

Evolving Trends and Gaps in Transit Accessibility Index Research in Asia: A Bibliometric Analysis¹

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ABSTRACT

Transit Accessibility Index (TAI) has become a key tool for evaluating how effectively public transport systems connect populations to essential opportunities in rapidly urbanising Asian cities. Despite increasing scholarly attention, existing studies remain fragmented, geographically concentrated, and methodologically constrained, limiting the development of context-sensitive and equity-oriented frameworks. This study addresses these limitations through a bibliometric analysis of TAI research in Asia from 2002 to 2024, based on 260 publications indexed in Scopus. The analysis examines publication trends, geographic distribution, collaboration networks, and thematic evolution. Results indicate significant growth in research output, reflecting the integration of accessibility into sustainable mobility and transit-oriented development agendas. However, research remains concentrated in a few countries, while collaboration is largely intra-national, limiting regional knowledge exchange. Thematic analysis reveals a strong focus on spatial accessibility and system performance, with limited attention to equity, informal mobility, and climate resilience. Although data-driven approaches are increasing, their application remains uneven. This study provides a systematic synthesis of TAI research in Asia and highlights the need for more inclusive, multidimensional, and context-sensitive accessibility frameworks to support sustainable urban planning.

INTRODUCTION

Building equitable and sustainable transport systems has become a central priority in rapidly urbanising Asian cities. The Transit Accessibility Index (TAI) is widely used to evaluate how effectively public transport networks connect populations to employment, education, and essential services (Leong et al., 2024). While accessibility measurement has matured in Western contexts, its application in Asia remains complex due to informal transit systems, income disparities, fragmented governance, and rapid land-use

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transformation. In addition, large-scale transit investments often generate uneven socio-spatial outcomes, including gentrification and displacement, which raise concerns about affordability and vertical equity. Although TAI serves as a practical diagnostic tool, existing models frequently oversimplify mobility experiences by overlooking service quality, affordability, and inclusivity (Guo et al., 2022).

Despite a growing body of research on transit accessibility in Asia, the literature remains fragmented and nationally concentrated, with limited cross-regional synthesis and methodological reflection. Many studies continue to rely on gravity-based or cumulative models without sufficient contextual adaptation to Asian socio-economic and transport conditions (Zhai et al., 2018). Furthermore, emerging dimensions such as informal mobility integration, vertical equity, and real-time data applications are unevenly represented, leaving critical knowledge gaps in understanding how TAI frameworks respond to Asia's diverse urban realities. The absence of a comprehensive bibliometric synthesis constrains theoretical consolidation and limits the policy relevance of accessibility research in the region.

In response, this study aims to systematically examine the evolution, thematic structure, and collaboration patterns of Transit Accessibility Index research in Asia from 2002 to 2024 through bibliometric analysis. Specifically, it seeks to map publication trends and country-level contributions, analyse author and institutional collaboration networks, and identify dominant and emerging research themes through keyword co-occurrence analysis that constrain the contextual relevance of TAI frameworks for Asian urban planning. By synthesising two decades of scholarship, the study provides an evidence-based roadmap for strengthening equity-oriented, context-sensitive, and policy-relevant transit accessibility research in the region.

The significance of this study extends beyond academic synthesis. Accessibility measurement is increasingly linked to global and regional urban policy agendas, particularly the pursuit of inclusive, safe, and sustainable transport systems under international sustainable development frameworks and national mobility strategies. Asian governments have adopted transit-oriented development and smart mobility policies to address congestion, environmental degradation, and social inequality (Uddin et al., 2023). However, without rigorous and context-adapted accessibility indicators, such policies risk emphasising infrastructure provision over distributive equity and long-term sustainability. By identifying persistent gaps in regional collaboration, this study provides a strategic reference for policymakers and planners seeking to strengthen accessibility-based evaluation and align transit planning with sustainable urban development objectives across diverse Asian contexts.

LITERATURE REVIEW

Transit accessibility has evolved as a central concept in transport and urban planning, reflecting the relationship between land use, mobility systems, and opportunity distribution. Traditional accessibility models are commonly classified into cumulative opportunity, gravity-based, and utility-based approaches. Among these, gravity-based models remain dominant in Asian research due to their capacity to incorporate distance decay and congestion sensitivity. While these models provide measurable and comparable outputs, a finding by Malekzadeh and Chung (2020) shows that their application often prioritises spatial efficiency over distributive equity. This new finding highlights that many accessibility frameworks inadequately capture qualitative dimensions such as affordability, service reliability, and inclusivity. Consequently, accessibility measurement risks becoming a technical exercise detached from broader socio-spatial realities.

Transit accessibility is closely linked to Transit-Oriented Development, which promotes compact, mixed-use, and transit-integrated urban forms. Empirical studies demonstrate that well-integrated transit systems reduce congestion, improve environmental performance, and enhance urban productivity (Uddin et al., 2023). However, the outcomes of TOD implementation vary significantly across contexts. In rapidly urbanising Asian cities, transit expansion often interacts with informal mobility systems, land speculation, and uneven governance structures. This statement is further strengthened by Wan et al. (2023), who comment that while TOD is frequently associated with sustainability benefits, its equity implications remain contested. Consequently, rail investments may increase land values and contribute to socio-spatial displacement if accessibility gains are unevenly distributed, which becomes a significant disparity that needs to be studied. These dynamics reveal a conceptual tension within TAI research. On one hand, accessibility indices are employed to quantify performance and support planning decisions. On the other hand, many indices insufficiently reflect the lived experiences of disadvantaged populations or the structural constraints shaping mobility choices. Guo et al. (2022) highlight that aggregate accessibility measures may mask disparities across income, gender, and age groups, indicating the need for more multidimensional frameworks.

Another topic to discuss is that recent scholarship has expanded accessibility analysis through the integration of GIS, smartcard data, GPS trajectories, and big data analytics (Farber & Fu, 2017; Shi et al., 2020). These advances enable dynamic measurement of travel time variability and network performance. However, technological enhancement does not automatically resolve conceptual limitations. Data-intensive approaches may reproduce digital divides by excluding populations without access to formal transit systems or digital footprints. In many Southeast and South Asian cities, informal modes such as paratransit and motorcycle taxis remain central to daily mobility yet are rarely incorporated into formal accessibility indices (Satranarakun & Kraiwanit, 2023). Furthermore, although several narrative and thematic reviews exist, comprehensive bibliometric syntheses focusing specifically on TAI in Asia remain limited. Existing reviews tend to emphasise methodological classification rather than map collaboration structures, geographic concentration, or thematic evolution over time. As a result, the broader intellectual structure of TAI research in Asia remains insufficiently examined.

Based on the findings from reviewed literature, it demonstrates three critical gaps. First, accessibility research in Asia remains methodologically concentrated around gravity-based and cumulative models, with limited adaptation to informal and heterogeneous mobility systems. Second, equity dimensions are frequently acknowledged but weakly operationalised within accessibility indices. Third, there is no systematic bibliometric mapping that synthesises how TAI research in Asia has evolved in terms of themes, geographic distribution, and collaboration networks. This study addresses these gaps by conducting a structured bibliometric analysis of TAI research in Asia from 2002 to 2024. By examining publication trends, thematic clusters, and collaboration patterns, the study moves beyond isolated methodological discussions and situates TAI within its broader intellectual and regional context. In doing so, this study provides an analytical foundation for strengthening equity-oriented and context-sensitive accessibility frameworks aligned with contemporary urban sustainability agendas.

METHODOLOGY

A bibliometric approach was employed to systematically examine the evolution, thematic structure, and collaboration patterns of TAI research in Asia. Bibliometric analysis enables quantitative evaluation of scientific literature and provides insights into research productivity, intellectual influence, and knowledge structures within a specific field. This approach is particularly suitable for identifying long-term research trends and structural gaps that are difficult to observe through conventional narrative literature reviews.

Scopus database was selected as the primary data source due to its extensive multidisciplinary coverage and strong representation of transportation, urban planning, and social science publications compared with other bibliographic databases such as Web of Science (Mongeon & Paul-Hus, 2016; Falagas et al., 2008). This broad coverage enhances dataset representativeness and ensures the inclusion of regionally relevant scholarship from Asian countries, where accessibility research has expanded significantly over the past two decades. The study timeframe was defined from 2002 to 2024, capturing the period during which accessibility-based planning and TAI frameworks increasingly became integrated into TOD and sustainable urban mobility research.

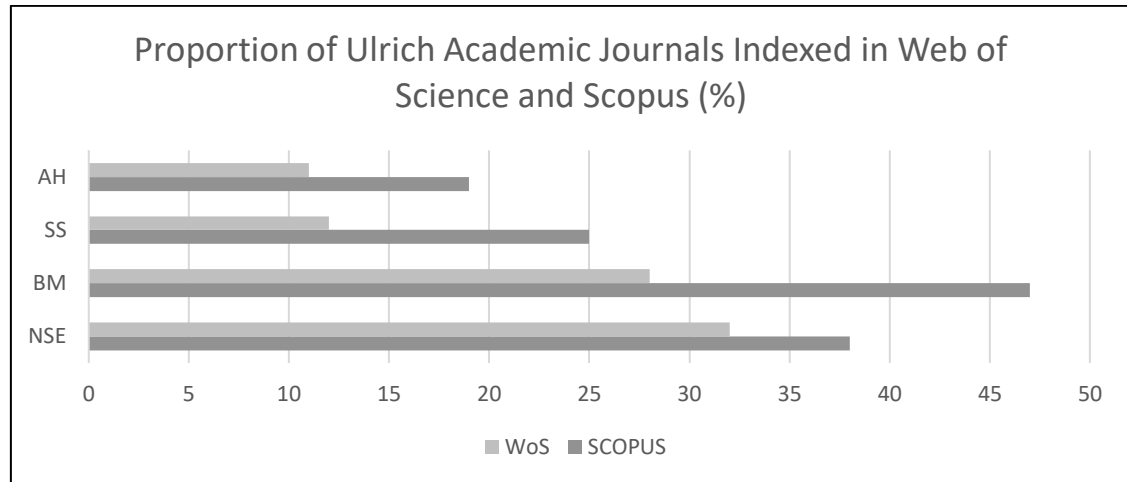


Fig. 1. Proportion of Ulrich Academic Journals Indexed in Web of Science and Scopus

Source: Mongeon and Paul-Hus (2016)

A structured search strategy was developed to ensure transparency and reproducibility of the data collection process as shown in Figure 2. Keyword combinations related to transit accessibility, accessibility index, and related concepts were applied within the Title, Abstract, and Keywords fields using Boolean operators. To ensure regional relevance, geographic filtering was implemented using the AFFILCOUNTRY function to restrict results to publications associated with Asian institutional affiliations. The document selection process followed four sequential stages: identification, screening, eligibility, and inclusion, consistent with systematic review practices. The initial search identified 731 documents, which were reduced to 313 publications after applying geographic filters. Further restrictions to the 2002–2024 timeframe and English-language publications resulted in 260 documents. Manual screening of titles and abstracts was then conducted to confirm thematic relevance to transit accessibility measurement and index-based evaluation. This filtering process ensured that the final dataset represents focused and high-quality scholarly contributions directly relevant to TAI research.

To address the research objectives and the gaps identified in the literature review, four bibliometric constructs were operationalised: research productivity, geographic and institutional contribution, thematic structure, and knowledge influence. These constructs collectively capture the intellectual development and structural characteristics of TAI research in Asia. Research productivity was operationalised through annual publication counts to evaluate the temporal evolution of TAI scholarship. This construct provides insight into the maturity and growth trajectory of accessibility research and enables identification of periods where academic attention increased due to policy developments, technological advancements, or emerging urban mobility challenges.

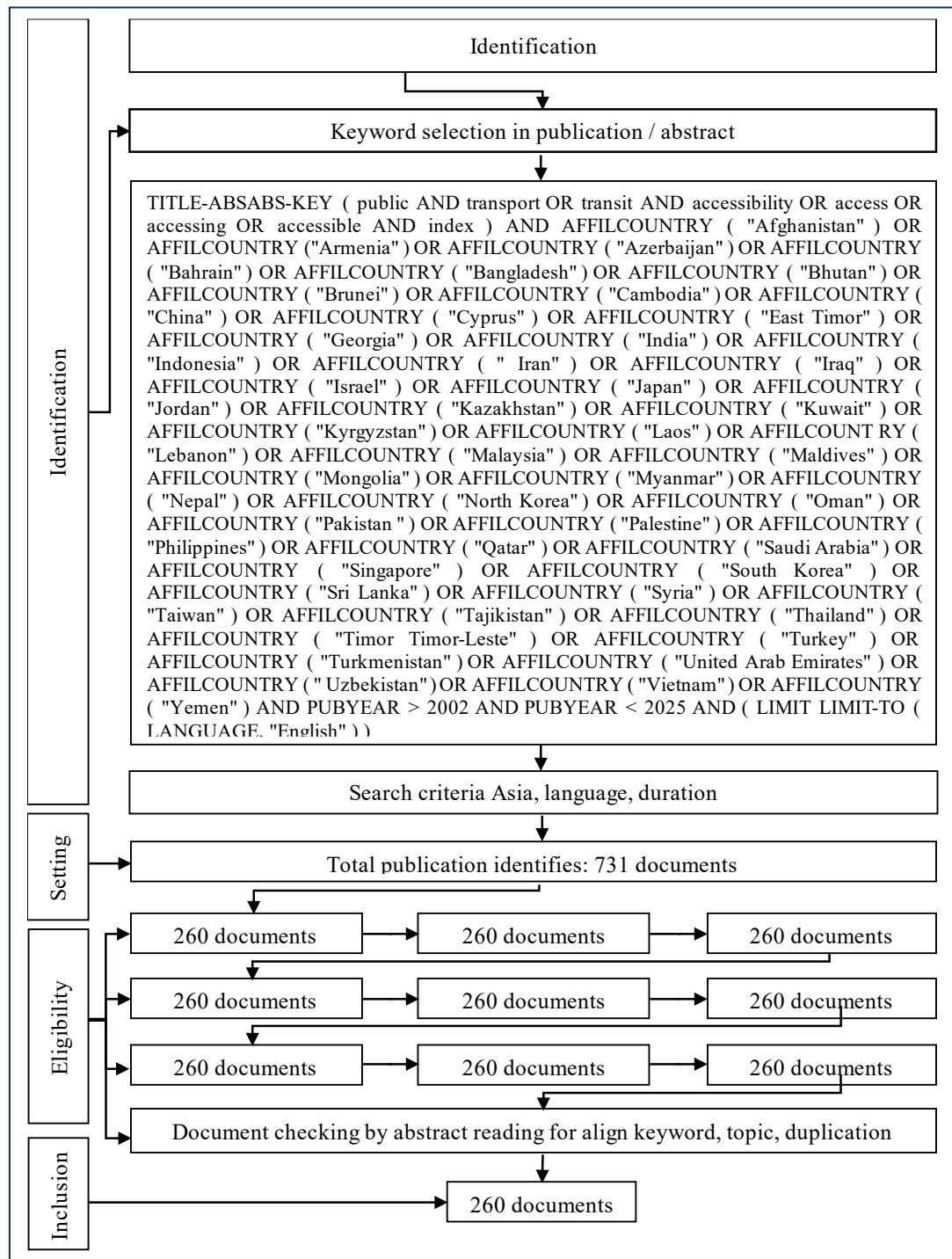


Fig. 2. Flowchart of TAI Bibliometric Analysis

Source: Authors (2025)

Geographic and institutional contribution was examined using author affiliations and country-level publication distribution. This analysis identifies the spatial concentration of research production and highlights potential regional imbalances in knowledge generation. Understanding these patterns is important because accessibility challenges and planning contexts vary substantially across Asian cities, and uneven research representation may limit the contextual applicability of existing frameworks.

Thematic structure was analysed using keyword co-occurrence networks generated through VOSviewer. Keywords represent the conceptual focus of individual studies, and their clustering reveals dominant research themes, methodological priorities, and emerging research directions. This construct enables identification of how accessibility research topics evolve over time and whether new issues such as equity, smart mobility, or big data integration are increasingly incorporated into TAI research.

Knowledge influence and intellectual structure were examined using citation analysis and network relationships among publications. Highly cited studies indicate foundational contributions shaping the development of accessibility research, while citation clusters reveal intellectual linkages among research themes and highlight areas that remain underexplored. This construct helps to identify influential research streams and structural knowledge gaps within the field.

The final dataset was exported from Scopus in RIS and CSV formats to enable bibliographic management and network analysis. Data preprocessing involved standardisation of author names, harmonisation of keywords, and verification of institutional affiliation metadata to improve analytical accuracy. Bibliometric networks were generated using VOSviewer version 1.6.2, applying the full counting method with minimum occurrence thresholds to enhance network clarity and interpretability. Network visualisation enabled identification of thematic clusters, collaboration patterns, and dominant conceptual domains within TAI research.

By integrating temporal trends, geographic distribution, thematic clustering, and citation influence, the bibliometric framework provides a multidimensional analysis of how TAI research has developed across Asia. This methodological approach directly addresses the research gaps identified in previous literature by moving beyond isolated methodological discussions and offering a systematic synthesis of research evolution, collaboration networks, and thematic priorities. Consequently, the analysis provides an empirical foundation for identifying methodological imbalances, emerging research directions, and underrepresented regions within TAI scholarship, thereby supporting the development of more equity-oriented and context-sensitive accessibility assessment frameworks for Asian urban planning.

RESULTS

This section presents the bibliometric findings on TAI research in Asia from 2002 to 2024, focusing on publication growth, geographic distribution, collaboration patterns, and thematic evolution to address the study objectives.

Trends of Publication

The temporal analysis indicates sustained growth in TAI research across Asia, increasing from two publications in 2002 to peak levels after 2018 (Figure 3).

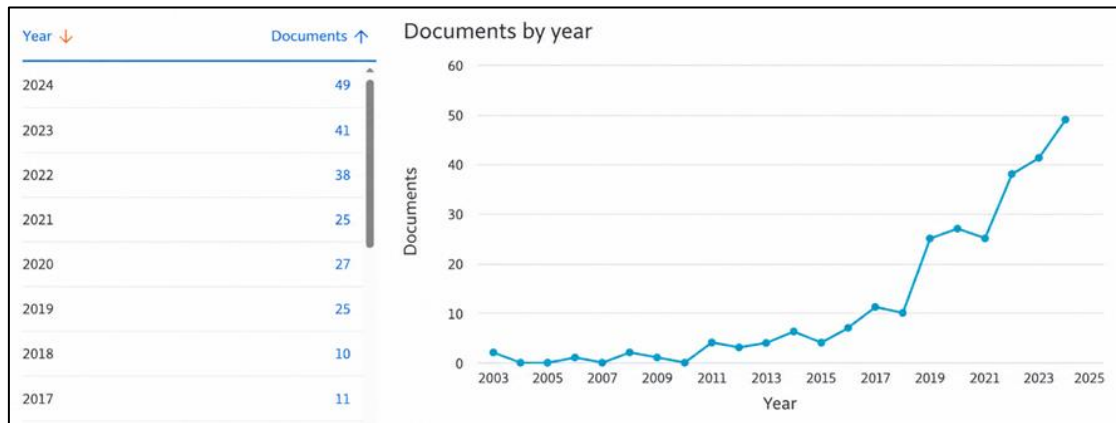


Fig. 3. Document Trends by Year

Source: Authors (2025)

This acceleration reflects the integration of accessibility indicators into transit-oriented development, smart mobility planning, and sustainability frameworks. The dominance of journal articles, representing many publications (Figure 4), suggests that the field has progressed beyond exploratory studies toward more established theoretical and methodological contributions. However, the relatively low proportion of review studies indicates limited synthesis efforts, reinforcing the need for systematic evaluation of research development.

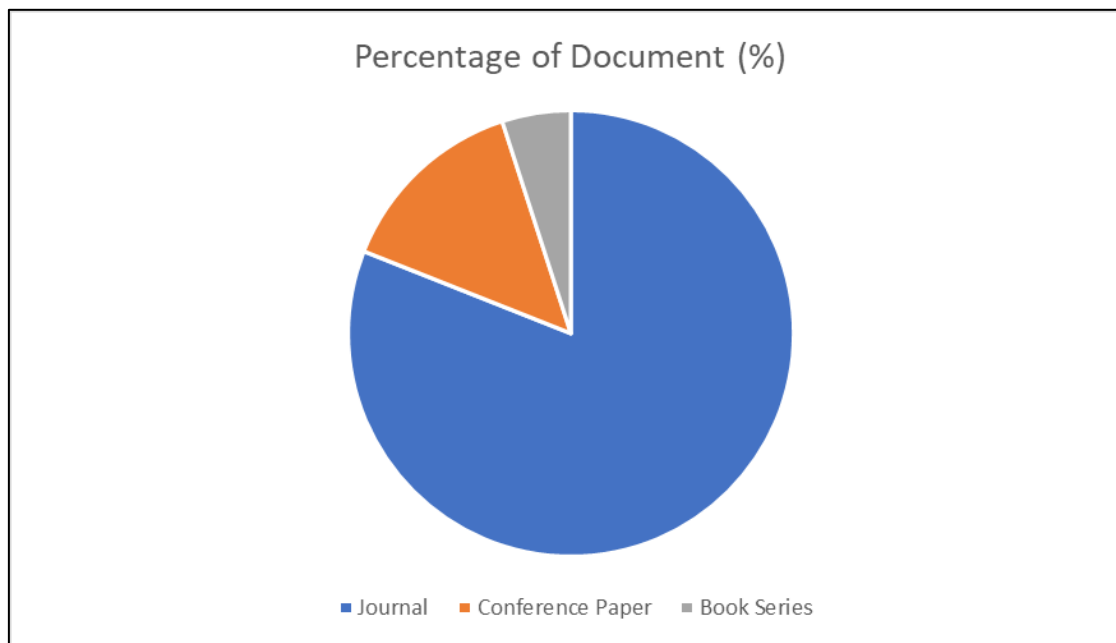


Fig. 4. Document Type Distribution

Source: Authors (2025)

Overall, the findings suggest that TAI research in Asia has evolved from an emerging topic to a maturing discipline, characterised by rising journal output, expanding open access, and broader thematic diversification. Nonetheless, gaps remain, particularly in metadata standardisation, inclusive indexing, and synthesis studies to integrate fragmented research. These trends highlight both the progress made and the challenges ahead in advancing TAI research across Asia.

Distribution of Countries

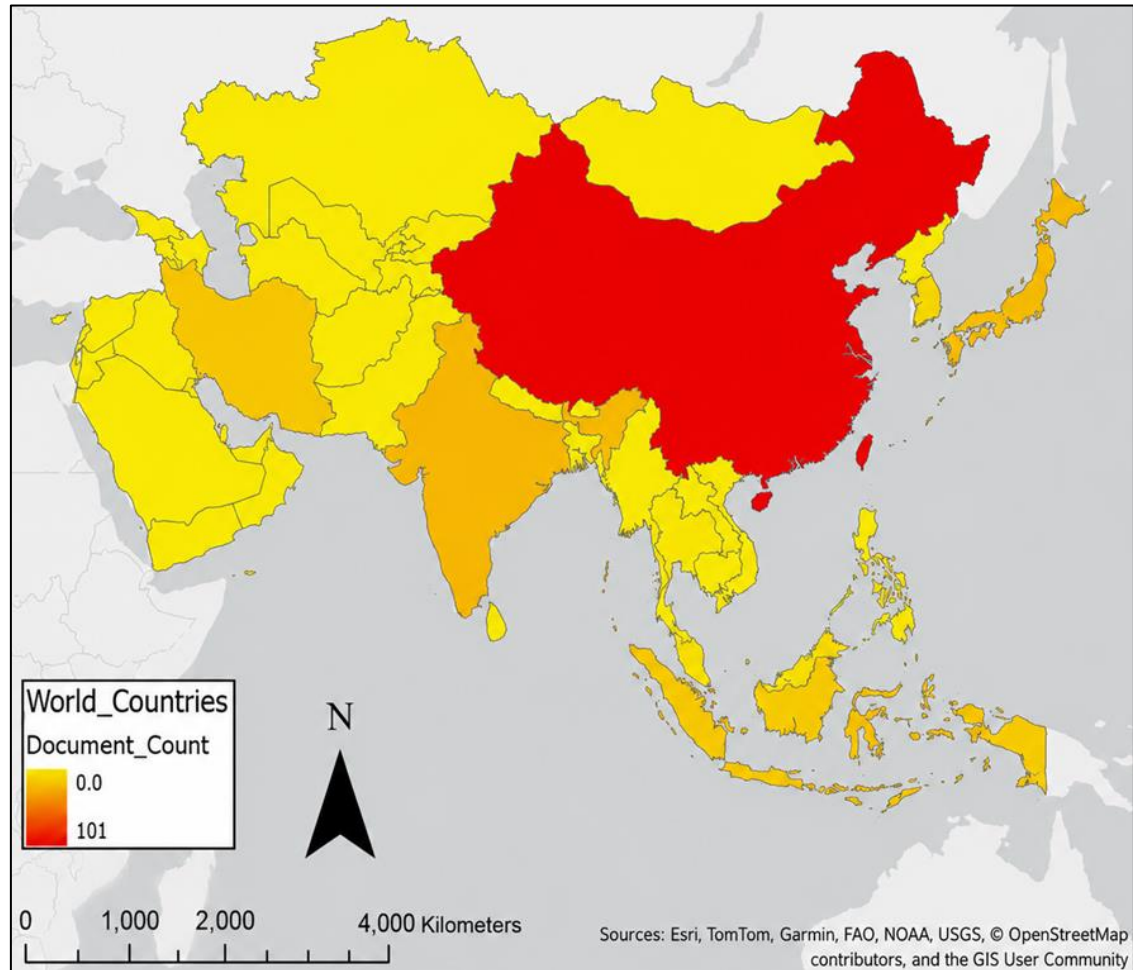


Fig. 5. Map for Document Distribution by Countries in Asia

Source: Authors (2025)

The contributions made by different countries were analysed based on document distribution, as illustrated in Fig. 6 and Fig. 7 respectively. Fig. 6 presents a heatmap highlighting the document distribution by country, where the colour intensity corresponds to the number of publications: darker shades represent higher document counts, while lighter shades indicate fewer contributions. Fig. 7 complements this by providing a detailed breakdown of document counts for individual countries through

a bar chart, allowing easier comparison across nations. China accounts for the largest share of research output, followed by India, Japan, South Korea, and Iran. Moderate contributions are observed from Southeast Asian countries such as Indonesia, Malaysia, and Thailand, while several Central and West Asian countries remain minimally represented.

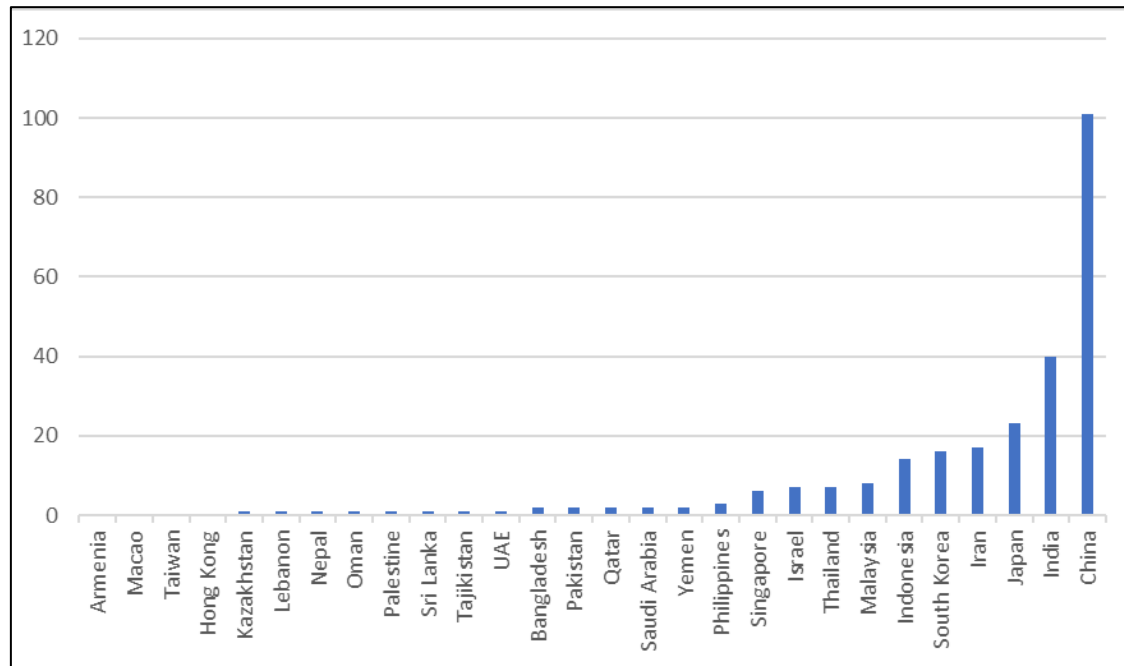


Fig. 6. Chart of Document Distribution by Countries

Source: Authors (2025)

This uneven distribution indicates structural disparities in research capacity and accessibility-related policy prioritisation across Asia. Countries with extensive transit investments and national urban mobility programs demonstrate higher research productivity, whereas lower-income and institutionally constrained countries contribute less frequently. This imbalance limits the regional representativeness of accessibility research and suggests existing frameworks may be shaped primarily by a small number of national contexts.

Collaboration Network of Authors

Author collaboration analysis reveals fragmented research networks characterised by strong national clustering and limited cross-country collaboration (Table 1, Table 2, and Figure 7). Major collaboration clusters are concentrated within China and Japan, reflecting the influence of national funding programs and institutional research networks.

Table 1. Authors Collaboration by Total Link Strength

Authors	Documents	Citation	Total Link Strength
Ishii, Kaori	3	55	22
Koohsari, Mohammad Javad	4	94	22
Oka, Koichiro	3	55	22
Shibata, Ai	3	55	22
Hanibuchi, Tomoya	2	37	15
Kaczynski, Andrew	2	37	15
Nakaya, Tomoki	2	37	15
Yasunaga, Akitomo	2	37	15
Bao, Shuming	1	143	14
Cui, Yunhe	1	143	14

Source: Authors (2025)

Table 2. Authors Collaboration by Citation

Authors	Documents	Citation	Total Link Strength
Ahati, Jiaerheng	1	462	6
Fang, Shifeng	1	462	6
Liu, Zhihui	1	462	6
Pei, Huan	1	462	6
Xu, Li Da	1	462	6
Yan, Jianwu	1	462	6
Zhu, Yunqiang	1	462	6
Chou, Kuo-Chen	1	247	3
Fang, Jian-An	1	247	3
Lin, Wei-Zhong	1	247	3

Source: Authors (2025)

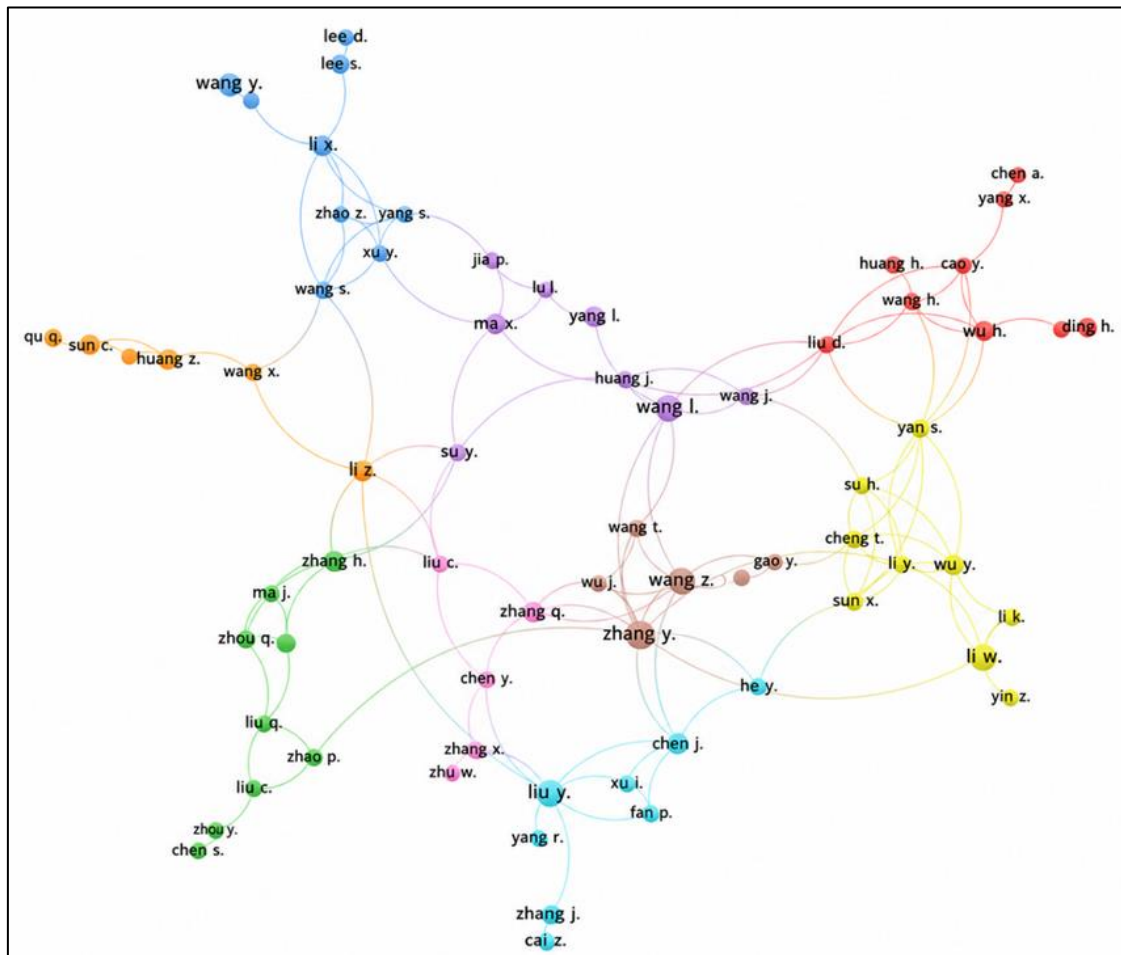


Fig. 7. Network Map by Leading Authors

Source: Authors (2025)

Although some authors demonstrate high citation influence, citation impact does not consistently correspond with collaboration intensity, indicating that individual landmark studies can shape the field independently of large research networks. The absence of extensive cross-national collaboration suggests limited regional integration in accessibility research, which may constrain methodological transfer and comparative analysis across diverse Asian urban environments.

Trend of Terms

Keyword co-occurrence analysis identifies “public transport,” “accessibility,” and “urban transportation” as the dominant research themes, indicating that most studies focus on measuring spatial accessibility and evaluating transit system performance (Figure 8). Supporting terms such as land use, mass transportation, and human mobility further demonstrate the integration of accessibility analysis with urban planning and transport system design. Additionally, these figures confirm the centrality of these themes and highlight the relative prominence of infrastructure- and service-oriented accessibility measures. However, equity-related dimensions appear less prominently, indicating that accessibility

[illegible]

Source: Authors (2025)

Temporal analysis demonstrates a clear shift in research focus over three phases (Figure 9). Early research emphasised foundational accessibility measurement and land use integration. The intermediate phase expanded toward sustainability and planning integration, reflecting growing policy attention to equitable urban mobility. Recent studies increasingly incorporate digital data sources, smart mobility systems, and dynamic accessibility modelling.

Mid-phase (2010–2015): Research broadened methodologically and thematically, integrating planning, transport optimisation, and sustainability frameworks (Le Blanc, 2015). Global debates on equity and sustainability, influenced by the Millennium Development Goals (MDGs), expanded attention from

service coverage to service quality and spatial equity. Studies included Mamun et al. (2013) using GIS for spatiotemporal service gaps, Tsou et al. (2012) applying space syntax for highway accessibility, and Monajem and Nosrati (2015) on subway integration with the Node-Place Model. This period highlighted liveability, equity, and green urbanism.

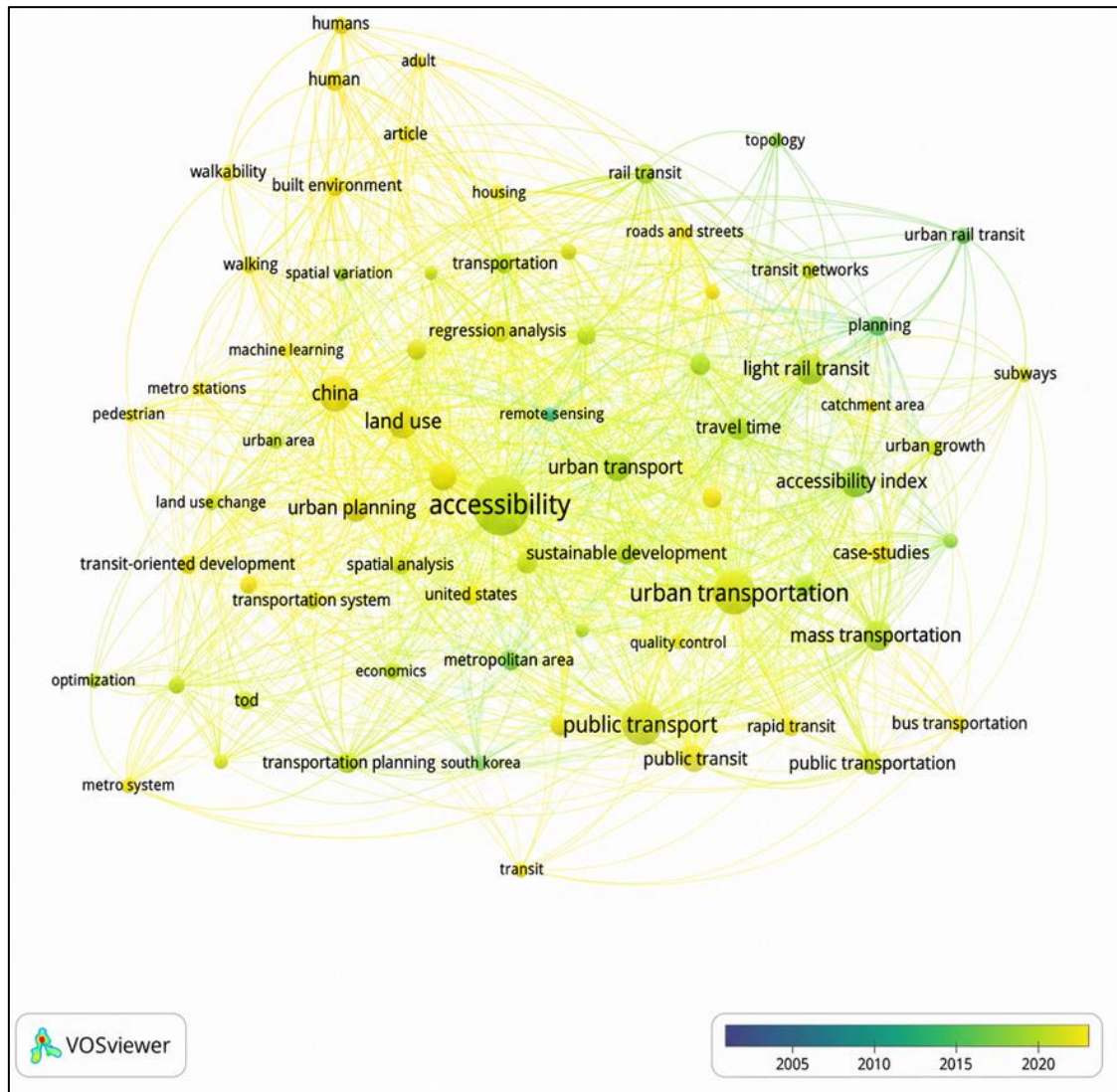


Fig. 9. Temporal Map for Co-Occurrence Terms in Abstract and Title

Source: Authors (2025)

Recent phase (2016–2024): Research shifted toward technology-driven and data-intensive approaches, influenced by smart city agendas, IoT, and geospatial big data. The New Urban Agenda and SDG 11 emphasised inclusive and dynamic mobility. Examples include walkability around light rail (Naharudin et al., 2017), applying PTALs for TOD (Hadi et al., 2018), using catchment models for green space (Gu et

al., 2017), using Baidu data for real-time accessibility (Wang et al., 2019), and integrating big data with SDGs (Zhang et al., 2024). Despite these methodological advances, the integration of real-time data and multidimensional equity indicators remains limited. Many studies continue to rely on conventional accessibility models without sufficient adaptation to informal transport systems and heterogeneous socio-economic conditions common in Asian cities.

Overall, the results reveal four structural characteristics of TAI research in Asia. First, research output has grown significantly, indicating increasing academic and policy interest in accessibility-based planning. Second, research production is geographically concentrated, limiting regional representativeness. Third, collaboration networks remain fragmented, with limited cross-national integration. Fourth, thematic development shows strong emphasis on spatial accessibility measurement, while equity integration and context-specific methodological innovation remain underdeveloped. These findings provide empirical evidence of the structural and conceptual gaps identified in the literature and establish the foundation for the discussion of policy and research implications.

DISCUSSIONS AND CONCLUSIONS

This study aimed to systematically evaluate the evolution, thematic structure, and collaboration patterns of TAI research in Asia between 2002 and 2024 using bibliometric analysis. Findings confirm that TAI research has expanded significantly, demonstrating an evolving method of accessibility assessment as a core indicator of sustainable urban mobility. Analysis of publication trends shows a clear transition from foundational accessibility modelling to more complex, technology-enabled approaches, indicating the maturation of the field. Geographic analysis reveals a strong concentration in a small number of countries, particularly China, India, Japan, and South Korea, confirming that research development is closely linked to national transit investments, urbanisation policies, and research funding capacity. This uneven distribution highlights structural disparities in knowledge production and suggests that accessibility frameworks currently reflect the priorities of a limited number of urban contexts rather than the full diversity of Asian cities. Collaboration analysis further demonstrates that TAI research remains fragmented, with strong intra-national networks but limited cross-border integration. This fragmentation restricts knowledge exchange and reduces opportunities to develop regionally adaptable accessibility models. Thematic analysis confirms that existing studies focus primarily on spatial accessibility measurement and transit system performance, while socioeconomic equity, informal mobility systems, and climate resilience remain insufficiently integrated. Temporal analysis shows a shift toward data-driven methodologies, including smartcard and geospatial data; yet these approaches are concentrated in technologically advanced cities, reinforcing disparities between high-capacity and resource-constrained regions. These findings collectively confirm the research gap identified in the literature, namely the absence of a comprehensive synthesis of how TAI research has evolved and the limited integration of equity-oriented and context-sensitive accessibility frameworks.

Furthermore, the novelty of this study lies in its systematic bibliometric mapping of TAI research specifically within the Asian context, providing empirical evidence of structural, geographic, and thematic imbalances that are not visible through individual case studies. By integrating publication trends, collaboration networks, and thematic evolution, this research establishes a comprehensive understanding of the intellectual structure of accessibility research in Asia. This shapes how government pursues urban planning through initiatives such as scholarships, industrial projects, and research grants by clarifying how accessibility measurement has been conceptualised and identifying priority areas for methodological advancement.

From a planning and policy perspective, this study's findings highlight the need to strengthen accessibility-based evaluation as a decision-support tool for sustainable urban development. First, accessibility models should incorporate socioeconomic dimensions such as income, age, gender, and physical ability to ensure that transit systems serve diverse population groups equitably. Second, informal and paratransit systems, which play a critical role in many Asian cities, should be systematically integrated into accessibility assessments to improve planning accuracy. Third, regional collaboration should be strengthened through shared datasets, cross-national research initiatives, and standardised accessibility indicators to improve methodological consistency and regional comparability. Fourth, urban authorities should leverage emerging geospatial and mobility data, including smartcard and location-based datasets, to develop dynamic accessibility indicators capable of supporting real-time planning and infrastructure investment decisions. This study also provides important implications for future research. Expanding accessibility analysis to underrepresented regions such as Southeast, Central, and West Asia would improve geographic balance and contextual relevance. Integrating multidimensional accessibility indicators that combine spatial, socioeconomic, and service quality factors would enhance the policy applicability of TAI. In addition, linking accessibility assessment with broader urban priorities, including climate adaptation, public health, and inclusive urban design, would strengthen its role as a core indicator of sustainable development.

In conclusion, Transit Accessibility Index research in Asia has evolved into a growing and increasingly sophisticated field but remains uneven in geographic coverage, methodological development, and thematic integration. Addressing these gaps requires stronger regional collaboration, integration of equity and informal mobility considerations, and adoption of data-driven yet inclusive analytical frameworks. By providing a systematic synthesis of research trends and structural gaps, this study establishes an empirical foundation for advancing accessibility-based planning and supports the development of more inclusive, resilient, and sustainable urban transport systems across Asia.

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