VOL. 14 , NO 1, 2026 (33-54)

JURNAL NATAPRAJA:
Kajian Ilmu Administrasi Negara

2406-9515 (p) / 2528-441X (e) https://journal.uny.ac.id/index.php/natapraja

A Decade of the Pentahelix Approach in Public Administration: A Bibliometric Analysis

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ARTICLE INFO

Article history:
Received 16 September 2025
Received in Revised from 29 November 2025
Accepted 18 February 2026

ABSTRACT

While the Pentahelix approach has been growing in the literature of collaborative governance, no systematic literature overview exists to portraying its conceptual progressions, thematic trends, and methodological patterns. This study aim to provides an overview of its development between 2015 and 2025 through a bibliometric analysis of 73 Scopus-indexed publications. The findings indicate that Indonesia a key driver in advancing the pentahelix approach. The model's application spread beyond conventional administrative settings encompass sustainability initiatives, tourism environmental management, and business innovation. However, it should be noted that the qualitative case studies continue to dominate research. This approach has little use quantitative or mixed-method and data-driven techniques like social network analysis and so artificial intelligence. Moreover, the analysis show that a dearth of across national and across sectors, comparative studies as well as of integration of urgent strategic especially digitalization and the circular economy. These gaps created robust advanced frameworks such as Pentahelix 4.0 and 5.0, incorporate digital technologies and big data as promoters of policy innovation. This paper emphasizes the value of interdisciplinary and empirically robust research to ensure that the pentahelix model can effectively promote strategic collaboration, innovation, and sustainable public governance.

Keyword:
Pentahelix, Paradigm, Public Administration, Bibliometrics

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https://doi.org/10.21831/natapraja.v14i1.89771

INTRODUCTION

Paradigm of modern public administration has shifted from a hierarchical bureaucratic model towards a collaborative governance approach that emphasizes multi-stakeholder participation in the formulation and implementation of public policy (Dupuy & Defacqz, 2022). In this context, the government is no longer the sole key actor, but acts as an enabler that orchestrates collaboration between the academic sector, business, community, and media to achieve sustainable development goals (Douglas et al., 2020). Kuhn, (2021) explains that paradigm shifts occur when existing theories are no longer able to address challenges or explain new phenomena, thereby prompting the emergence of more relevant conceptual frameworks. Science develops in phases of normal science when research proceeds within accepted paradigms, but unexplained anomalies accumulate and create a crisis that triggers a paradigm shift (Yu, 2022). In public administration, this shift is evident from the era of the classical bureaucratic paradigm to the current development of collaborative network-based approaches (Hattke & Vogel, 2023). Every paradigmatic transition is formed not only by theoretical knowledge but also by implementation needs to solve public problems that require fast and flexible solutions.

Public administration has developed multiple critical essential stages which have formulated its present-day form. The classical paradigm, introduced by Woodrow Wilson, emphasized a clear separation between politics and administration, marked by rigid hierarchies, procedural efficiency, and a centralized, formal organizational structure (Vogel & Hattke, 2022). Criticism of the technocratic and rigid nature of this paradigm gave rise to the neo-classical and human relations paradigms in the 1950s–1970s, which placed greater emphasis on organizational behavior, decision-making processes, and human interactions within bureaucracies. Subsequently, New Public Administration (NPA) emerged in the 1970s with a focus on social justice, citizen participation, and addressing inequality. NPM in the 1980s–1990s and the subsequent NPS only briefly emphasized market orientation and public service, but both left gaps in addressing the complexity of cross-actor issues. Due to increasingly high public demands and the growing complexity of issues, there is a need for actors other than the government to play a role, namely other actors who are connected to the issues.

These limitations led to the emergence of the post-NPM paradigm in the early 1990, which is oriented toward governance and networks. According George et.al (2023) The government operates in this framework because it no longer controls all decision-making processes but instead directs policy development through its role as government steerer while non-state organizations handle implementation work which includes business sector operations and civil society activities and academic research and media organization activities. Furthermore Osborne's (1992) argue that concept of “steering not rowing” became the main governing principle, because Osborn’s (1992) demonstrated that teh government as a facilitator, catalyst, regulator, and coordinator. Instead of implementer of policies role (Elliott et al., 2024). The collaborative governance model then developed which requires its participants to engage in decision-making through deliberation. It’s so differing both from bureaucratic system or market system (Bianchi et al., 2021; Dai & Azhar, 2024).

The pentahelix approach, the initiatives springing from collaboration take a very concrete form. The framework componens five primer stakeholders (government, academia, business, communitu group, and the media outlet) into a collaboration ecosystem. Several studies have found that the model’s demonstrates its ability to create sustainable solutions through various fields which include participatory village tourism development, regional

technological innovation, COVID-19 pandemic, and deradicalization efforts in conflict affected regions (Ardiansyah et al., 2023; Firmansyah et al., 2022; Novy Setia et al., 2023; Taufik et al., 2021). Pentahelix framework advance the capacity of governance by recognizing academic institutions and news organizations as separate but essential institutional components. This framework expansion describes a development of governance theory which now recognizes complex knowledge systems and shared accountability together with public value creation through both knowledge and communication domains (Ansell & Gash, 2007; Emerson et al., 2012; Minnes, 2019).

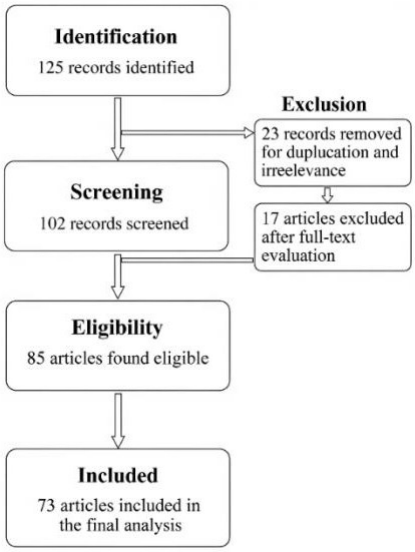
Study about public administration has resulted extensive scholarly domain, but direct studies that connect the pentahelix with public administration evolution remain underexplored. The existing research about the pentahelix has examined tourism and technology and crisis management as separate thematic areas without establishing connections to scientific paradigm shifts according to Hattke & Vogel (2023). However, understanding the pentahelix as part of the evolution of public administration will enrich theoretical and practical perspectives in public policy management. In addition, no bibliometric study has yet delineated the pentahelix as a developing paradigm of public administration, rather than merely a collaborative model. This literature gap opens up opportunities to explore the pentahelix's contribution to shaping a new governance model that is more collaborative, decentralized, and multi-actor-based.

Bibliometric analysis offers an appropriate method for comprehensively mapping the development of pentahelix research in public administration. Through bibliometric analysis, a topic can be scientifically evaluated in terms of its contribution over a certain period of time and research trends that can be explored in the future (Roziqin et al., 2022; Sulistyaningsih et al., 2024). However, not many studies have placed the pentahelix within the broader framework of the evolution of the public administration paradigm. This study aims to address this gap by mapping pentahelix research trends over the past decade, identifying research gaps, and formulating novelty that can enrich the development of public administration theory and practice. The research results are expected to contribute to strengthening adaptive public governance capacity while serving as a strategic reference for policymakers and cross-sectoral collaboration actors.

METHODS

This study uses a bibliometric approach to analyze the development of pentahelix studies in the context of public administration over the past decade (2015–2025). The bibliometric approach was chosen because it provides a quantitative and visual overview of knowledge development, topic trends, key actors, and patterns of collaboration among researchers (Donthu et al., 2021). Furthermore, a bibliometric study can illustrate a map of the distribution of knowledge structures, measurement, and assessment within a specific topic (Purnaweni et al., 2021). From bibliometric information, the researcher will find it simple asses to determine novelty in future research. Bibliometrics has secured substantial acknowledgment within the discipline of social and public administration research, because attributable to its capability to objectively reveal the correlations among several concepts through the systematic review of indexed scholarly work. The primary data source for this research was obtained from the Scopus database, its given comprehensive coverage, rigoros quality control, and its widespread acceptance in the international academic sholars. To indentify relevan studies, the search strategy employed the keywords “Pentahelix” OR “Penta Helix” which were combined with terms related in the field of public administration. The

literature search concentrated on original article which published within the past ten year to capture research developments while still allowing an examination of historical trends.



Source: processed by researchers, 2025

Figure 1. Systematic Literature Review Prosessed with PRISMA Framework sourced from Scopus database.

Figure 1 ilustrates the procedure for selecting the literature included in this study, which followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This stage represents part of the exclusion and inclusion process to determinan article are eligible for review. The selection prosess started with identification stage, where 125 documents obtained. The next stage is screening that result 102 articles after removing duplicates and irrelevant record, The eligibility stage through full text review to ensure consistency with the research objective. The final stage, only articles that explicitly explored the pentahelix in the context of public administration and contained suitable data for analysis. Its leaving final set data of 85 eligible articles. At the final inclusion stage resulted 73 articles that were selected for further analysis. The selected documents consist of scientific journals, conference proceedings, and research reports. All documents were downloaded in CSV format file from Scopus data base to enable extraction of metadata. The metadata analyzed in this study included publication year, journal source, document type, country of origin of the research, subject area, authors, and research methods employed. By adopting this approach, the analysis was performed in systematic manner and provided possibility replication by future researchers.

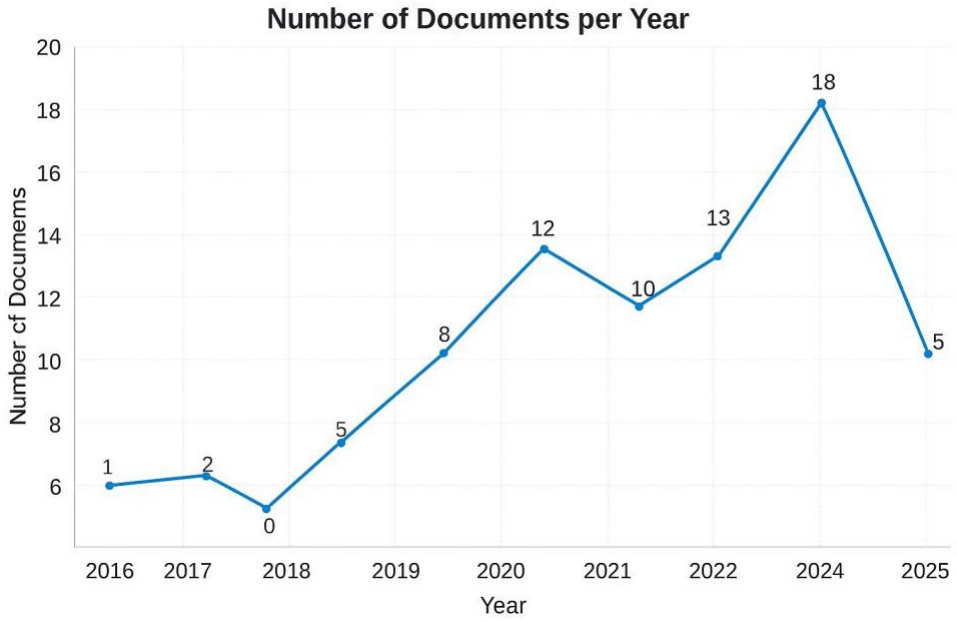
Data analysis was performed carried out using VOSviewer software, a tool specifically developed to visualize knowledge networks derived from bibliometric datasets. The features used include Co-Authorship to map collaborations between authors, Co-Occurrence to analyze keyword correlations and topic trends, Citation Analysis to identify the most influential articles, as well as Bibliographic Coupling and Co-Citation Analysis to understand the conceptual relationships between articles. We focused on these various features to visualize the scientific contribution of the pentahelix concept. In visualization, this study uses two main modes. First, Network Visualization, which maps relationships between entities such as authors, keywords, and documents in the form of a network of nodes and links. Second, Overlay Visualization, which is specifically used in Co-Occurrence analysis to display the development of topic trends over time. The results of this analysis are expected to identify research gaps, research trends, and opportunities for novelty in pentahelix studies in the

field of public administration. These findings not only contribute to conceptual knowledge mapping but also serve as a basis for the development of theory, policy, and multi-stakeholder collaboration practices in public governance.

RESULT AND DISCUSSIONS

Findings From Scopus analysis results

To understand the pattern of scientific development of the pentahelix approach in research, it is necessary to examine the number of articles published in the last 10 years. The following presents the results of the analysis based on Scopus analysis results.



Source: Scopus analysis results, 2025

Figure 2. Documents by year

The first publication on pentahelix appeared in 2016 in a paper published in the International Conference on ICT for Smart Society, ICISS 2016, authored by Effendi, D., Syukri, F., Subiyanto, A.F., and Utdityasan, R.N. This paper discusses the Smart City developed by Telkom. The paper highlights the implementation of information technology in the context of city management, taking into account local wisdom based on the pentahelix model. The research findings indicate that each component of the pentahelix model plays a distinct role in the development of the Smart City Nusantara initiative. In 2017, the first journal publication on the pentahelix model was published, titled “The penta helix model of innovation in Oman: An HEI perspective,” authored by Halibas, A.S., Sibayan, R.O., and Maata,

R.L.R. This study offers an academic perspective on the role of HEIs (Higher Education Institutions) in utilizing the Penta Helix innovation network for business and social innovation. The article discusses the opportunities and challenges in fostering an innovation culture (Halibas et al., 2017).

The second article discusses how the community in the study area (Jatinagor) is already familiar with the concept of green marketing, but their daily behaviors are not yet oriented toward green marketing. A community education model for green- oriented marketing must involve the Penta Helix, which includes the community, academia, government, businesses, and media (Subagyo, 2021). In 2018, there were no publications on the penta-helix,

indicating a lack of attention, recognition, or interest in this concept in research. In 2019, publications began to reappear (5 documents), marking the initial adoption of the penta-helix concept. In 2020, publications increased slightly. There were 8 publications on the pentahelix model, indicating that more academics are beginning to explore this approach. In 2021, there was a significant increase, with 12 documents discussing the pentahelix concept.

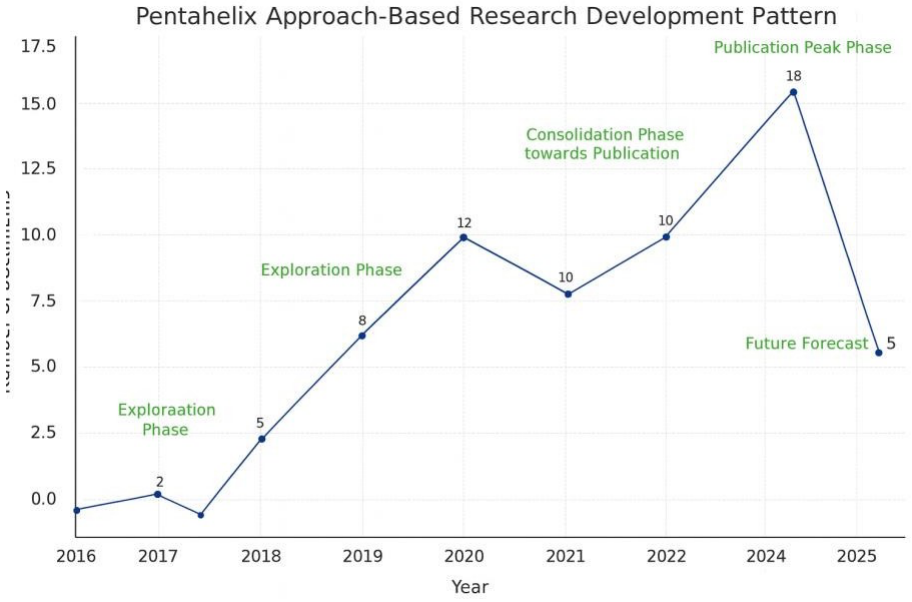
The increasing application of the collaborative governance model with the pentahelix approach is evident in various fields, including public policy, innovation, and regional development (Arianti, 2018). This is likely due to a strong push to create synergy among actors to produce more sustainable and adaptive solutions. In 2022 and 2024, the pentahelix concept continued to show sustainability, although in 2022 there was a downward trend, though not very significant. In 2024, the highest number of publications (18 documents) was recorded, indicating that this concept has reached its peak in academic popularity and is increasingly accepted in research and policy. Meanwhile, in 2025, there were only 4 publications on the pentahelix concept. There is a possibility that publications will continue to increase due to the ongoing Scopus indexing process. There is a possibility that the research trend may increase or decrease. If the trend increases from the previous year, this concept is still highly sought after by academics. If the research trend on this concept decreases, this indicates saturation or a shift toward newer approaches. This is natural in the evolution of scientific paradigms, as stated by (Kuhn, 2021).

At this point, the fluctuations in publication trends can be associated with the broader developmental cycle of public administration theory, which typically progresses from emergence and diffusion to maturity and eventual shifts toward new approaches. The sharp rise in 2021 can be attributed to the surge in post-pandemic research, as many scholars underscored the importance of multi-actor collaboration, cross-institutional coordination, and more adaptive governance models for navigating uncertainty. The pandemic intensified the involvement of government, communities, academia, businesses, and the media in addressing public challenges, making the pentahelix concept particularly relevant and contributing to the rise in related publications (Choi, 2020). The rise publication in 2024 reflects a stage of conceptual maturity. At this stage, academics tend to utilize established concepts that are easily applied in various context, which a lead to higher number of publications.

A concept or approach may reach a saturation point when the dominant paradigm files to produce new innovations and instead reproduces previously established findings. The Alternative research direction, may explore by examining how pentahelix approach is applied within specific policies contexts like smart cities, digital transformation, or environmental sustainability initiatives. The pentahelix is not only relevant in public administration but also in innovation management, the creative economy, education policy, and sustainable development. Future research could focus more on the synergy of actors across various sectors and regions. From the above description, the development pattern of the pentahelix approach can be illustrated based on Rogers' (2003) concept of innovation adoption, which discusses the stages of innovation diffusion that are highly relevant for applying new concepts (such as pentahelix) in scientific communities and the broader society, namely : Innovation/Exploration Phase (innovation/knowledge), Early Adoption Phase (persuasion/decision), Growth/Diffusion Phase (implementation), Consolidation/Peak Phase (confirmation), and Normalization or Decline Phase (when adoption reaches its peak, then stabilizes or declines).

The development pattern of pentahelix research can be analysed through Rogers et al. (2019) innovation adoption framework, with each phase clearly reflected in the dynamics of

scientific publications. Innovation/exploration phase is evident when this concept is not yet widely discussed and is still in its early stages of introduction in the academic community. Early adoption phase begins to appear when researchers start to test the relevance of pentahelix through exploratory studies, especially in the context of local policy and regional development. The surge in attention in 2021 reflects the growth/diffusion phase, reinforced by a wave of post-pandemic research on multi-actor collaboration and cross-institutional coordination. Next, the consolidation/peak phase saw the pentahelix being used as an established analytical framework in various sectors such as innovation, digital governance, and sustainability. Latest trends indicate a normalisation/decline phase, with academic attention shifting to alternative collaborative approaches, bringing the pentahelix into a stable or saturated phase as predicted in the innovation adoption cycle.



Source: Author analysis, 2025

Figure 3. Development Patterns Based on the Pentahelix Approach

Based on Figure 3 regarding the graph of the development pattern of research based on the pentahelix approach, it can be explained that at the beginning of the use of this concept, the figure shows that the exploration phase indicates that the number of publications is very minimal, only reaching 1 to 2 documents per year, and in 2018, there were no publications using the pentahelix approach. This situation indicates that the pentahelix approach is still in its early stages in the field of public administration and policy research. (Effendi, D., Syukri, F., Subiyanto, AF, Utdityasan, 2016) in their proceedings noted this phase with the first publication related to the pentahelix, which formulated the concept through the development of a Smart City based on local wisdom. This underscores that the initial introduction and application of innovative concepts require time, in line with the findings of Halibas and team (2017), who emphasize the important role of academic actors (HEIs) in the dissemination of innovation. In the adoption phase, an increase in the number of publications began to be seen in 2019 with 5 documents, which increased again in 2020 to 8 documents. This indicates that the pentahelix approach is beginning to be accepted in studies and policy practices. The success of collaboration between various parties, as described by (Deliana et al., 2017) in the context of green marketing, also contributes to this. This phase is similar to the “take-off” stage in the innovation diffusion cycle (Rogers, 2003), where new ideas begin to be more widely accepted by the scientific community.

There has been a very rapid growth in the number of publications, with a total of 12 documents in 2021 and increasing to 13 documents in 2023. It is estimated that this number will peak at 18 documents in 2024. This period indicates that diffusion has occurred effectively, as the research ecosystem has developed well and the pentahelix model has begun to be accepted as a framework for inter-sectoral collaboration in management, innovation, and regional development (Halibas et al., 2017; Effendi et al., 2016). The relevan of this model has grown significantly in addressing the complex challenges of public policy in the digital era and during the transition from Society 4.0 to 5.0. In 2024, recordef the highest number of publications. totaling 18 documents, indicating a high level of recognition and acceptance of the pentahelix concept within academic literature. Nevertheless, the number of publications decrease in 2025 with only five documents published. The phenomenon may reflect a normalization prosses or even indicate beginning of a new research cycle, which may also be influenced by delays in the indexing of publication.

This pattern aligns "innovation life cycle", which explains that rapid growth is often followed by stabilization or adjustment phase (plateau) before new innovations or approaches emerge. The development pattern of the pentahelix approach above reinforces the argument that the pentahelix model functions well as a framework for collaboration among various parties, including the government, academia, the business sector, the community, and the media, in addressing complex public governance challenges. According to Effendi and colleagues (2016) and Halibas and team (2017), the importance of synergy among actors is highly influential in creating innovation and driving social change. The pentahelix model also differs from the triple helix model by incorporating community and media elements, which are increasingly important in the digital age and as information becomes more open. In line with global trends, where collaboration among various actors is key to the success of sustainable development (UNWTO, 1999)

Furthermore, the sources of pentahelix concept publications need to be traced to identify pentahelix research trends in various specific fields. The following presents research publication sources using the pentahelix approach.

Table 1. Sources of Pentahelik Publications

No	Publication Source	Total
1	IOP Conference Series: Earth and Environmental Science	14
2	E3S Web of Conferences	7
	Geojournal of Tourism and Geosites	3
3	Australasian Accounting Business and Finance Journa	2
4	Business: Theory and Practice	2
5	Journal of Infrastructure policy and Development	2
6	Lecture Note: In Networks and System	2

Source: Scopus analysis results, 2025

Based on Table 1 of the pentahelix publication sources, it can be seen that IOP Conference Series: Earth and Environmental Science dominate with 14 documents. This

indicates that the pentahelix concept is widely applied in studies related to the environment and earth sciences. In second place is E3S Web of Conferences with 7 documents, indicating the presence of Pentahelix studies in scientific forums related to sustainability and socio-economic development. Next is Geojournal of Tourism and Geosites with 3 documents, indicating that the Pentahelix concept is beginning to be applied in the tourism and geoscience industries. Then there are the Australasian Accounting Business and Finance Journal and Business: Theory and Practice, each with 2 documents, showing that the Pentahelix research concept has expanded into the fields of accounting, business, and finance.

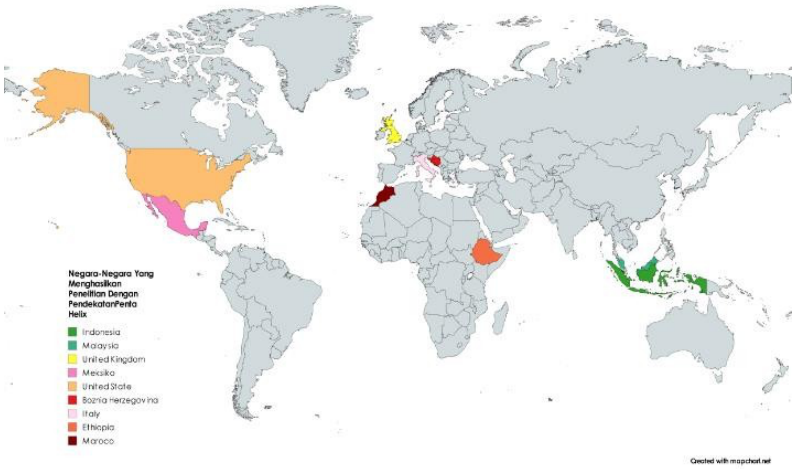
Based on the publication year, it can be seen that from 2019 to 2021, the number of publications from IOP Conference Series increased significantly and reached its peak in 2021. Meanwhile, E3S Web of Conferences has a relatively stable number of publications and experienced an increase in 2025, indicating that the Pentahelix concept remains a relevant topic of discussion within the scientific community. The dominance of journals in the fields of environment, business, and tourism indicates that the Pentahelix approach is widely applied in studies on sustainable economics and regional development. Variation in publication trends indicate that while this concept has received considerable in multiple disciplines. The focus of research is remains dynamic.

The journal publications trend on the Pentahelix approach indicate rapid growth, with its applications expanding across multiple disciplines, particularly in the field environment, business, and tourism. In recent studies, indicate that this model has received wider academic recognition and has shown a strong capacity for adaption (Noviana et al., 2025). Comparative examination research of trends on the Pentahelix approach accros different countries is important for identifying opportunities for cross national collaboration. The table below display global publications on the Pentahelix approach, accompanied by a map that visualizes their geographical distribution worldwide. The prevalence studies related to environmental and tourism suggests that the Pentahelix approach has mainly developing in policy area that emphasize community-based initiative and sustainability oriented. This pattern reflected collaborative nature of these sectors, with multi-actor engagement is mainly required to address ecological challenges, local resources management, and support community-driven development (Fatimah et al., 2023).

Tabel 2. Article by countries

No	Country	Number of publications
1	Indonesia	61
2	Malaysia	7
3	United Kingdom	4
4	Meksiko	2
5	United State	2
6	Boznia and Herzegovina	1
7	Ethiopia	1
8	Italy	1
9	Marocco	1

Source: scopus analisys result



Source: Anaylsed by mapchart.org, 2025

Figure 4. Geographic Distribution

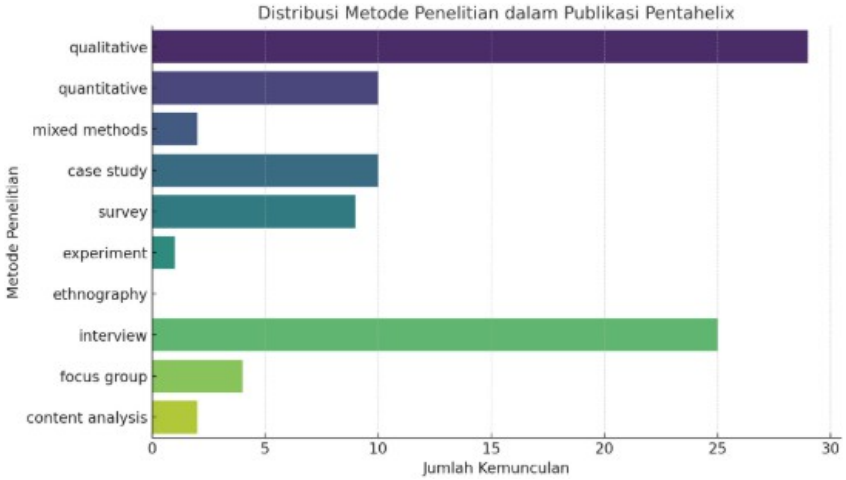
Figure 4 displayed the geographical distribution indicates that the pentahelix approach has developed into a cross-continental and multi context, conceptual tool accepteble for tourism development, social innovation, digital governance, and capacity building in region area. Indonesia and Malaysia have emerged as key centers for using, exploring advancing this model, particularlly in tourism, village innovation, and collaborative governance. Indonesia researcher is showing dominant interest to exploring in pentahelix approach. This robust advancement is driven by the fact that both countries have establish policies madating the stakeholder collaboration such as related village development programs, digitization of public services, and enhancement of creative economy sector, which adobts of the pentahelix concept as an analytical and operational framework. The methodology is similarly implemented in Ethiopia and Morocco and in advance nations like the United Kingdom and the United States. The application of this model in Southern and Central Europe, including such as Italy and Bosnia and Herzegovina, as well as several African contexts, illustrate how adaptable and relevance this approach for sustainable development and community empowerment.

As shown int Table 2 illustrates that several countries have contributed research on the pentahelix, with Indonesia has highes publication (61 publications), it's indicating that in the past 10 years, Indonesia has strong engagement in this area. The pentahelix has become a

highly relevant research topic in Indonesia, likely due to the growing policies on innovation, the development of the creative industry ecosystem, and inter-sectoral collaboration in the country. The large number of publications from Indonesia indicates that government, academic, and private sector initiatives are actively promoting the Pentahelix model in regional development and innovation-based economies. Indonesia is committed to achieving the SDGs.

In second place, Malaysia has 7 publications, indicating that the Pentahelix concept is also a focus for academics and practitioners in this country. There is a tendency for Malaysia to adopt the Pentahelix model in the development of the higher education sector, the tourism industry, and collaboration among stakeholders in digital economic development. Followed by the United Kingdom (4 publications), indicating the involvement of academics and research institutions from the UK in supporting the Pentahelix model. Mexico and the United States (each with 2 publications) indicate that this concept is also beginning to be applied in the context of Latin America and innovation-based economies in the United States. Other countries such as Bosnia and Herzegovina, Ethiopia, Italy, Morocco, and Oman each have 1 publication, indicating that this concept has gained global attention, although the number is still limited.

This distribution of publications reveals a clear geographic bias, where Southeast Asia particulary Indonesia and Malaysia dominating the search literature. This bias is likely driven by strong adobtion of policy initiative in these countries, particularly in tourism development, village governance, and digital transformation agendas, which emphazis on multile stakeholder collaboration. Meanwhile, limited adoption and lower policy visibility in regions such as Africa, Latin America, and parts of Europe contribute to the relatively small number of publications, suggesting that the Pentahelix model has not yet been institutionalized or widely integrated into their development frameworks.



Source: secondary data from Scopus-indexed articles, 2025

Figure 5. Distribution of Research Methods Used in Pentahelix Research

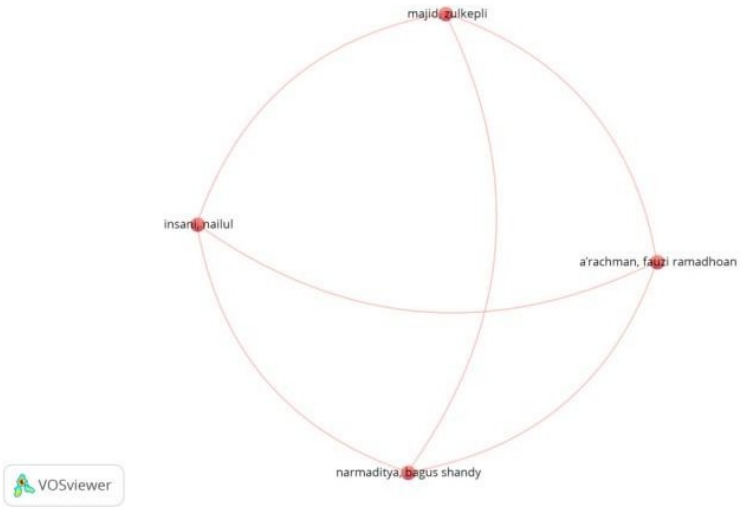
Based on the empirical data in Figure 5, the distribution of research methods used in the pentahelix approach shows a research gap, where research is dominated by qualitative methods and the use of mixed methods is still minimal.

Meanwhile, there are few studies related to the pentahelix that use statistical analysis, mathematical models, or simulations to measure the effectiveness of the pentahelix model. From this gap, the novelty of the need for mixed-methods-based studies or big data analytics-

based research emerges in understanding the relationships among pentahelix actors. There is a need to explore how pentahelix- based policies and programs are tested on a small scale before being implemented on a larger scale. Experimental methods have great potential for use in further research, namely testing the effectiveness of the pentahelix model through policy experiments or social simulations or social engineering in various industrial sectors and regions.

Analysis Results from Vosviewer

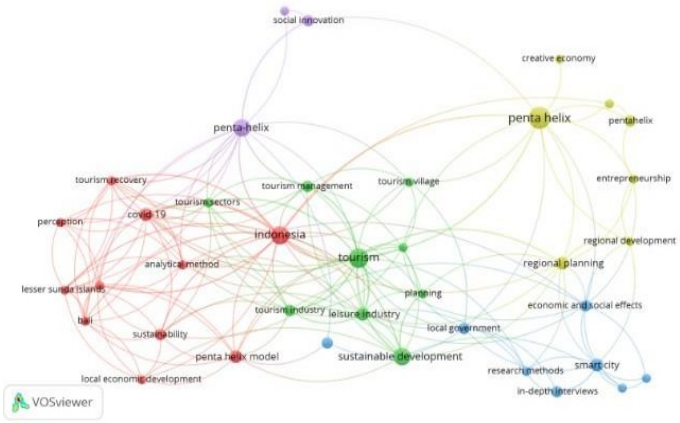
Co-authorship provides information about the author collaboration network (co-authorship network). Each node (point) represents an author, and the lines connecting them to other authors indicate collaborative relationships in scientific publications. Co-authorship can help identify new collaboration opportunities based on existing scientific networks.



Source: Analyzed by VOSViewer, 2025

Figure 6. Author Collaboration Network

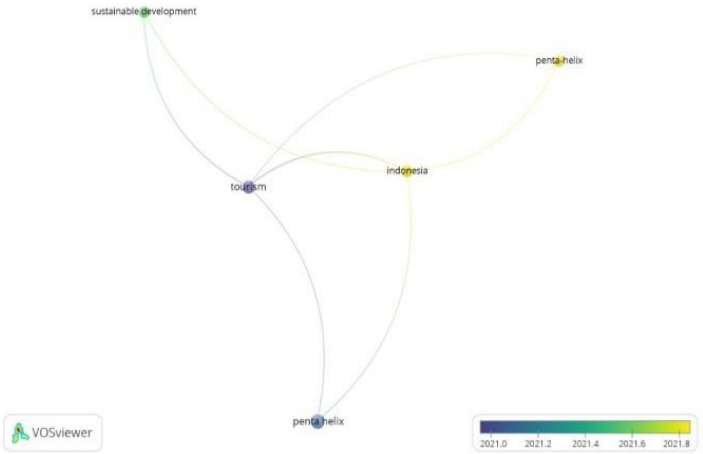
Based on the visualization in Figure 6 regarding the author collaboration network, it can be seen that there are four pairs of authors who have collaborative relationships, namely Majid and Zulkepli; A'rahman and Fauzi Ramadhoan; Insani and Nailul; and Narmaditya and Bagus Shandy. They collaborate with each other, though the form of collaboration is not extensive but close. The closeness of the relationship can be seen from the thickness of the lines (Total Link Strength – TLS). The circular network structure indicates that all four authors are interconnected without any isolated authors. Since there are only four collaborating authors, there is potential here to expand research collaboration further. However, the limited number of collaborators and the absence of international collaboration indicate that research on the pentahelix is still developing at the local level. The low level of cross-border collaboration is an obstacle because it limits the exchange of ideas and slows down the formation of a stronger pentahelix epistemic community. Next, we will analyze co-occurrence visualized in a network visualization. The co-occurrence network visualization explains the theme map based on keywords and the relationships between themes in the research



Source: Analysed by VOSViewer, 2025

Figure 7. Main Cluster Findings of Pentahelix-Based Research

Based on Figure 7 regarding the visualization of the co-occurrence network, five main clusters were identified, one of which is the red cluster focusing on topics such as COVID-19, tourism recovery, sustainability, and the pentahelix model. This indicates that there are many studies in the tourism sector using a pentahelix approach. The green cluster focuses on the tourism industry, tourism villages, the leisure industry, and sustainable development. This shows the relationship between the tourism industry and sustainable development and tourism planning. The blue cluster focuses on smart cities, research methods, in-depth interviews, and economic and social effects. This illustrates that there is in-depth research on the concept of smart cities in relation to tourism. Meanwhile, the purple cluster focuses on the penta-helix and social innovation, showing the relationship between the penta-helix model and social innovation in tourism development.



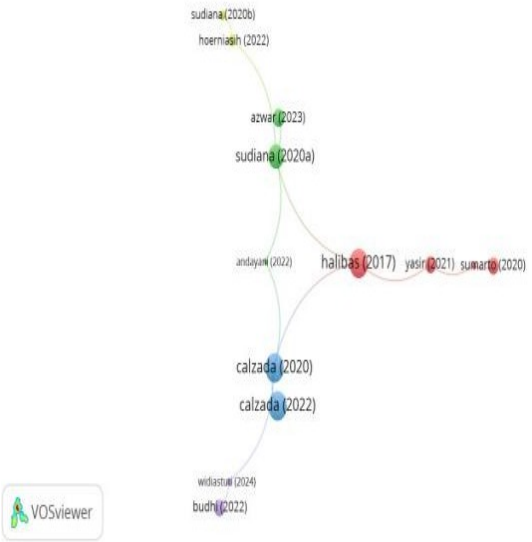
Source: Analysed by VOSViewer, 2025

Figure 8. Keywords that frequently appear in pentahelix-based research based on time range

Based on Figure 8, it can be seen that there are five frequently occurring keywords in research related to the pentahelix approach: penta-helix, Indonesia (yellow), tourism, penta helix (blue), and sustainable development (green). The colors in the overlay visualization indicate the temporal trends of a term's appearance in the literature (van Eck & Waltman, 2023). Blue transitioning to green indicates keywords that appeared earlier, while yellow

indicates newer keywords (around late 2021). Pentahelix and tourism are the two main keywords in the research. Indonesia and pentahelix indicate that Indonesia has made a significant contribution to the development of this approach and is widely used in addressing issues related to sustainable development. The blue-colored keyword "tourism" indicates that this keyword emerged earlier and developed before the pentahelix approach gained traction in Indonesia. From the above image, it can be concluded that research on pentahelix-based tourism in Indonesia has been increasing since 2021.

The Pentahelix approach began to develop within the context of sustainable development and tourism. The lines indicating the relationship between "Sustainable Development" and 'Tourism' do not yet show a strong connection with "Penta Helix." While the Pentahelix approach has been widely used in research, studies on its concrete implementation in sustainable tourism policies and practices remain limited. The novelty of the research that can be explored is the integration of sustainable tourism development and the Pentahelix approach. If the research is conducted, it will contribute to a more explicit Pentahelix model aligned with the principles of sustainable tourism development. Identifying challenges and opportunities in implementing the Pentahelix approach in specific tourist destinations in Indonesia represents a novelty in future research. Another novelty is the Collaborative Model for Pentahelix-based Sustainable Tourism. After discussing the theme based on network co-occurrence visualization and overlay co-occurrence, we will continue with an explanation of citation visualization. This network-citation visualization shows the citation relationships between various scientific publications in the dataset used.



Source: Analysed by VOSViewer, 2025

Figure 9. Visualization of Inter-Author Citations

Based on the visualization in Figure 9 regarding inter-author citations, it can be seen that Halibas' article is a highly influential publication. This article is also the first to be published in journal form, focusing on historical and current efforts to promote innovation by Higher Education Institutions (HEIs) in Oman. Halibas recommends the establishment of a network channel that enables key actors in the innovation system to share information and collaborate. This article also contributes to the development of an innovation culture within HEIs. Initial findings suggest that universities believe innovation originates within their institutions and is the responsibility of academics. However, empirically, most innovation programs are initiated by the government in Oman, while HEI involvement remains weak and

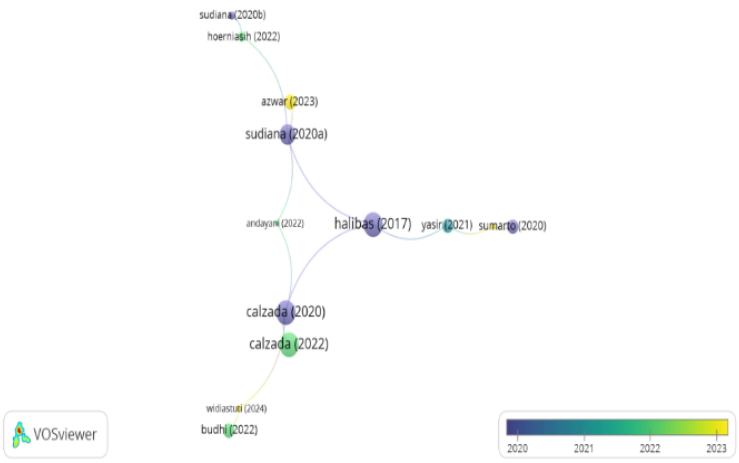
has not emerged as a major force in the innovation system. The highlight needs to adopt best practices in innovation strategy and management, curriculum and assessment, reward systems, funding, ICT infrastructure, research commercialization, and community engagement. Halibas further highlights need depth analysis of synergies and collaborative relationships in the pentahelix model, recommending large-scale surveys as a strategic tool to evaluate status and impact of regional innovation.

In addition, the visualization also shows a green cluster related to empirical research in the fields of tourism and the creative economy. This group consists of Sudiana (2020a, 2020b), Azwar (2023), Hoerniasih (2022), and Andayani (2022), who form an interconnected citation network. Sudiana, for example, developed the pentahelix variable construct in the context of innovation and knowledge-based economy by dividing it into five dimensions: academia, business, government, community, and media (ABGCM) (Sudiana et al., 2020). Azwar investigates the influence of key stakeholders on local community involvement in community-based tourism (CBT) development and explores the potential for multi-stakeholder collaboration through the pentahelix as a strategy for sustainable CBT development (Azwar et al., 21 C.E.). His findings emphasize the importance of local wisdom as the primary driver of pentahelix actor collaboration. Furthermore, Hoerniasih examined the management of village entrepreneurial potential through cross- stakeholder collaboration using the pentahelix model (Hoerniasih et al., 2022). Her research results showed improvements in knowledge, entrepreneurial skills, as well as better marketing strategies and business control. Meanwhile, Andayani researched pentahelix strategies in accelerating the reduction of stunting rates (Andayani et al., 2022). She found that the success of this strategy was supported by the involvement of government officials at the village level, academics, business partners, the mass media, and the community, who together supported the policies of the Sumenep Regency government. This emphasizes the importance of pentahelix collaborative action in public health issues, particularly stunting prevention.

The prominance of tourism in this cluster can be explained theoretically prespective. Tourism inherently depends on coordination multi-actor, place-based development approach, and community participation, making it suitable sector for applying and testing the pentahelix model. The dependence on shared resources and cross-organizational collaboration strengthen collaborative governance frameworks (Noviana et al., 2025). The concentration of studies in this area shapes the development of the pentahelix concept, directing it toward practical, community-oriented, and sustainability-focused applications, while at the same time creating a sectoral bias that may limits it broader theoretical generalization.

The blue cluster focuses on the themes of smart cities and digital transformation. Calzada's (2020) article discusses a multi-stakeholder policy framework from a social innovation perspective, proposing a new pentahelix model that involves the public sector, private sector, academia, civil society, and entrepreneurs or social activists. Calzada emphasizes the unique multi-stakeholder composition, diverse preferences in business and social models, the role of the fifth helix as an intermediary, and the willingness to experiment with democratic arrangements outside the dominant public-private partnership framework. Calzada's research then continued the study by providing an updated review of the Personal Information Protection Law (PIPL) in China (Calzada, 2020). This analysis highlights data privacy as a global issue and compares it with the GDPR in Europe and the CCPA in the United States. Methodologically, this research employs in- depth policy analysis with a case study of Shenzhen and emphasizes the importance of multi-stakeholders within the pentahelix framework. The connection between Calzada's 2020 and 2022 publications shows

continuity in linking digital transformation, smart cities, and the influence of technology on the pentahelix model in the context of tourism and public policy (Calzada, 2022).



Source: Analysed by VOSViewer

Figure 10. Citation Interconnectivity between Articles based on Publication Year

The visualization results in Figure 10 (Overlay Citation) show the citation interconnectivity between articles based on publication year and their relevance in the pentahelix research network. From the visualization, it can be identified that blue represents older publications (≤ 2020), green indicates mid-range publications (2021–2022), and yellow depicts the latest publications (2023–2024). The article by Halibas's (2017) provided an early discussion on innovation. It became an important reference point in the emergence of the pentahelix concept, which was later further by studies such as Sudiana (2020a) and Calzada (2020, 2022). Another important node is Calzada's article emphasis digitalization and smart cities, marking importance contribution to the development of pentahelix research. Recent research trends have developed through Azwar's (2023) study on community-based tourism and the article by Widiastuti et al., (2024) which focus on gender-based empowerment. This progression indicates a shift in research focus, beginning from innovation issues (2017), digitalization and smart cities (2020–2022), later expanding community-based tourism (2023) and gender empowerment (2024). By 2025, there have been no studies indentified as influential articles.

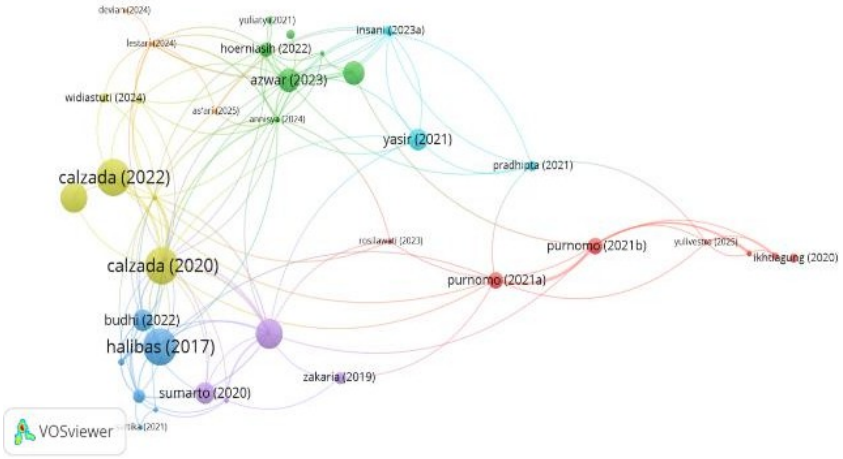
Key Figures, Main Themes and Epistemological Implications

Figure 10 (Overlay Citation) present visualization of citation network between articles based on their publication year as well as their relevance within pentahelix research network. Study by Halibas's (2017) emerge as the earliest and most central reference network, providing the conceptual foundation for later pentahelix studies. Later influential studies include Sudiana (2020a) and Calzada (2020, 2022), also accupy as key position as a major node in citation network. Recent influential works include those Azwar (2023) and Widiastuti et al. (2024), although the literatur have not yet identified any new dominant author emerged in 2025.

Color mapping in the overlay visualization reveals a chronological evolution of themes in pentahelix research: blue nodes represent early works (≤ 2020) focus on innovation; green nodes (2021–2022) show an increasing interes on digitalization and smart cities; and yellow nodes (2023–2024) indicate newer themes such as community-based tourism and gender-based empowerment. These changes highlight a clear progression from conceptual exploration toward more context-specific applications.

The observed citation patterns show that the pentahelix framework has evolved from abstract theoretical foundation to interpretations that are more socially embedded and practice-oriented interpretations. This development implies a border epistemological perspective, where early innovation arguments have progressively involved socio-cultural isues such as local tourism ecosystems and gender empowerment. As a consequence, the field reflect increasing greater methodological diversity and an expanded understanding of how collaborative multi stakesholders frameworks work in real-world environments.

After presenting the citation visualization results, the analysis moves forward to bibliographic coupling network visualization. This visualization plays important role because it highlights how relationships between among articles with the same references, highlighting interconnections between studies discussing the pentahelix approach. The advantage of this visualization is that it can helps to identify research groups that share similar theoretical foundation and methodologies. In this network, each node ilustrate an article on the pentahelix, where the larger the node size, indicate the more other studies share the same references as that article. The connecting lines between nodes indicate similarities in references between articles, while the thickness of the lines indicates a stronger degree of similarity. The color of the nodes follows the publication year scale displayed in the lower right corner. The results of the bibliographic coupling visualization are shown below.



Source: Analysed VOSViewer, 2025

Figure 11. Visualization of the Relationship Between Articles with the Same References

Based on the visualization in Figure 11, it can be seen that the articles by Halibas (2017) and Calzada (2020) have large nodes or points, indicating that both are primary references in studies on the pentahelix approach. Halibas (2017) is the initial literature that defined the term pentahelix, while Calzada (2020, 2022) played a significant role in the development of innovation policy and collaborative strategy studies. Additionally, the articles by Sudiana (2020a), Purnomo (2021a; 2021b), and Yasir (2021) show overlapping nodes, indicating that they use the same references and develop similar models in the context of the pentahelix as a continuation of previous research. An example Sudiana et al (2020), discusses the development and validation of the pentahelix construct, stressing the role of startups in the innovation process and the use of research results for commercial application. In other studi, Purnomo, et al (2021) explore to use of the pentahelix in sustainable tourism development and strategies to support the recovery of the tourism industry following COVID-19. Yasir addressing the development of community-based tourism (CBT), illustrates that the the pentahelix model is play importance role in empowering local communities (Yasir et al., 2021).

Furthermore, more recent studies such as Azwar (2023) and Prajanti et al., (2023) show that the pentahelix concept continues to evolve, with more contextual approaches and case studies. Azwar discusses the involvement of key stakeholders in CBT development, while Prajanti emphasizes the development of sustainable creative economy based on local wisdom. This indicates that pentahelix research trends are shifting toward tourism and the creative economy, in line with the increasing attention to the development of these sectors in Indonesia. In 2024, an article by Widiastuti highlighted gender-based women's empowerment, marking the expansion of pentahelix research dimensions into the realm of social equality (Widiastuti et al., 2024). The small yellow nodes representing these publications indicate the emerging influence on this theme.

The pattern of bibliographic coupling in the visualization also shows a clear shift in scientific orientation. Large nodes on Halibas and Calzada indicate the early phase of research focused on innovation, followed by the phase of digitization and smart cities. After that, the denser group of nodes on Purnomo, Yasir, and Azwar shows a shift in orientation towards the themes of tourism and the creative economy. In the most recent period, small yellow nodes such as Widiastuti illustrate the growing research focus on empowerment and equality issues. Thus, changes in research themes not only follow the year of publication but also reflect the direction of scientific development from innovation to digitalization to tourism to empowerment.

The overall interpretation indicates that the pentahelix theme developed gradually, since its introduction in 2017 and continue to envolve 2024. Early research by Halibas (2017), his research focused on innovation. While the period around, Calzada (2020) introduce new theme such as digitalization and smart cities, as well as innovation within pentahelix framework (Sudiana). During 2021 demonstrate growing addressing on themes of smart cities, sustainable tourism, and CBT, as evidence by research of Purnomo and Yasir. In literatur 2023 introduce new developments, particularly studies addressing on the creative economy grounded in local wisdom, alongside continued advancement Community Base Tourism (CBT). The year 2024, the scope of research expanded to gender-based community empowerment within the pentahelix framework. This The transition indicates a consolidation of themes developments, progressing from innovation focus topic toward digitalization, tourism, creative economy, and community empowerment, culminating in highest number of publications recorded in 2024.

CONCLUSION

This The Finding of This bibliometric analysis indicate that the pentahelix approach has become important foundations in public administration research over the past decade. Base on analysis of 73 Scopus-indexed publication (2015–2025) reveals a growth pattern similar with Rogers' (2003) innovation diffusion cycle, The prosess star with an exploratory stage characterized by limited publications. Then move into implementation and consolidation stage marked by rapid growth, and reaching its highest publication level in 2024. Indonesia is playing central role this development, showing how developing countries can play primary role in initiating and adapting collaborative innovation multiple actors within public governance. Indonesia occupies a central position in this development, demonstrating the role of developing countries in initiating and adapting collaborative innovation across actors in the context of public governance nance.

The result demonstrates that pentahelix model is applicable not only in public administration but also in other sector such as the environmental, business, and tourism sectors. Nevertheless, the field has expanded, most studies are still dominated by qualitative

approaches and local case studies. In contras the adoption of quantitative methods, mixed methods, and digital analytical approaches such as machine learning, social network analysis (SNA), and PLS-SEM remains relatively limited. This finding point of a research gap in developing a universal evidence-based model that can more comprehensively evaluating the effectiveness of multi stakeholder collaboration different sectors and national context.

This study contributes to the theoretical development of public administration by positioning the Pentahelix model as an expanded governance framework, and bya explained its developing conceptual structure and its role promoting multi-stakeholders' collaboration in contemporary policy contexts.

Future research implications addressing the need methodological innovation and expanded research. Further studies are need to integrate pentahelix framework with global policy issues such as the SDGs, smart governance, circular economy, and digital transformation. It is essential to enhance the adaptability of the concept in addressing global sustainability challenge. Futhermore, the development of advance framework such as Pentahelix 4.0 or 5.0 in integrate non-traditional actor including digital startups, international NGOs, online communities, and by utilizing big data and artificial intelligence, to help close current research gaps. Therefore, the pentahelix has strong potential as strategic collaboration mechanism for policymakers to promote sustainable development, reinforce governance system, and stimulate innovation in punbic policy for the future.

AI DICLOSURE STATEMENT

In preparing this manuscript, generative AI tools were used only for language editing and paraphrasing to improve the readability of this manuscript. All research design, analysis, interpretation, and conclusions were developed by the authors. The author takes full responsibility for all intellectual input and the final content of the manuscript.

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