

Knowledge Map of Human Capital Development: A Scientometric Study Using VOSviewer

Loso Judijanto¹, Yanto Budi Prasetya²

¹IPOSS Jakarta

²Universitas Pawayatan Daha Kediri

Article Info	ABSTRACT
<p>Article history:</p> <p>Received August, 2025 Revised August, 2025 Accepted August, 2025</p>	<p>This study presents a comprehensive scientometric analysis of global research on human capital development (HCD) using VOSviewer to map its intellectual structure, thematic evolution, and collaborative networks. Bibliographic data were retrieved from the Scopus database, covering the period 2000–2025, and analyzed through co-authorship, co-citation, keyword co-occurrence, overlay, and density mapping techniques. The results reveal that <i>human capital development</i> remains the central research theme, strongly linked to <i>economic growth</i>, <i>economic development</i>, and increasingly to <i>sustainable development</i>, reflecting a shift towards integrating economic and sustainability paradigms. The co-authorship network highlights the United States as the primary research hub, with emerging contributions from Nigeria, Malaysia, and the Russian Federation, indicating both concentration and diversification of scholarly influence. Keyword overlay analysis shows recent research trends moving toward sustainability, globalization, and inclusive labor market outcomes, while density mapping confirms economic and sustainability themes as the conceptual core of the field. These findings provide actionable insights for policymakers, academics, and practitioners seeking to design integrated strategies that balance economic performance, environmental stewardship, and social equity in human capital policies. The study contributes to theory by reinforcing the need for multidisciplinary frameworks and offers a practical reference for guiding future HCD research agendas.</p>
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<p>Corresponding Author:</p> <p>Name: Full Name Institution: IPOSS Jakarta e-mail: losojudijantobumn@gmail.com</p>	<p><i>This is an open access article under the CC BY-SA license.</i></p> 

1. INTRODUCTION

Human capital development (HCD) has long been recognized as a critical driver of economic growth, organizational competitiveness, and social progress. The concept, popularized by the works of [1], emphasizes investment in people through education, skills, and health as a means to improve productivity and foster sustainable

development. In recent decades, globalization, technological change, and the shift towards a knowledge-based economy have amplified the importance of human capital as a key intangible asset that underpins innovation and adaptability [2], [3]. Consequently, governments, industries, and academia have intensified their efforts to

understand, measure, and enhance HCD strategies at both macro and micro levels.

The rapid advancement of digital technologies, artificial intelligence, and automation has further transformed the nature of work, creating new demands for skill sets and redefining workforce capabilities [4]. Organizations are now required to design learning and development frameworks that not only enhance technical skills but also strengthen soft skills, resilience, and lifelong learning abilities [5]. This transformation has prompted researchers to explore HCD from multidisciplinary perspectives, integrating insights from management science, education, economics, and organizational behavior. As a result, the academic landscape on HCD has grown more complex and fragmented, necessitating tools to map and synthesize the evolving body of knowledge.

Bibliometric and scientometric approaches have emerged as powerful methodologies to systematically analyze research landscapes, identify influential works, and detect emerging themes [6]. In the field of HCD, scientometric analyses can uncover how research priorities have shifted over time, which institutions and countries contribute most to the discourse, and how collaborations shape knowledge dissemination. VOSviewer, in particular, has gained prominence as a visualization tool for mapping co-authorship networks, keyword co-occurrences, and citation patterns, enabling researchers to make sense of large bibliographic datasets with high clarity [7].

Existing literature reveals that human capital research spans diverse areas such as workforce training, talent management, leadership development, and the role of higher education in skill formation [8], [9], [10]. However, despite the breadth of topics, there is limited integrative analysis that visualizes the entire knowledge network of HCD research. Most prior studies adopt traditional literature reviews or meta-analyses, which, while valuable, often lack the quantitative mapping capacity to reveal the structure and dynamics of the research field over time.

Moreover, the increasing policy relevance of HCD, particularly in the context of the United Nations Sustainable Development Goals (SDGs), underscores the urgency of understanding the intellectual structure of this field. For instance, SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth) are directly linked to human capital policies, making it essential for policymakers, academics, and practitioners to access a consolidated map of research trends, influential scholars, and thematic clusters. A scientometric analysis using VOSviewer offers an evidence-based pathway to meet this need by visualizing the patterns, collaborations, and thematic evolutions in HCD scholarship.

While human capital development has been extensively studied, existing research is dispersed across disciplines and lacks a consolidated scientometric mapping that can capture the interconnections, knowledge clusters, and emerging trends in a holistic manner. This fragmentation limits the ability of scholars and policymakers to identify research gaps, benchmark influential contributions, and formulate evidence-based strategies for advancing HCD in an era of rapid socio-economic transformation. This study aims to construct a comprehensive knowledge map of human capital development research using scientometric analysis with VOSviewer.

2. METHODS

This study employed a **scientometric approach** to systematically analyze and visualize the research landscape of human capital development (HCD). The methodology followed established bibliometric protocols [6] and was designed to capture the intellectual structure, thematic trends, and collaboration networks in the field. Data were retrieved from the **Scopus database**, selected for its broad coverage of peer-reviewed academic publications across multiple disciplines and its compatibility with bibliometric analysis tools. The search strategy combined controlled keywords and Boolean operators such as “*human capital*

development" OR "human resource development" OR "workforce development" in the title, abstract, and keyword fields, covering the period **2000–2025** to reflect both historical foundations and contemporary developments. Only journal articles, conference papers, and reviews written in English were included to ensure consistency and quality of data.

The bibliographic dataset extracted from Scopus was **exported in RIS and CSV formats** to facilitate compatibility with both Microsoft Excel for preliminary cleaning and VOSviewer for network visualization. Data cleaning involved removing duplicates, correcting inconsistencies in author names and affiliations, and standardizing keywords to ensure accurate mapping. The analysis focused on **co-authorship networks** (to examine research collaboration patterns), **co-citation** (to identify influential works and authors), and **keyword co-occurrence networks** (to reveal thematic clusters and emerging research trends). Fractional counting was applied in VOSviewer to normalize contributions from multi-authored papers, and the minimum threshold for inclusion in the network maps was determined based on frequency distributions to balance comprehensiveness and interpretability.

3. RESULTS AND DISCUSSION

Co-Authorship Network

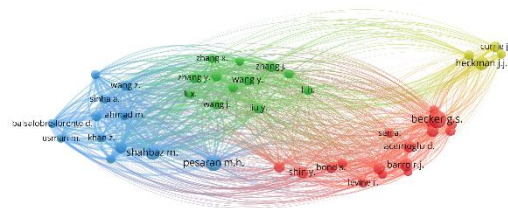


Figure 1. Author Visualization

Source: Data Analysis

Figure 1 illustrates the **co-citation relationships among key authors in human capital development research**, with nodes representing individual authors and links indicating the frequency of their joint citations. The network is divided into **four distinct clusters**, each reflecting a thematic or

theoretical orientation in the field. The **red cluster** centers on influential figures such as Becker G.S., Acemoglu D., and Barro R.J., highlighting foundational works in human capital theory, economic growth, and labor economics. The **green cluster** includes scholars like Zhang J., Wang Y., and Luay W., suggesting a focus on applied economic modeling and policy evaluation. The **blue cluster** features authors such as Wang Z., Ahmad M., and Shahbaz M., indicating strong engagement with empirical studies linking human capital to macroeconomic performance and sustainability. Finally, the **yellow cluster** led by Currie J. and Heckman J.J. points to the microeconomic and econometric analysis of education, skills formation, and labor market outcomes.

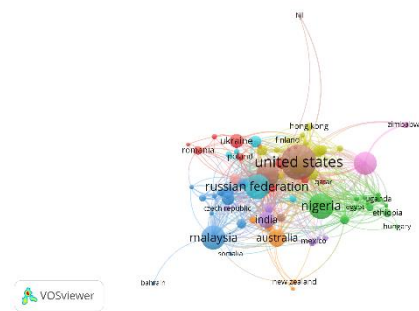


Figure 2. Country Visualization

Source: Data Analysis

Figure 2 shows the **global research network on human capital development**, where node size reflects publication volume and link thickness indicates the strength of co-authorship relationships between countries. The **United States** emerges as the most dominant node, signifying its central role and high output in the field, with extensive collaborative ties across continents. Surrounding clusters reveal regional research hubs: the **green cluster** led by Nigeria connects with Hungary and Zimbabwe, reflecting emerging collaborations in African and European contexts; the **blue cluster** centered on Malaysia and the Russian Federation links to diverse countries such as India, Australia, and the Czech Republic, suggesting cross-regional cooperation in Asia and Eastern Europe; and the **red cluster** connects the United States with nations like

Ukraine, Romania, and Finland, highlighting transatlantic scholarly partnerships.

Citation Analysis

Keyword Co-Occurrence Network

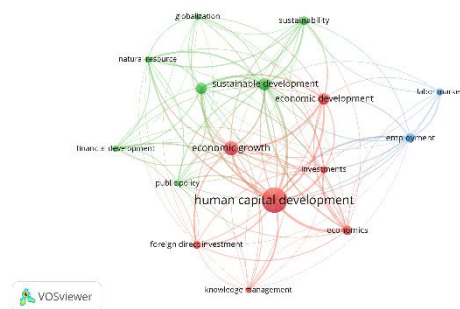


Figure 3. Network Visualization

Source: Data Analysis

Figure 3 depicts the **conceptual structure of research on human capital development (HCD)**, with nodes representing keywords and their size indicating frequency of occurrence in the dataset. The **red cluster**, where "human capital development" sits as the central node, connects to themes such as *economic growth*, *economic development*, *economics*, *foreign direct investment*, and *knowledge management*. This suggests that a significant proportion of HCD research is anchored in economic theory and policy, focusing on how human capital directly influences macroeconomic indicators, attracts investment, and supports knowledge-based economies. The density of links within this cluster indicates a strong scholarly consensus on the role of human capital as a foundation for sustainable economic advancement.

The **green cluster** is anchored around *sustainable development*, linking closely with concepts like *globalization*, *natural resources*, *financial development*, and *public policy*. This reflects a growing body of literature that situates HCD within the broader sustainability discourse, recognizing that developing human capabilities is essential for achieving long-term environmental, social, and economic goals. The co-occurrence of "sustainability" and "economic growth" suggests that scholars are increasingly examining how human capital policies can balance immediate economic gains with long-term ecological and societal well-being. This

aligns with global development frameworks such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 and SDG 8.

The **blue cluster** is smaller and revolves around labor market and employment-related terms. Keywords such as *labor market*, *employment*, and *economic development* highlight research that examines the practical outcomes of human capital investments in terms of workforce participation, job creation, and structural shifts in labor demand. The relatively fewer nodes in this cluster may indicate a specialized subfield focusing on microeconomic labor studies and the direct link between human capital and employability. This cluster's connection to both the red and green clusters underscores that labor market outcomes are influenced by both economic policy frameworks and sustainable development strategies.

The network also reveals **interlinkages between clusters**, suggesting that the boundaries between economic, sustainability, and labor-focused research in HCD are fluid. For example, *economic growth* appears as a bridge between the red and green clusters, indicating that growth is a shared concern in both economic-centric and sustainability-oriented research streams. Similarly, *economic development* connects labor market discussions to the macroeconomic perspective, showing that job creation and skills development are core mechanisms through which human capital contributes to national progress.

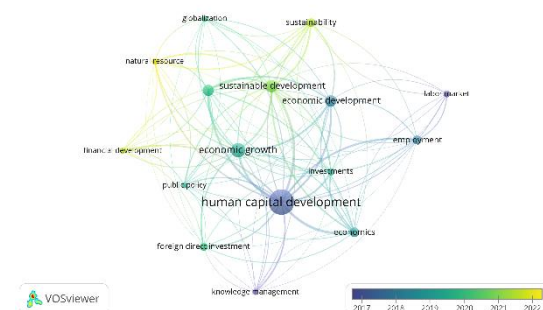


Figure 4. Overlay Visualization

Source: Data Analysis

Figure 4 presents the **temporal evolution of keywords in human capital**

development (HCD) research from 2017 to 2022. The color gradient indicates the average publication year of each keyword, with darker blue tones representing earlier studies and yellow tones representing more recent research. Core terms such as *human capital development*, *economic growth*, and *economic development* appear in blue to green shades, signifying their consistent prominence since the earlier years of the study period. These foundational themes have served as the backbone of the literature, anchoring discussions on how human capital influences macroeconomic performance and national competitiveness.

In contrast, keywords such as *sustainability*, *natural resource*, and *globalization* appear in green to yellow shades, reflecting their increasing relevance in recent years. This suggests a research shift towards integrating HCD with sustainability-oriented frameworks and global development agendas, particularly in response to challenges such as climate change, environmental degradation, and the United Nations Sustainable Development Goals (SDGs). The appearance of *public policy* and *financial development* in similar shades highlights growing interest in how governance structures and financial systems can support sustainable human capital growth. At the same time, labor-related keywords like *labor market* and *employment* show a moderate recency in green hues, suggesting continued but evolving interest in the employment outcomes of HCD investments. This indicates that while economic theory remains central, scholars are increasingly emphasizing practical labor implications and equitable workforce participation.

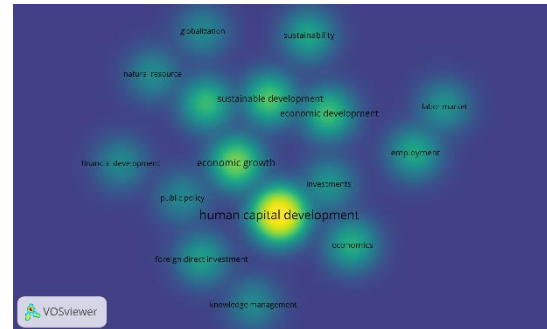


Figure 5. Density Visualization

Source: Data Analysis

Figure 5 highlights **research intensity within the field of human capital development (HCD)** by showing areas with high keyword occurrence and co-occurrence frequencies. The central and brightest spot is *human capital development*, indicating it as the most frequently discussed and interconnected term across the dataset. Surrounding this core are other high-density keywords such as *economic growth*, *economic development*, and *sustainable development*, reflecting their central role in framing scholarly debates and policy discussions on HCD. The brightness and proximity of these terms suggest that much of the literature situates HCD as a driver of macroeconomic performance and as a pillar for achieving sustainability goals. Moving outward, the visualization shows lower-density but still significant areas such as *labor market*, *employment*, *public policy*, *financial development*, and *foreign direct investment*. These keywords, while not as central, represent specialized subthemes that contribute to the broader discourse. The relatively dimmer color of these peripheral areas implies that they may either be niche research topics or emerging areas with growing but not yet dominant attention.

Practical Implication

The findings of this study provide several actionable insights for policymakers, educators, and organizational leaders. The identification of *human capital development*, *economic growth*, and *sustainable development* as central themes underscores the need for integrated policy frameworks that simultaneously enhance workforce capabilities, foster inclusive economic progress, and align with sustainability

objectives. For national governments, the strong interlinkage between HCD and *public policy* suggests that effective legislative and institutional support is essential for translating human capital investments into measurable socio-economic outcomes. For international development agencies, the global collaboration patterns—particularly the dominance of the United States and emerging hubs like Nigeria and Malaysia—highlight opportunities to leverage cross-country partnerships to transfer knowledge, build research capacity, and localize best practices in developing regions. Businesses and educational institutions can also draw on these results to design targeted training, capacity building, and upskilling programs that address both current labor market demands and future sustainability challenges.

Theoretical Contribution

From a scholarly perspective, this study advances the theoretical understanding of human capital development by mapping its intellectual structure and thematic evolution. The results confirm the enduring relevance of foundational economic theories (e.g., Becker's human capital theory) while illustrating their integration with sustainability paradigms and globalization discourse. The co-occurrence and overlay maps reveal a theoretical shift from an economics-centered view toward a multidisciplinary framework that incorporates environmental and social dimensions of HCD. This suggests that future theoretical models should move beyond linear cause-effect relationships between human capital and economic growth, toward systems-oriented models that capture feedback loops between education, employment, sustainability, and policy. Moreover, the visualization of collaboration networks reinforces the idea that knowledge production in HCD is increasingly shaped by transnational and cross-sector partnerships, supporting theories of global knowledge networks and co-production of development strategies.

Limitation

While this study provides a comprehensive scientometric overview, it is not without limitations. First, the reliance on

the Scopus database, though extensive, may have excluded relevant literature indexed in other databases such as Web of Science or Google Scholar, potentially underrepresenting certain regions or disciplines. Second, the focus on English-language publications may bias the results toward Anglophone scholarship, underrepresenting research from non-English speaking countries that could offer valuable perspectives. Third, bibliometric methods such as co-occurrence and co-citation analysis capture patterns of scholarly communication but do not directly assess the quality or depth of individual studies. Finally, the temporal scope (2000–2025) captures long-term trends but may not fully reflect very recent developments, especially in fast-evolving topics like AI-driven workforce training or post-pandemic human capital policies.

Future Research Directions

Building on these findings, future studies could expand the analysis to include multiple databases to capture a more holistic view of the global HCD literature. Incorporating non-English sources would provide a richer understanding of region-specific challenges and innovations, particularly from emerging economies. Methodologically, combining scientometric mapping with qualitative systematic reviews could yield deeper insights into the conceptual frameworks, methodologies, and policy implications embedded in the literature. Future research could also focus on longitudinal cluster evolution analysis to track how topics such as *sustainability*, *digital transformation*, and *labor market shifts* evolve over time within the HCD discourse. Additionally, comparative scientometric studies across related fields—such as human resource development, talent management, and educational policy—could reveal cross-domain linkages and opportunities for interdisciplinary integration.

4. CONCLUSION

Based on the scientometric analysis conducted using VOSviewer, this study concludes that research on human capital

development (HCD) has evolved into a multidimensional field that bridges economics, sustainability, labor market dynamics, and public policy. The mapping results reveal that while foundational economic theories remain central, there is a clear and growing integration of sustainability-oriented perspectives, reflecting the alignment of HCD with global development agendas such as the Sustainable Development Goals. Collaboration patterns indicate that the United States serves as a

dominant research hub, supported by emerging contributors like Nigeria, Malaysia, and the Russian Federation, highlighting both the concentration of scholarly influence and the potential for broader international partnerships. Keyword analyses further suggest that future research directions are shifting towards addressing environmental considerations, globalization impacts, and inclusive employment outcomes.

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