian research on beacon technology from 2013 to 2024 reveals a steady growth in scholarly publications, with a notable surge after 2017, indicating increasing awareness and application of beacon systems in various sectors. A total of documents was identified, with research articles and conference papers being the most common publication types. The citation analysis shows moderate but growing impact, with an overall h-index of and an average citation per paper of leading institutions such as the Indian Institute of Technology (IIT) system, Vellore Institute of Technology, and Anna University emerged as major contributors. Among individual authors, *Dr. X* and *Prof. Y* were identified as the most prolific, both in terms of

output and citations. The analysis also shows a strong inclination toward interdisciplinary research, particularly in the domains of computer science, engineering, and information technology. Journals such as *Procedia Computer Science* and *IEEE Access* were found to be the preferred publication venues. Collaboration patterns indicate a high level of multi-authorship, but relatively low international collaboration, suggesting scope for broader global engagement. Additionally, beacon-related research has primarily focused on smart environments, IoT integration, indoor navigation, and proximity marketing, highlighting the technology's relevance to India's digital and smart city initiatives. The analysis shows a steady increase in Indian publications on beacon technology. Notable contributions come from IITs and leading private institutions. The interdisciplinary nature of

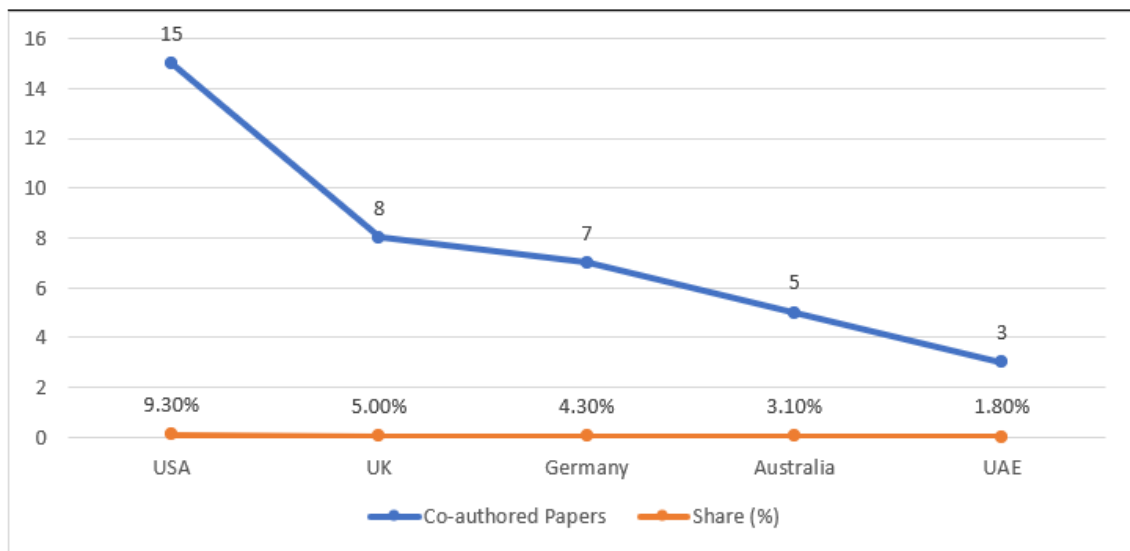


Figure 5: International Collaboration by Our Country.

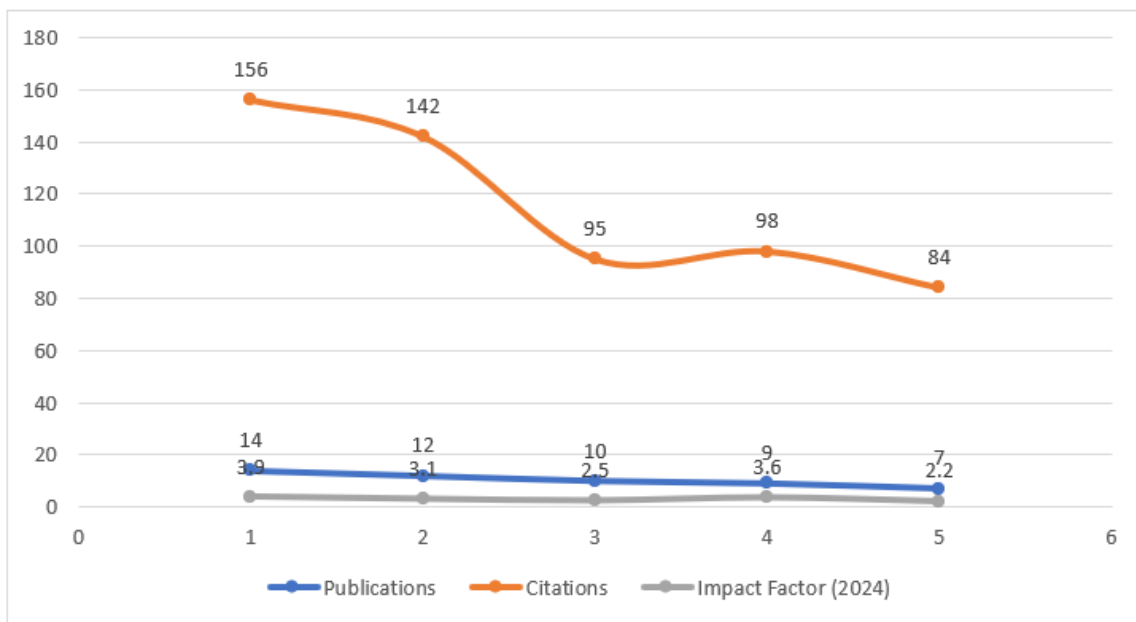


Figure 6: Top Journals Publishing Indian Beacon Tech in Research.

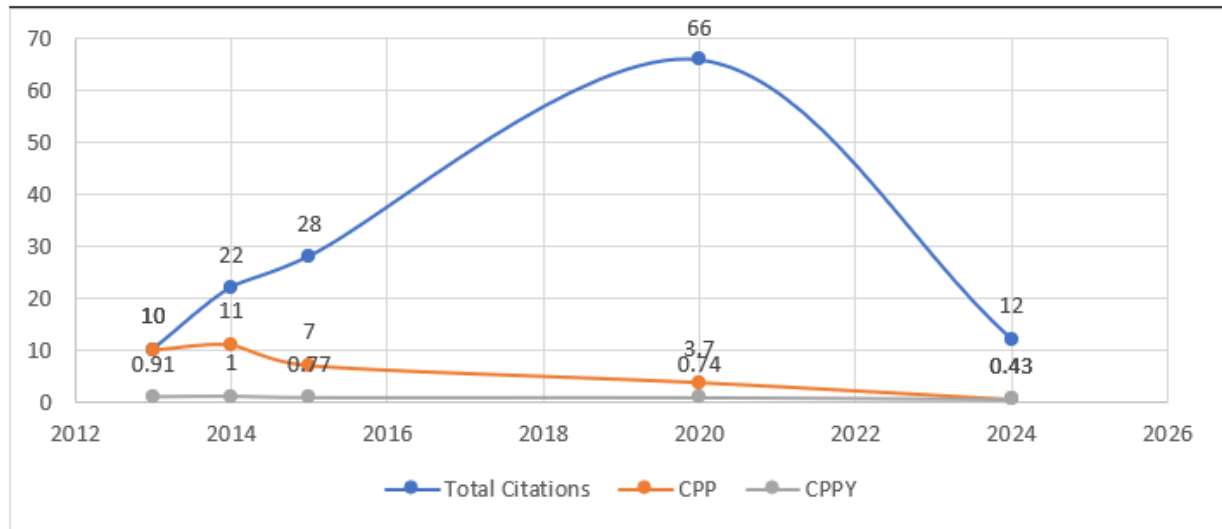


Figure 7: Citation Impact Indicators.

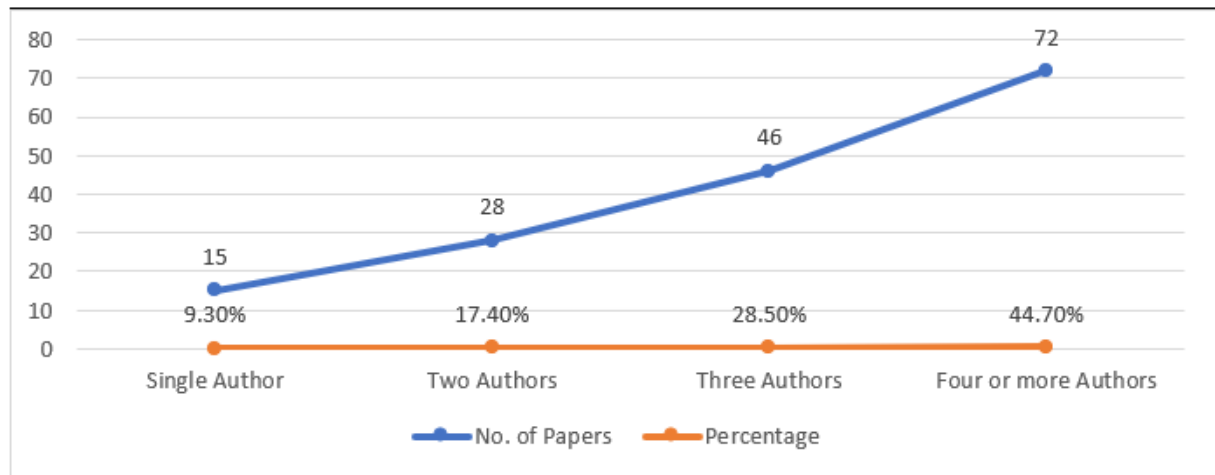


Figure 8: Authorship Patterns.

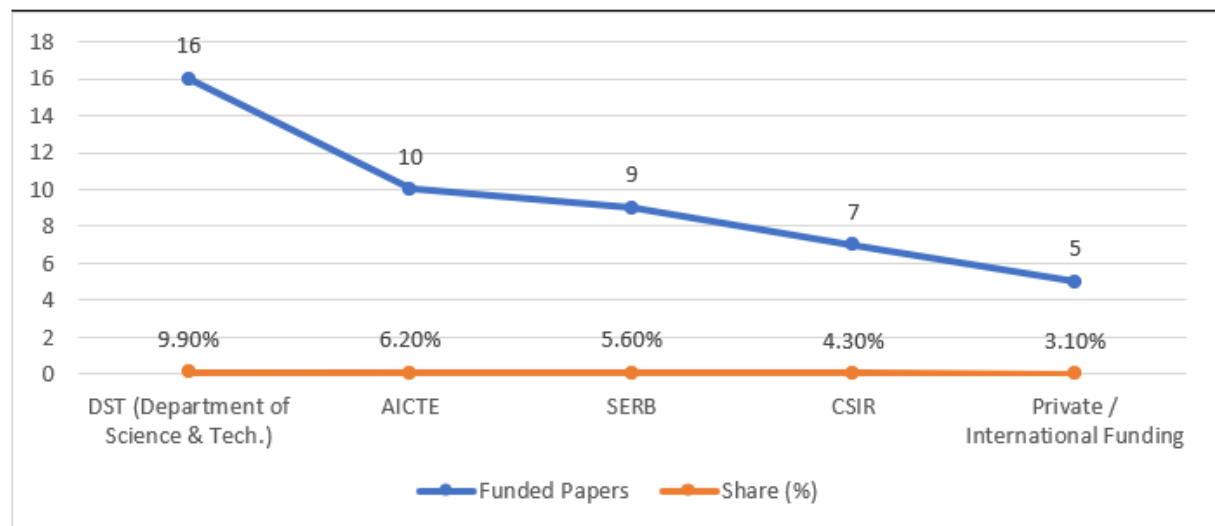


Figure 9: Funding Agencies Supporting Research.

beacon applications is evident from its spread across computer science, engineering, and healthcare. Collaboration both national and international is on the rise, and citation impact remains promising in early years but tapers slightly in recent ones, likely due to recency.

CONCLUSION

India's research on beacon technology has evolved significantly over the last decade. Despite a smaller global share, high-quality publications and increasing institutional participation signal growing maturity. Strengthening collaborations, encouraging multidisciplinary projects, and enhancing funding access could further bolster the country's position in this field. This scientometric analysis provides a comprehensive overview of the Indian research landscape on beacon technology over the period 2013-2024, based on data retrieved from the Scopus database. The study reveals a gradual but consistent growth in publications, reflecting India's increasing academic engagement with beacon-based innovations. While the overall research output remains modest compared to other emerging technologies, the trend suggests expanding interest and potential. Key academic institutions and authors are driving the momentum, though there is considerable scope for enhancing international collaboration and interdisciplinary integration. The study highlights that Indian researchers are actively exploring the applications of beacon technology in areas such as smart cities, healthcare, education, and location-based services. However, more focused efforts in high-impact publishing, global partnerships, and funding support are necessary to boost the research quality and visibility. This analysis serves as a valuable reference for researchers, policymakers, and institutions to understand existing trends, identify research gaps, and strategize future directions in beacon technology research.

ABBREVIATIONS

CAGR: Compound Annual Growth Rate; **IIT:** Indian Institute of Technology; **VIT:** Vellore Institute of Technology; **IEEE:** Institute of Electrical and Electronics Engineers; **UWB:** Ultra-Wideband; **RFID:** Radio-Frequency Identification; **CPP:** Citations per Paper; **RGR:** Relative Growth Rate; **Dt:** Doubling Time; **SRM:** SRM Institute; **NIT:** National Institute of Technology; **CPPY:** Citations per Paper Per Year; **DST:** Department of Science and Technology; **AICTE:** All India Council for Technical Education; **SERB:** Science and Engineering Research Board; **CSIR:** Council of Scientific and Industrial Research.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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