

DELINEATING THE INTELLECTUAL STRUCTURE OF SOCIO-ECONOMIC RUBBER FARMING RESEARCH: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Over the past twenty years, increasing worries about rural livelihoods, market instability, and changes in land use have triggered a rise in socio-economic studies on natural rubber farming. Understanding the findings of this growing body of research is crucial. This bibliometric analysis examines 226 publications indexed in Scopus from 2006 to 2025, aiming to chart the productivity trends, thematic structure, and collaborative dynamics within this research area. To assess the evolution of research in this field, methods such as performance indicators, co-word analysis, thematic mapping, and co-authorship network analysis were applied. The findings indicate a consistent growth in research output, with a notable concentration in Southeast Asia and Southwest China. Themes like studies on livelihoods and land use, especially those centred on China, have emerged as strategically important and conceptually developed topics. The collaboration analysis revealed tightly connected networks of authors and countries, primarily dominated by China, Thailand, and Indonesia, with minimal cross-regional collaboration. In short, the analysis overall highlights both the depth and fragmentation within research in this field, emphasising the necessity for more thematic integration and increased global cooperation to advance this discipline.

KEYWORDS: rubber farming, natural rubber, socio-economic analysis, bibliometric analysis, collaboration networks

1. INTRODUCTION

Annually, over 6.5 million tons of dry natural rubber are produced worldwide from more than 9.5 million hectares of rubber tree (*Hevea brasiliensis*) plantations spread across roughly 40 countries. In contrast, the global demand for natural rubber was around 12 million tons in 2020, indicating that current production levels are insufficient to meet this demand.[1]. According to the 2021 data, the rubber industry consumed approximately 30 million tons of rubber, encompassing both synthetic and natural types, with natural rubber comprising a significant share of this total [2]. A major contributor to this production is the rubber smallholders. They are not merely participants in the industry, but also serve as the primary driving force behind natural rubber production.

In numerous tropical nations, especially in Southeast Asia and certain regions of Africa, rubber production is largely dominated by smallholders. In countries like Thailand and Malaysia, these smallholders account for approximately 85-93% of the rubber plantations, while in Indonesia, rubber is frequently grown by small-scale farmers within agroforestry systems [3,4]. In Nigeria, small-scale rubber farming plays a crucial role in enhancing rural socio-economic conditions by generating jobs and income [5]. Over time, rubber cultivation has shifted rural communities from subsistence farming to economies focused on market production. For example, since the early 2000s, the introduction of rubber in Northeastern Thailand has transitioned local livelihoods from shifting cultivation and subsistence agriculture to cash crop production, thereby changing land use and the economic framework [6].

Rubber smallholders earn significant income, often serving as the primary source of livelihood for rural families. This crop benefits not only the farmers but also rural workers engaged in tapping, processing, and marketing activities [5,7,4]. Research has indicated that rubber cultivation boosts household income, which subsequently enhances dietary variety and food security [8]. For instance, in areas such as Southern Yunnan (China), smallholder rubber plantations have raised per capita income and contributed to the economic growth of rural communities [9]. By increasing income and providing access to a broader range of foods, rubber farming positively influences household dietary diversity. This nutritional enhancement is a vital social advantage of this cultivation in rural regions [8].

Nevertheless, rubber prices are influenced by global market fluctuations, primarily driven by demand from sectors like automotive (tires) and medical supplies. This price instability is further exacerbated by competition from synthetic rubber and alternative crops. For example, in Malaysia, rubber smallholders have faced reduced productivity and income since 2011 due to declining demand and prices, pushing many into poverty [10, 11]. Options for managing price risk are limited, and farmers often lack access to futures markets or financial tools to protect against price declines [12, 13]. This results in income fluctuations that hinder farmers' ability to plan and invest in their farms. When prices drop, farmers cut back on inputs or abandon rubber farming, sometimes turning to other livelihoods like gold mining or other cash crops, which disrupts income stability and community cohesion [14]. This volatility also impacts household consumption, with farmers prioritizing non-food expenditures such as fuel and social obligations over food security during prosperous times, but struggling during economic downturns [15].

In many tropical areas, the swift expansion of rubber plantations has frequently led to the replacement of forests or diverse agricultural systems. For example, in southern India, the proportion of land dedicated to rubber plantations increased from 30% to 74% over fifty years, boosting farmers' incomes but also causing significant environmental degradation [16]. Similar patterns are evident in Laos and Southeast Asia, where government initiatives encourage rubber cultivation as a means to alleviate poverty, often neglecting ecological sustainability [17]. This shift to rubber monoculture diminishes agricultural diversity, potentially harming household dietary variety and resilience to economic shocks [8]. In addition, it results in environmental impacts such as deforestation, biodiversity loss, soil degradation, and a decline in ecosystem services like water retention and carbon sequestration [18, 19]. These ecological alterations can adversely affect the economic stability of farming communities, threatening their long-term prosperity [16].

Another issue of concern is the shortage of labor, which poses a major challenge, particularly because rubber tapping is labor-intensive and requires a lot of manual work, due to which younger people are moving to urban areas or different industries. This scarcity drives up labor costs and limit the scale of rubber farming. Moreover, many rubber farmers lack access to affordable loans or capital to invest in farm enhancements, such as improved planting materials, fertilizers, or mechanization. Extension and technical support services are frequently inadequate, hindering farmers' ability to boost productivity or adopt sustainable practices [19,17].

Although rubber plays a crucial role in providing jobs and generating income in rural areas, many small-scale rubber farmers still face poverty or are vulnerable. In Malaysia, a significant number of these smallholders are classified as living in extreme poverty, failing to reach the government's targeted income levels. The vulnerability of these farmers is worsened by falling rubber prices, which compel them to either find other income sources or cut spending [10, 20]. Analysis of household spending patterns shows that families involved in rubber farming allocate a large share of their earnings to non-food expenses, such as cultural and social commitments, which can strain budgets during price downturns [15]. In certain regions, food insecurity is a concern because of reduced farm production diversity and unstable incomes [17]. Although social capital, such as community networks and cooperative efforts, can mitigate some of these risks, they are often weak or not fully utilized in rubber farming communities [21]. To enhance resilience, it is advised to strengthen social capital and offer better institutional support.

In rubber research, the socio-economic aspect is frequently overshadowed by agronomy and industry due to their direct connection to quantifiable productivity and economic outcomes, the complexity and qualitative nature of socio-economic elements, and the current funding and policy priorities. Nonetheless, socio-economic studies are crucial for comprehending the overall effects of rubber cultivation on rural communities and for meeting sustainable development goals within the rubber sector [7, 22, 23, 24].

Knowledge gap. Extensive research exists on rubber and its cultivation, yet past studies on rubber farming have been dispersed across various themes, including livelihoods, productivity, land use, value chains, and risk. Different aspects have been examined separately, such as the effects of rubber monoculture on biodiversity and changes in land use, the socio-economic factors driving land transfer and fragmentation, and the impacts on smallholder livelihoods and agricultural productivity [3, 25, 26, 27]. For instance, research on land use change often highlights the risks of deforestation and biodiversity loss associated with rubber expansion [3, 28]. At the same time, other studies explore farmers' decision-making processes in land transfer to enhance resource allocation efficiency [27]. Additionally, analysis of value chains and risk assessments are typically treated as separate topics, lacking integration with ecological or livelihood perspectives [25, 29]. This thematic fragmentation hinders a comprehensive understanding of the complex socio-ecological and socio-economic dynamics of rubber farming.

It appears that there is no direct evidence from the sources provided that indicates a previous bibliometric or systematic mapping study specifically targeting the socio-economic aspects of rubber research. Although there is a study involving mapping rubber plantations using remote sensing and phenology methods [30], it does not cover socio-economic dimensions or bibliometric analysis. Conducting a bibliometric or systematic mapping study on this domain would be beneficial in revealing emerging trends, collaboration patterns, and thematic changes, similar to what has been achieved in other socio-economic research areas [31, 32]. Such a study could help pinpoint research gaps, regional disparities in collaboration, and evolving intellectual structures, thereby guiding future research priorities and policy interventions. In conclusion, there is no evidence of prior bibliometric or systematic mapping focused on rubber socio-economic studies, leaving the evolution, themes, and collaboration patterns in this field largely unexplored. This presents a clear opportunity for future research.

Research Question and Objectives

Although there is an increasing amount of literature on rubber farming, research that explores its socio-economic aspects is still conceptually disjointed and varies significantly by region. Nevertheless, there is still a lack of a systematic understanding of the evolution of this literature over time, the organization of its main themes, and the collaboration among scholars in this field. Bibliometric analysis provides a rigorous and transparent method to fill these gaps by quantitatively mapping research productivity, intellectual structure, and collaboration patterns.

In this regard, the current bibliometric study attempts to address the following research question:

How has socio-economic rubber farming research evolved in terms of productivity, thematic concentration, and scientific collaboration?

To answer this central question, the study is guided by three distinct research objectives:

1. To evaluate the research productivity, pertinent sources, and geographical distribution of socio-economic rubber farming studies over time.
2. To identify and analyse the key thematic clusters and conceptual structure of socio-economic rubber farming research through co-word analysis.

3. To examine the structure of scientific collaboration in the field using co-authorship analysis at the author and country levels.

By fulfilling these objectives, the study offers a thorough overview of the development and organisation of socio-economic rubber farming research. The findings offer insights into prevailing and emerging themes, regional research strengths, and collaboration dynamics, thereby laying a structured foundation for future empirical, theoretical, and policy-oriented research in this area.

MATERIALS AND METHODS

In order to explore the stated research question and objectives, this study employs a systematic bibliometric research design. This approach involves a methodical and thorough examination of scientific literature, primarily utilising quantitative and statistical methods to identify patterns, trends, and impacts within a specific research domain. It is widely adopted in business and management research for its capability to manage large datasets and generate high-impact insights [33, 31].

Data collection

The data collection for this analysis consists of gathering bibliometric data from reliable scientific databases like Scopus, Web of Science, or Google Scholar. Data typically include publications, citations, keywords, authorship, and affiliations [33, 34]. The study uses the Scopus database, which covers an extensive range of scientific publications, including over 102.6 million records from more than 21.9 million active author profiles and more than 7,000 publishers worldwide, making it a reliable source of scholarly literature [35]. Scopus only includes journals that have gone through a rigorous review process, providing high-quality articles. Finally, researchers have access to the raw data and tools, empowering to explore and generate insightful metrics.

The researchers have identified the essential concepts that are central to the research on socio-economic rubber farming. The selection of keywords was guided by the description in the context of the research problem (Table 1). The primary concepts, such as “Rubber farming” and its related terms in the scientific literature, along with several secondary concepts related to the initial context of this research, have been prioritised. The combination “TITLE-ABS-KEY” has been applied in the entirety of our search string. The Boolean operators, AND, OR, and NOT, combined with parentheses, quotation marks, and truncation/wildcards, have been used to combine or exclude search terms to refine and control search results in databases and literature searches [36]. These operators help researchers focus or expand their search to retrieve relevant literature efficiently and avoid missing critical information or retrieving irrelevant data [37, 38].

Table 1: Search string.

Topic	Search string
Rubber Farming (Principal Concept) TITLE-ABS-KEY	“rubber farming” OR rubber cultivation” OR “rubber plantation*” OR “rubber smallholder*” OR “natural rubber” OR “Hevea brasiliensis”
AND Socio-economic Aspects (Secondary Concept) TITLE-ABS-KEY	“socio-economic” OR “socioeconomic” OR livelihood* OR income OR poverty OR welfare OR “rural development” OR adoption OR “technology adoption” OR efficiency OR productivity OR “cost of cultivation” OR profitability OR “value chain” OR “market access” OR “price risk” OR labor OR “farm worker*” OR “working condition*” OR “outgrower” OR “contract farming”
NOT TITLE-ABS-KEY	“industrial rubber” OR “synthetic rubber” OR “rubber processing” OR “latex products” OR “polymer”
Final Combined Search String	((“rubber farming” OR “rubber cultivation” OR “rubber plantation*” OR “rubber smallholder*” OR “natural rubber” OR “Hevea brasiliensis”) AND (“socio-economic” OR “socioeconomic” OR livelihood* OR income OR poverty OR welfare OR “rural development” OR adoption OR “technology adoption” OR efficiency OR productivity OR “cost of cultivation” OR profitability OR “value chain” OR “market access” OR “price risk” OR labor OR “farm worker*” OR “working condition*” OR “outgrower” OR “contract farming”) AND NOT (“industrial rubber” OR “synthetic rubber” OR “rubber processing” OR “latex products” OR “polymer”))

In the course of the search, there was no restriction on the year, with papers dating back to 1958. However, after the screening and cleaning process, the bibliometric analysis was confined to the years 2006 to 2025. It was discovered that records before 2006 were limited, poorly indexed, and not suitable for co-word analysis. Many documents were irrelevant and did not pertain to socio-economic rubber farming studies. To enhance the quality of the paper, the researchers limited their search to articles, reviews, and conference papers. While English dominated the literature, the researchers opted to maintain linguistic diversity; therefore, no languages were excluded. The study was ultimately conducted on October 31, 2025.

The initial search generated 1939 records, but ultimately, only 226 documents were retained, comprising 15 review papers, 20 conference papers, and 191 research articles. The entire process of identifying records is illustrated using the PRISMA flowchart, as depicted in Fig.1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is a standardized guideline designed to enhance the transparency, completeness, and accuracy of reporting in systematic reviews and meta-analyses. It assists authors in clearly explaining why the review was conducted, the methods employed, and the results obtained, ensuring that the review can be critically evaluated and replicated [39, 40]. PRISMA mandates a flow diagram that visually maps the number of records identified, screened, included, and excluded, along with the reasons for exclusions, thereby enhancing transparency in the study selection process [41].

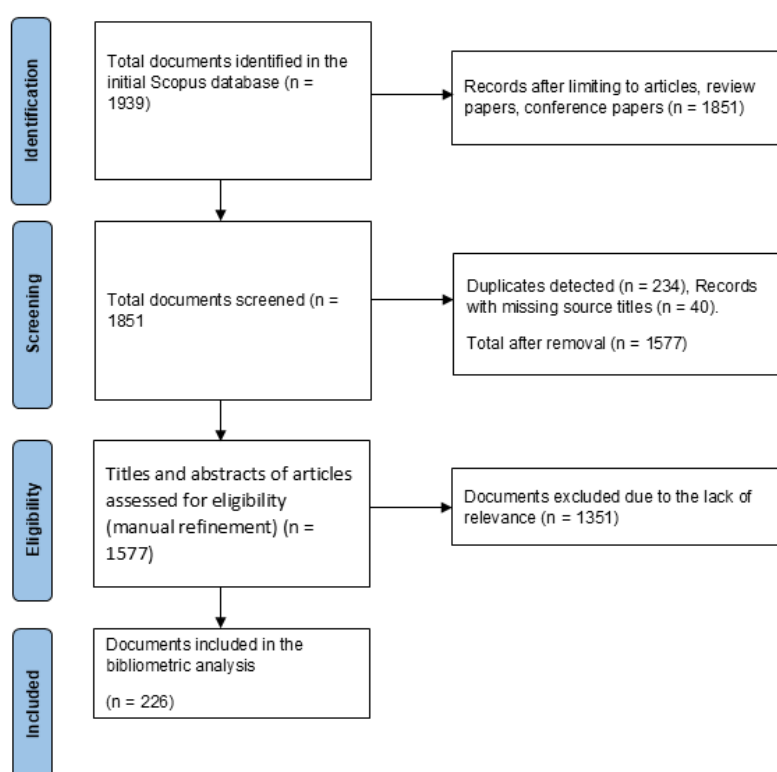


Fig. 1. PRISMA flow chart

Screening and eligibility

The aim of screening and selecting for eligibility is to address the predefined research question using robust methodology and relevant data [42, 43]. The inclusion criteria outline study characteristics such as population, intervention, comparator, outcomes, and study design (PICOS), along with publication timeframe, language, and type [43, 44]. For this analysis, documents were selected if they specifically addressed socio-economic aspects of rubber farming, including household livelihoods and income strategies, value chain, market accessibility, price mechanisms, labour-migration, and working conditions, technology adoption, productivity, and efficiency, rural development, welfare, and poverty outcomes, socio-economic impacts of land-use change, agroforestry, or intercropping, and household or community-level responses to price risk, climate risk, or market volatility. Any document analysing rubber cultivation's relationship to people, households, labour, markets, welfare, or developments was qualified for inclusion.

Additionally, an exclusion criterion should be established that commonly excludes studies with irrelevant designs, such as qualitative studies when quantitative ones are needed, animal research, non-English language studies (if justified), or those outside the specified timeframe [43]. The documents that were excluded included those related to polymer or materials science, synthetic rubber studies, industrial or chemical processing of rubber, or latex agronomy papers that lacked socio-economic analysis, such as those focusing solely on soil nutrients, clonal performance, or tapping physiology. Furthermore, papers on pure ecology or biodiversity without any connection to livelihoods or socio-economic factors, as well as engineering, chemistry, or physics papers where "rubber" referred to non-agricultural studies like synthetic rubber, rubber compounds, polymer blends, or latex engineering, were also excluded. These exclusions ensured that the analysis remained concentrated on natural-rubber farming within socio-economic contexts.

Data preparation and bibliometric tools

For each document, Scopus provided metadata fields such as abstract, affiliation, author, cited references, DOI, document type, journal, language, publication year, title, total citation, keywords, corresponding author, and keywords plus. These fields were utilized for performance analysis, conceptual structure analysis, and collaboration mapping. The bibliometric analysis was conducted using Biblioshiny, an R tool for scientific mapping in bibliometrics. The initial goal was to perform a performance analysis, which involved calculating descriptive bibliometric indicators like annual scientific output, most significant sources, leading countries in productivity, citation distribution, and author productivity metrics. These analyses describe the expansion, distribution, and influence of research on socio-economic rubber farming. The second objective examined intellectual structure using co-word analysis of author keywords and thematic mapping based on Callon's metrics. This revealed conceptual relationships and positioned research topics as Motor, Basic, Niche, and Emerging or Declining themes. The final goal is the analysis of collaboration structures. Collaboration networks were formed using author co-authorship networks and country collaboration networks. The bibliometric analysis calculated linkage strength between authors and countries, SCP (single-country publications) and MCP (multi-country publications), as well as network density and cluster structures. These analyses depict how researchers and countries collaborate, emphasising regional research centres and international scientific connections.

RESULTS AND DISCUSSION

Overview Of The Dataset

Upon exporting the final raw data into the software, Biblioshiny presented a summary of the dataset's bibliometric features. Table 2 offers a comprehensive analysis of all 226 documents from 2006, revealing an annual growth rate of 5.95%, which signifies a consistent yet non-exponential increase. The dataset comprises 1939 references, 851 keywords, and 737 authors' keywords. With an average of 16.35 citations per document, the field demonstrates significant scholarly influence. The dataset encompasses 705 authors, but only 22 of them wrote single-authored papers, highlighting the collaborative nature of socio-economic rubber farming research. Apart from this, with 3.99 co-authors per document and 35.84% international collaborations on average, the research shows strong transnational networks across producer and non-producer countries.

Table 2: Main bibliometric information about the data

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2006:2025
Sources (Journals, Books, etc.)	143
Documents	226
Annual Growth Rate %	5.95
Document Average Age	6.9
Average citations per doc	16.35
References	1939
DOCUMENT CONTENTS	
Keywords Plus (ID)	851
Author's Keywords (DE)	737
AUTHORS	
Authors	705
Authors of single-authored docs	22
AUTHORS COLLABORATION	
Single-authored docs	23
Co-Authors per Doc	3.99
International co-authorships %	35.84
DOCUMENT TYPES	
article	191
conference paper	20
review	15

Performance analysis

The performance analysis is a fundamental component of bibliometric research, offering a quantitative measure of the productivity and impact of scholarly work, and shedding light on the development and influence of scientific disciplines [45, 46, 47]. This section will present the findings related to the paper's first objective, the performance analysis, which includes annual scientific output, key sources, and scientific production at the country level.

Annual scientific production. Figure 2 illustrates the annual scientific output from 2006 to 2015, highlighting a shift from occasional contributions to a consistently expanding research area. Early years saw minimal output (3 papers in 2006, 1 in 2007, 2 in 2008); however, a significant rise started around 2015, increasing from 11 papers in 2015 to 21 in 2018, and remaining relatively high thereafter. The output peaked at 22 documents in 2021 and 2024, indicating that studies on this subject have become a recognised niche within the broader natural-rubber literature. Although the apparent drop to 9 papers in 2025 should not be seen as a genuine decline, as Scopus indexing for the latest year is not yet complete, this is a common occurrence in bibliometric time series.

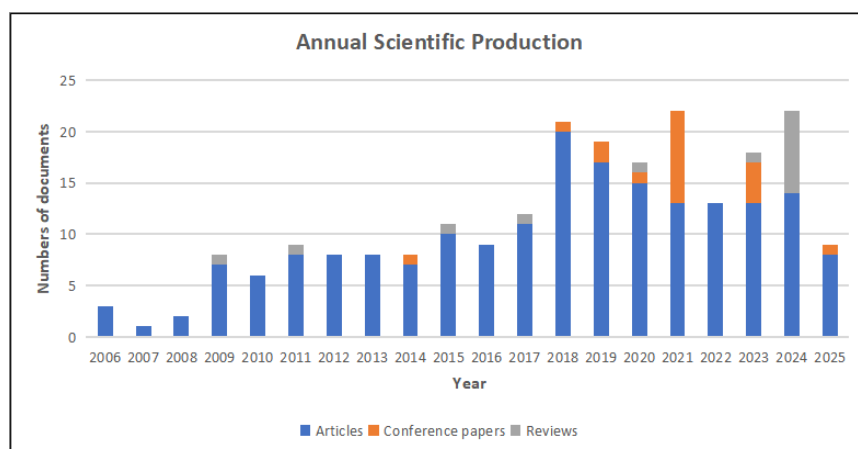


Fig. 2. Annual scientific production

Most relevant sources. Table 3 presents the key publication sources in this discipline, with their publications from the final dataset. It reveals that a small number of publication sources dominate a significant portion of this discipline. E3S Web of Conferences emerges as the most prolific source, contributing 11 documents, primarily focusing on environmental and agricultural sustainability in Asia. Among peer-reviewed journals, Agroforestry Systems and the Kasetsart Journal – Social Sciences follow up with 8 and 7 documents respectively, emphasising the strong connection between rubber farming, mixed land-use systems, and rural socio-economic issues. High-impact journals in policy and economics, such as Forest Policy and Economics, and Agriculture (Switzerland), are also among the key sources. This indicates that research in this field is not confined to niche publications but is increasingly appearing in more general agricultural, forestry, and sustainability journals, where work relevant to policy can reach a broader audience.

Table 3: Most relevant sources

Sources	Publications
e3s Web Of Conferences	11
Agroforestry Systems	8
Kasetsart Journal - Social Sciences	7
Forest Policy And Economics	6
Agriculture (Switzerland)	5
Australian Journal Of Crop Science	4
Iop Conference Series: Earth And Environmental Science	4
Agricultural Systems	3
Bois Et Forets Des Tropiques	3
Forest And Society	3
Forests, Trees, And Livelihoods	3
Geoforum	3
International Journal Of Sustainable Development And World Ecology	3
Journal Of Peasant Studies	3
Journal Of Plantation Crops	3

Country-level scientific production. In the final segment of performance analysis, as outlined in the objective, Table 4 lists the fifteen most productive countries. The production of papers in this field is predominantly concentrated in a handful of nations. China leads with 33 papers (14.6%), followed by Thailand (30 papers, 13.3%), and Indonesia (23 papers, 10.2%). These countries are also major producers of natural rubber globally, which highlights their domestic policy focus on smallholder livelihoods, land-use changes, price fluctuations and other socio-economic variables. The SCP (Single Country Publications) and MCP (Multiple Country Publications) columns in the table provide metrics for

assessing the productivity and collaboration patterns of countries in scientific research. SCP denotes publications authored by individuals affiliated with institutions within the same country, indicating intra-country collaboration or research conducted solely within one nation. In contrast, MCP represents publications co-authored by researchers from institutions in multiple countries, indicating international collaboration [49, 50]. The collaboration indicators reveal varying participation styles. China and Thailand exhibit a strong SCP presence alongside a significant MCP share, suggesting robust national research systems capable of leading domestic studies while also participating in international projects. However, Indonesia, despite ranking third, shows a much lower international engagement with only 8.7% MCP share. Conversely, Germany, Japan, the USA, France, and Mexico, though contributing fewer papers in absolute numbers, have very high MCP percentages of 76.9%, 60%, 55.6%, 57.1%, and 66.7%, respectively, reflecting their strong integration into the global research network.

Table 4: Most productive countries

Country	Publications	Publications %	SCP	MCP	MCP %
China	33	14.6	21	12	36.4
Thailand	30	13.3	20	10	33.3
Indonesia	23	10.2	21	2	8.7
Germany	13	5.8	3	10	76.9
India	12	5.3	10	2	16.7
Japan	10	4.4	4	6	60
Malaysia	10	4.4	9	1	10
Usa	9	4	4	5	55.6
France	7	3.1	3	4	57.1
Benin	4	1.8	3	1	25
Sri Lanka	4	1.8	4	0	0
Brazil	3	1.3	2	1	33.3
Canada	3	1.3	3	0	0
Denmark	3	1.3	0	3	100
Mexico	3	1.3	1	2	66.7

Subsequently, Fig. 3 illustrates the cumulative production trends for the top seven countries. China and Thailand have demonstrated steady growth since 2006, but have been accelerating post-2014. Indonesia and Malaysia begin contributing later, but experience significant growth after 2015. Germany and France show slower yet steady growth, indicative of their roles as long-term international collaborators rather than leading producers. Meanwhile, India is gradually catching up to Malaysia and France, producing slightly less than them but steadily increasing its publications.

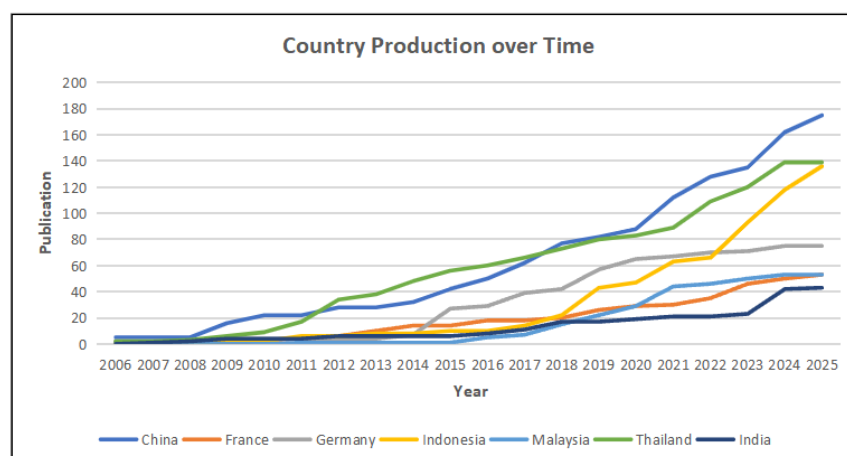


Fig. 3 Country production over time for the seven most productive countries

In general, the performance analysis in socio-economic rubber research has risen significantly since 2015. The expanding volume of research highlights a transition in academic and policy focus from solely the agronomic aspects of rubber cultivation to the socio-economic dimensions of rubber farming, which has gained importance across various disciplines. The consistent growth in papers with multiple authors and international collaborations underscores the view that the field

is becoming more collaborative and methodologically varied, incorporating insights from economics, geography, ecology, and agricultural sciences. This suggests that the field is geographically concentrated in major rubber-producing regions.

Intellectual structure: Co-word and thematic analysis

Co-word network analysis. Fig. 4 illustrates a co-word or co-occurrence network, depicting a cohesive yet multi-centred intellectual framework organised around several interconnected thematic clusters. The figure identifies six clusters, with the prominent node "rubber" situated in the blue cluster (cluster two), which serves as a hub for a set of closely associated socio-economic terms such as intercropping, livelihood, agroforestry, deforestation, smallholders, income, and migration. Also, terms in this cluster include Laos, Indonesia, and Northeast Thailand, representing countries in Southeast Asia where rubber farming is prevalent. This cluster highlights the primary socio-economic focus of the field: the intersection of rubber production with rural livelihoods, land-use changes, household income strategies, and the broader social-ecological systems in Southeast Asia. The second significant clusters are the violet (cluster four) and orange (cluster five), which revolve around "natural rubber," linked to rubber price, income diversification, rubber smallholders, rubber farmers, and family farming. This group encapsulates research on price volatility, livelihood diversification strategies, and the vulnerabilities faced by rubber-dependent smallholders in producer countries. The prominence of terms related to price and income emphasises strong policy relevance, especially during times of global price instability. The green cluster (cluster three), positioned toward the right of the network, emphasises land-use and regional transformation, linking China, Xishuangbanna, rubber plantation, land use, and adoption. This reflects a significant body of work exploring how rapid rubber expansion, particularly in Southwest China and mainland Southeast Asia, has transformed landscapes, household decision-making, and agricultural adoption patterns. The red cluster (cluster one) is more environmentally focused, connecting sustainability, biodiversity, and climate change, indicating a cross-cutting concern with the ecological impacts of rubber expansion and the integration of sustainability frameworks into socio-economic analyses.

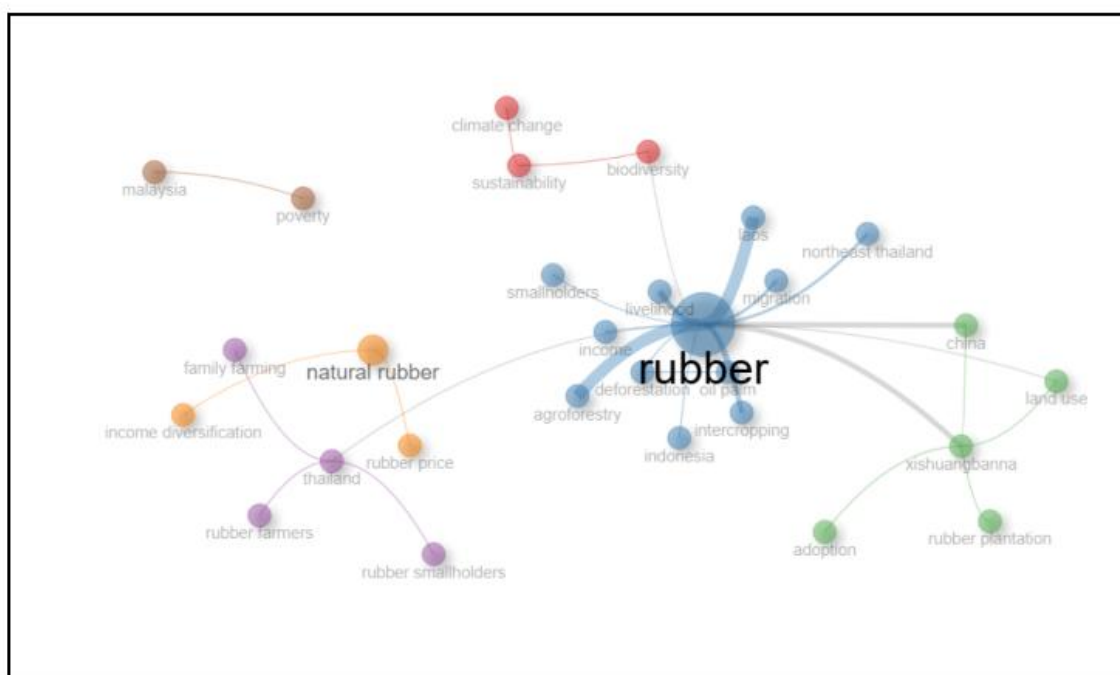


Fig 4. Co-word network of Author Keywords

The co-word network collectively reveals that research on socio-economic aspects of rubber farming is organised around several key themes: livelihood and household economics, price and market dynamics, land-use change and regional development, and environmental sustainability issues. This research is strongly rooted in specific geographic areas, including Thailand, Indonesia, Laos, Xishuangbanna, and Malaysia.

Thematic map analysis. While co-word analysis reveals conceptual relationships, it doesn't indicate thematic importance or maturity. To address this, thematic map analysis was utilised to arrange themes according to their centrality and density, offering a strategic perspective on the conceptual framework of the field. This method provides a thorough understanding of research landscapes by illustrating the interconnections and progression of themes, thereby informing future research paths and strategic planning in scientific domains. Cobo et al. [50] initially introduced this approach, employing a strategic diagram with four quadrants. Each quadrant categorises themes into groups: motor theme, niche theme, emerging/declining theme, and basic theme, corresponding to quadrants 1, 2, 3, and 4, respectively [51].

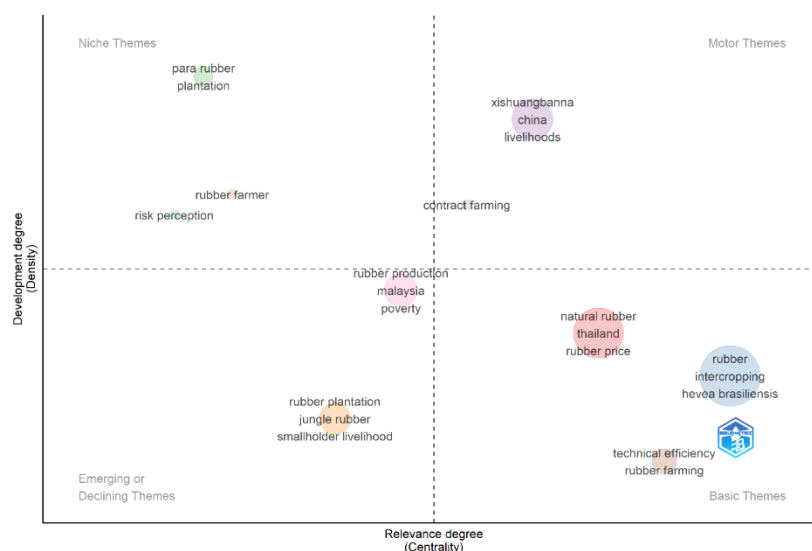


Fig. 5. Thematic map of socio-economic rubber farming research (Author Keywords)

The thematic map in Fig. 5 provides a more formal classification of research themes based on their centrality (relevance to the field) and density (developmental maturity). There are four quadrants embedded with four themes. The first quadrant contains motor themes (high centrality, high density), featuring livelihoods in China, particularly in Xishuangbanna. Keywords like China and livelihoods indicate a mature and central body of research on socio-economic transformations linked to rubber expansion in Southwest China, focusing on household income changes, livelihood diversification, and the socio-economic consequences of land-use transitions, positioning this cluster as a driving force in the field. Moreover, contract farming is positioned close to this quadrant's boundary, indicating its increasing significance and incorporation into wider socio-economic discussions, while still showing moderate thematic progress.

The second quadrant (low centrality, high density) represents niche themes such as para rubber plantation, rubber farmer, and risk perception. These themes reflect specialised research on farmer-level decision-making, behavioural responses to risk, and plantation-specific contexts. Although methodologically mature, their limited prominence suggests they remain peripheral or secondary topics rather than being incorporated into the main socio-economic discourse.

The third quadrant (low centrality, low density), positioned in the lower-left, represents emerging or declining themes, including rubber plantation, jungle rubber, and smallholder livelihood. These themes suggest either emerging research interests that have yet to gain traction or declining topics that are losing prominence as research priorities shift. Given the continued relevance of smallholder livelihoods in policy and development debates, their positioning likely reflects conceptual fragmentation rather than declining importance, indicating opportunities for further integration into mainstream socio-economic analysis. In the same quadrant, another cluster near the boundary includes themes such as rubber production, Malaysia, and poverty, indicating partial thematic integration, where production-poverty linkages are examined separately rather than being incorporated into wider conceptual frameworks such as livelihood transformation, value chains, or market dynamics. By strengthening the links between production-oriented poverty research and more central socio-economic themes, the analytical coherence and policy relevance of this research area could be improved.

The fourth quadrant (high centrality and low density), located in the lower-right, contains basic themes and comprises three clusters. The first cluster includes natural rubber, Thailand, and the rubber price, highlighting the pivotal role of price fluctuations and market instability in socio-economic research on rubber farming. Despite their significance across various studies, these themes exhibit relatively low density, suggesting that the research is either fragmented or conceptually broad rather than deeply integrated. Similarly, the second cluster focuses on rubber intercropping and *Hevea brasiliensis* highlights the significance of diversifying farming systems to connect agronomic practices with socio-economic outcomes like income stability and risk reduction. Technical efficiency and rubber farming's positioning indicate productivity analysis as a foundational yet methodologically scattered aspect of the field.

In summary, the thematic map reveals a research domain centred on a few key themes focused on livelihoods and markets, with a notable concentration in Southeast Asia and Southwest China. While these central themes show high relevance, several foundational topics remain insufficiently consolidated, especially those concerning price dynamics, farming system diversification, and efficiency. The presence of niche and emerging themes suggests that the field is still in a state of growth, offering significant opportunities for theoretical integration and synthesis across themes. Additionally, themes that are not well-integrated, such as those related to rubber production, indicate areas of potential development rather than decline.

Integration of co-word and thematic findings

This section integrates co-word and thematic findings to understand the conceptual structure of socio-economic rubber farming research. The co-word analysis reveals relational linkages among frequently co-occurring concepts, while the thematic map contextualises these relationships by positioning themes by relevance and development. By considering both analyses together, one can gain a more comprehensive understanding of how thematic clusters operate within the wider research context.

In the co-word network, the livelihood-oriented cluster shows dense connectivity, confirmed by its motor theme placement in the thematic map, indicating strong influence. Moreover, in the co-word network, the keywords related to Xishuangbanna, China, land use, and rubber plantation clearly form a moderately connected cluster, positioned as motor themes with high centrality and development in the thematic map. Taken together, these findings suggest that land-use and plantation-focused studies in the Xishuangbanna context represent an influential, mature research stream, contributing substantively to the field without dominating its overall relational structure.

The foundational concepts, such as natural rubber, Thailand, and rubber price, demonstrate high connectivity in the co-word analysis but appear as basic themes in the thematic map, indicating conceptual fragmentation. This integration suggests that market dynamics and productivity concerns serve as essential reference points across studies but lack cohesive theoretical consolidation. Meanwhile, themes concerning rubber production, Malaysia, and poverty show weak connectivity in the co-word and appear as emerging or under-integrated themes in the thematic map, suggesting isolated research contexts rather than integrated into core conceptual frameworks.

The combined results indicate a field characterised by strong livelihood cores, fragmented foundational themes, and emerging research directions that are not well-connected.

Collaboration patterns: co-authorship analysis

Author collaboration network. Author collaboration networks map relationships between researchers through their joint publications, with authors as nodes and co-authorships as edges. The frequency and strength of these connections indicate collaboration intensity, making such networks a reliable way to study scientific cooperation [52]. Figure 6 illustrates the network map of collaboration, using authors as the unit of analysis. The network displays eight clusters. The dominant blue cluster (cluster two) is centred around Buncha Somboonsuke, whose large node size and multiple co-authorship links indicate a role as a major collaboration hub. This author is connected to many co-authors within its group, forming a dense local network. Authors in this group demonstrate high closeness centrality, indicating their proximity to the network's centre and their relatively short average path length to other researchers. Nonetheless, their betweenness centrality scores are moderate, implying that although they hold influence within their own community, they do not act as significant intermediaries between different research groups.

The pink cluster (cluster seven), centred around Hermann Waibel, represents a closely-knit but relatively isolated community. Its compact form and the few connections to other clusters align with low betweenness centrality values, suggesting that these authors mainly collaborate within their own circle. Nevertheless, their PageRank scores are moderate, indicating that despite their isolation, they work with relatively productive or well-connected individuals within their cluster.

A third significant group is the orange cluster (cluster five), headed by authors like Eric Penot and Fetrina Oktavia, which demonstrates strong internal collaboration but with limited external connections. This cluster includes other authors like Dwi Shinta Agustina, Lina Fatayati Syarif, Risal Ardika, Hajar Asywadi, and Andi Nur Cahyo, and exhibits low closeness and betweenness values, indicating its peripheral position in the network and tendency toward repeated collaborations with a consistent group.

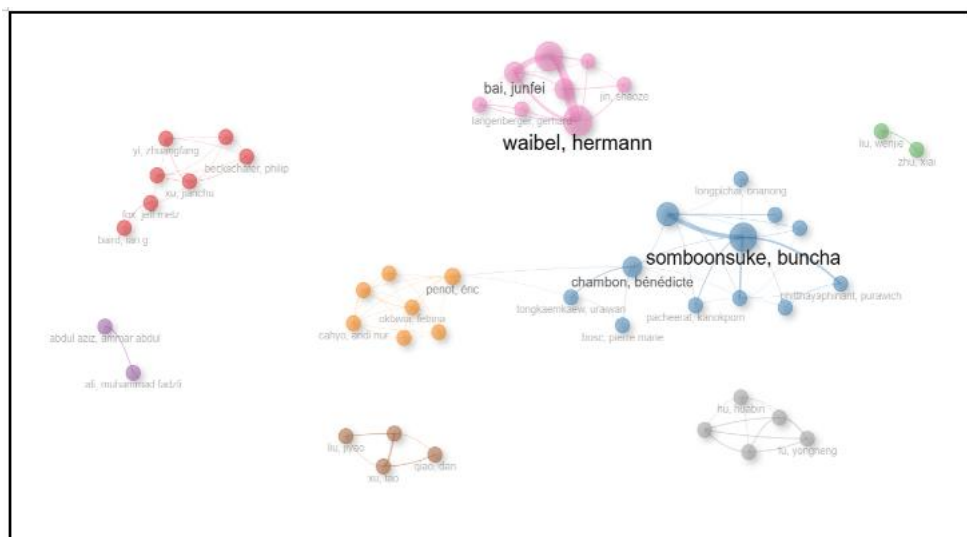


Fig. 6. Author co-authorship network in socio-economic rubber farming research

In addition, there are several smaller groups of two or three, such as the duo of Ammar Abdul Aziz and Muhammad Fadzli Ali from the purple cluster (cluster four), and the pair of Wenjie Liu and Xiaizhu from the green cluster (cluster three). These individuals are positioned on the fringes of the network. They exhibit limited connections beyond their direct co-authors, as indicated by their very low betweenness and PageRank scores. Their marginal position suggests that while they contribute to the field, their collaborative efforts are mostly detached from the main research communities. In conclusion, the network structure indicates that research in this area is marked by clustered collaboration rather than extensive, field-wide connectivity. In the analysis of collaboration networks, this is typically referred to as a clustered or

fragmented structure, where authors form close-knit intra-group communities with relatively few links bridging different groups across the broader field. This points to strong local or institutional collaboration but weak integration across the field, leading to knowledge and co-authorship circulating within subgroups rather than throughout the entire research domain [53, 54, 55]. While moderately central hubs facilitate within-cluster collaboration, low betweenness values across most authors suggest weak inter-group bridging.

Country collaboration network. The author collaboration network reveals micro-level research partnerships, while country collaboration networks demonstrate broader international cooperation patterns. These networks display research partnerships between nations through co-authorship, with countries serving as nodes and collaborative relationships represented as weighted edges [56, 57]. Fig. 7 displays a collaboration network focused on countries that exhibits a somewhat centralised but regionally clustered structure, reflecting research cooperation patterns in socio-economic rubber farming. In this network, the size of each node indicates a country's total participation in collaborative publications, while the edges signify co-authorship connections across national affiliations. The network depicts uneven international collaboration, with a few countries in dominant positions.

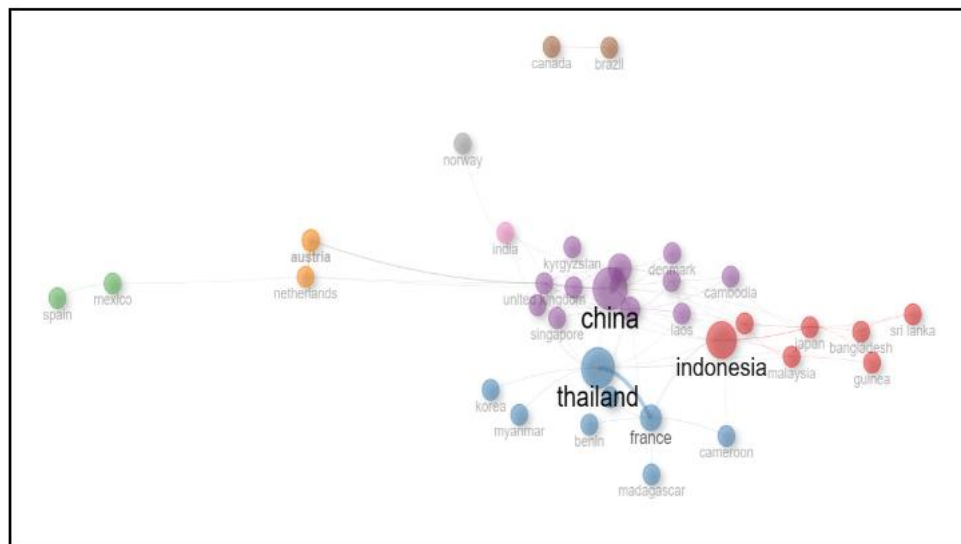


Fig. 7 Country collaboration network

China emerges as the largest and most central node in the purple cluster (cluster four), indicating high collaboration activity and extensive connectivity with multiple countries. The Biblioshiny report's metric profile indicates that China has high values for both closeness and PageRank, indicating strong embedding within the global collaboration structure. While China's betweenness centrality is moderate rather than exceptionally high, it plays a significant role in enhancing network cohesion by linking many neighbouring Asian countries.

The second major hub in the network is Thailand in the blue cluster (cluster two), collaborating with France, Myanmar, Korea, Benin and Madagascar. The dataset's relatively high closeness scores suggest that it is centrally located within the network, allowing it to connect with most countries in fewer steps compared to more peripheral nodes.

Another substantial collaboration node from the red cluster (cluster one) is Indonesia, which connects with Japan, Bangladesh, Sri Lanka, Guinea, Malaysia, and Cambodia. Unlike China and Thailand, Indonesia shows slightly stronger betweenness characteristics that bridge Southeast and South Asian research communities. The size and placement of its node suggest that it is not only productive but also plays a significant role in linking projects across multiple countries. Surrounding the main centres, a decentralised group comprising India, Singapore, and the UK acts as a meaningful secondary partner, connecting two distinct clusters. In contrast, countries like Canada and Brazil, along with Spain and Austria, form isolated peripheral pairs with low betweenness centrality, functioning independently from major collaboration networks.

The research landscape remains predominantly Asia-centric, with China, Thailand, and Indonesia serving as key regional hubs. Although there are limited cross-regional ties, a noticeable gap exists between these main centres and the scattered peripheral contributors, highlighting a lack of deep global integration in socio-economic studies on rubber farming.

In summary, the collaboration networks highlight concentrated yet uneven research partnerships at both the author and country levels, or in short, they are clustered. Among authors, collaboration is structured into distinct, tightly linked clusters with minimal connections between groups, suggesting that knowledge sharing mainly happens within rather than across research communities. On a country level, this pattern is magnified, with China, Thailand, and Indonesia serving as the central hubs of international collaboration, surrounded by smaller, more peripheral participants. These patterns suggest that socio-economic research on rubber farming is propelled by regionally embedded networks, characterised by strong intra-cluster cooperation but relatively weak or limited inter-cluster and cross-regional integration. Moreover, it also indicated that researchers who collaborate often focus on the same subjects, and it is uncommon for different topic groups to work together.

Conclusion And Limitation

While this study offers a thorough examination of socio-economic research on rubber farming, it is important to recognise several limitations. The analysis exclusively relies on Scopus data, which, despite its extensive coverage and robust citation indexing, omits certain regional journals, government documents, and non-English publications that might provide valuable socio-economic insights, especially from rubber-producing nations in Southeast Asia and Africa [58]. Another limitation is the dependence on bibliometric metadata, such as titles, abstracts, author keywords, and citation details, which means that the conceptual framework is derived from available keywords rather than an in-depth content analysis. The use of author keywords varies significantly across different journals and regions, potentially leading to conceptual fragmentation or the underrepresentation of specific themes. Similarly, co-word and thematic analyses rely on frequency thresholds that might overlook emerging but infrequent concepts. Additionally, collaboration networks are based on co-authorship, capturing formal collaborations but not informal partnerships, advisory roles, or cross-institutional influences that do not result in shared authorship [59]. Consequently, these networks depict structural collaboration rather than the complete range of scientific interactions. Moreover, publication and citation patterns are affected by time-lag effects, meaning that recent publications are less frequently cited and may be underrepresented in trend analyses. Furthermore, since this study was conducted before the end of 2025, incomplete indexing for the most recent year artificially reduces production counts for the current year.

Despite these constraints, this study offers a detailed bibliometric analysis of socio-economic research on rubber farming, highlighting its productivity trends, thematic framework, and collaborative dynamics from 2006 to 2025. The results indicate a consistent growth in the field, signifying increased academic interest. The study reveals significant depth in certain thematic and regional areas, though integration remains inconsistent. Moreover, the combined co-word and thematic analyses show that studies focused on livelihoods and land-use form the strategic core of the field, particularly in region-specific research settings like China and Southeast Asia. Additionally, collaboration patterns at both the author and country levels indicate that research networks are organised into cohesive clusters, with China, Thailand, and Indonesia acting as central hubs.

In conclusion, these results emphasise the need for greater thematic integration and stronger international collaboration to advance research in this area. By elucidating the structure and collaborative dynamics, this analysis offers a comprehensive and clear mapping of the field, laying a solid foundation for future studies and promoting more coordinated and effective research endeavours.

IMPLICATIONS AND CONTRIBUTIONS

The study explains the evolution of research themes and collaboration patterns by incorporating performance analysis, co-word analysis, thematic mapping, and collaboration networks. It contributes to the current body of literature by systematically charting the intellectual structure of socio-economic rubber farming research using bibliometric analysis methods. The results have important implications for future research by identifying conceptually developed areas, fragmented foundational themes, and under-integrated research streams. This structured overview can help researchers position new empirical studies and improve theoretical integration across research focused on livelihoods, markets, and production. Additionally, recognising clustered collaboration patterns highlights opportunities to expand cross-regional and interdisciplinary partnerships, potentially enhancing knowledge exchange and thematic consolidation within the field.

REFERENCES

1. Venkatachalam, P., Jayashree, R., Rekha, K., Sushmakumari, S., Sobha, S., Jayasree, P. K., Kala, R. G., & Thulaseedharan, A. (2006). Rubber Tree (*Hevea brasiliensis* Muell. Arg). In K. Wang (Ed.), *Agrobacterium Protocols Volume 2* (pp. 153–164). Humana Press. <https://doi.org/10.1385/1-59745-131-2:153>
2. Rodríguez Urbina, J. C., Osswald, T. A., Estela García, J. E., & Román, A. J. (2023). Environmentally safe preservation and stabilization of natural rubber latex in an acidic environment. *SPE Polymers*, 4(3), 93–104. <https://doi.org/10.1002/pls2.10089>
3. Warren-Thomas, E., Dolman, P. M., & Edwards, D. P. (2015). Increasing Demand for Natural Rubber Necessitates a Robust Sustainability Initiative to Mitigate Impacts on Tropical Biodiversity. *Conservation Letters*, 8(4), 230–241. <https://doi.org/10.1111/conl.12170>
4. Noordwijk, M. eine van, Boutin, D., Wibawa, G., Beukema, H. J. (Rien), & Joshi, L. (2002). Options for smallholder rubber producers to increase productivity while maintaining 'forest functions'. <https://www.cifor-icraf.org/publications/downloads/Publications/PDFS/RP02063.pdf>
5. Uwumarongie, A. M. D., Emuedo, O. A., Uzunuigbe, E. O., Omorogbe, J. A., Ugiagbe-Ekue, U., Research Operations Department, Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria., Chukwuka, A. N., Research Operations Department, Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria., Aghedo, S. O., Research Operations Department, Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria., Momoh, R. L., Research Operations Department, Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria. Research Outreach Department, Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria, Musa, S. O., Research Outreach Department, Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria, Fashoranti, F. M., Research Operations Department, Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria., Idahosa, E. O., & Research Outreach Department, Research Institute of Nigeria, Iyanomo. P.M.B 1049, Edo State, Nigeria. (2025). SMALL-SCALE RUBBER FARMERS AND THEIR RELEVANCE TO RUBBER PRODUCTION IN NIGERIA: A COMPREHENSIVE REVIEW. *Greener Journal of Agricultural Sciences*, 15(1), 8–11. <https://doi.org/10.15580/GJAS.2025.1.011525007>

6. Thongyou, M. (2014). Rubber Cash Crop and Changes in Livelihoods Strategies in a Village in Northeastern Thailand. *Asian Social Science*, 10(13), p239. <https://doi.org/10.5539/ass.v10n13p239>
7. Jayathilake, H. M., De La Porte, C., Chang, J. W. J., Edwards, D. P., & Carrasco, L. R. (2023). Transnational evidence for socio-economic factors affecting income and plantation expansion into natural habitats in smallholder rubber. *Resources, Conservation & Recycling Advances*, 18, 200161. <https://doi.org/10.1016/j.rcradv.2023.200161>
8. Luo, Y., Min, S., & Bai, J. (2021). The role of rubber farming in household dietary diversity in the upper Mekong region, Southwest China. *Food and Energy Security*, 10(3), e285. <https://doi.org/10.1002/fes3.285>
9. Khaswarina, S., Sucherly, Kaltum, U., & Ariawaty, R. R. N. (2023). The Efficiency of Smallholder Rubber Plantations and the Factors That Influence It: A Case Study in Indonesia. *International Journal of Design & Nature and Ecodynamics*, 18(2), 261–267. <https://doi.org/10.18280/ij dne.180203>
10. Wee, S. M., Wee, J., & Singaravelloo, K. (2018). INCOME TARGETS AND POVERTY OF RUBBER SMALLHOLDERS IN FOUR STATES OF MALAYSIA. <https://pdfs.semanticscholar.org/0d39/582176ab574ac73cab72bbfbfd0b1bb20b08.pdf>
11. Khin, A. A., Leh Bin, R. L., Keong, O. C., Win Yie, F., & Liang, N. J. (2019). CRITICAL FACTORS OF THE NATURAL RUBBER PRICE INSTABILITY IN THE WORLD MARKET. *Humanities & Social Sciences Reviews*, 7(1), 199–208. <https://doi.org/10.18510/hssr.2019.7124>
12. Kumar, K. A., Pinto, P., Hawaldar, I. T., Spulbar, C., & Birau, R. (2021). Crude oil futures to manage the price risk of natural rubber: Empirical evidence from India. *Agricultural Economics (Zemědělská Ekonomika)*, 67(10), 423–434. <https://doi.org/10.17221/28/2021-AGRICECON>
13. Chawananon, C. (2014). FACTORS AFFECTING THE THAI NATURAL RUBBER MARKET EQUILIBRIUM: DEMAND AND SUPPLY RESPONSE ANALYSIS USING TWO-STAGE LEAST SQUARES APPROACH [California Polytechnic State University]. <https://doi.org/10.15368/theses.2014.65>
14. Irwan, I., & Oktarin, E. S. (2024). Rural Community Income from Rubber Farmers to Gold Miners in Nagari Padang Laweh, Koto VII Sijunjung District. *Jurnal Pendidikan Sosiologi Dan Humaniora*, 15(1), 113. <https://doi.org/10.26418/j-psh.v15i1.74767>
15. Yuliadi, I., & Meilita, Y. (2023). Determinants of Rubber Farming Household Consumption A Case Study of Musi Rawas Regency, South Sumatera Province. *E3S Web of Conferences*, 444, 02020. <https://doi.org/10.1051/e3sconf/202344402020>
16. Vijayan, D., Girindran, R., Sam, A. S., Sathyan, A. R., & Kaechele, H. (2024). The large-scale expansion of rubber plantations in southern India: Major impacts and the changing nature of drivers. *Environmental Monitoring and Assessment*, 196(4), 356. <https://doi.org/10.1007/s10661-024-12517-1>
17. M., K.-L., & G., W. (2016). Challenges and opportunities for sustainable rubber in the Lao People's Democratic Republic. Center for International Forestry Research (CIFOR). <https://doi.org/10.17528/cifor/006244>
18. Neyret, M., Robain, H., De Rouw, A., Soulileuth, B., Trisophon, K., Jumba, K., & Valentin, C. (2018). The transition from arable lands to rubber tree plantations in northern Thailand impacts weed assemblages and soil physical properties. *Soil Use and Management*, 34(3), 404–417. <https://doi.org/10.1111/sum.12431>
19. Somboonsuke, B., Pacheerat, K., & Wettayaprasit, P. (n.d.). A Socio-economic Simulation of Rubber Smallholding Systems: A Case Study of Phatthalung and Songkhla Provinces in Southern Thailand. Vo 1.
20. Yamin, M., Tafari, M. F., & Andelia, S. R. (2023). The Comparison of Household Economic Level from Conventional to Organic Rubber Farming farming to support Sustainable Development in Agriculture. *BIO Web of Conferences*, 69, 04009. <https://doi.org/10.1051/bioconf/20236904009>
21. Zusmelia, Z., Irwan, I., Amelia, A., & Virginia, D. (2022). Strategies For Strengthening Social Capital In Rubber Farming Communities In Facing Disaster In Lake Village, Nalo Tantan District. *International Journal of Educational Research & Social Sciences*, 3(5), 2078–2082. <https://doi.org/10.51601/ijersc.v3i5.440>
22. Liu, W., Hu, H., Ma, Y., & Li, H. (2006). Environmental and Socioeconomic Impacts of Increasing Rubber Plantations in Menglun Township, Southwest China. *Mountain Research and Development*, 26(3), 245–253. [https://doi.org/10.1659/0276-4741\(2006\)26%255B245:EASIOI%255D2.0.CO;2](https://doi.org/10.1659/0276-4741(2006)26%255B245:EASIOI%255D2.0.CO;2)
23. Binitha, M. (n.d.). A Study on Socio-Economic Condition of Rubber Plantation Labourers in Kanyakumari District.
24. Bhowmik, I. (2018). Social and Economic Conditions of Rubber Stakeholders. 5(4).
25. Andriesse, E. (2019). The Philippines: Fragmented Agriculture, Aquaculture, and Vulnerable Livelihoods. In J. Digby Rigg, J. Gillen, & E. Thompson (Eds.), *Asian Smallholders in Comparative Perspective* (1st ed., pp. 181–212). Amsterdam University Press. <https://doi.org/10.1017/9789048540204.008>
26. Leemann, E., & Tusing, C. (2024). Indigenous collective land titling and the creation of leftovers: Insights from Paraguay and Cambodia. *Journal of Agrarian Change*, 24(1), e12561. <https://doi.org/10.1111/joac.12561>
27. Liu, H., Zhang, H., Xu, Y., & Xue, Y. (2024). Decision-Making Mechanism of Farmers in Land Transfer Processes Based on Sustainable Livelihood Analysis Framework: A Study in Rural China. *Land*, 13(5), 640. <https://doi.org/10.3390/land13050640>
28. Trisurat, Y., Shirakawa, H., & Johnston, J. M. (2019). Land-Use/Land-Cover Change from Socio-Economic Drivers and Their Impact on Biodiversity in Nan Province, Thailand. *Sustainability*, 11(3), 649. <https://doi.org/10.3390/su11030649>
29. Xu, J., Lebel, L., & Sturgeon, J. (2009). Functional Links Between Biodiversity, Livelihoods, and Culture in a Hani Swidden Landscape in Southwest China. *Ecology and Society*, 14(2), art20. <https://doi.org/10.5751/ES-02916-140220>
30. Xu, H., Chen, Y., Chen, B., Mansaray, L. R., Lu, D., & Wang, S. (2025). A new framework for mapping rubber plantations through the combination of semiautomatic sample migration, dynamic phenology, and change detection

- variables based on time series Landsat images. *GIScience & Remote Sensing*, 62(1), 2587939. <https://doi.org/10.1080/15481603.2025.2587939>
31. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
 32. Yermukhanova, L., Kuzembayev, M., Salkhanova, A., Narymbayeva, N., Tazhiyeva, A., Makhanbetkulova, D. N., & Afshar, A. (2025). Exploring socio-economic dimensions in HIV research: A comprehensive bibliometric analysis (1992–2024). *Global Health Action*, 18(1), 2474787. <https://doi.org/10.1080/16549716.2025.2474787>
 33. Öztürk, O., Kocaman, R., & Kanbach, D. K. (2024). How to design bibliometric research: An overview and a framework proposal. *Review of Managerial Science*, 18(11), 3333–3361. <https://doi.org/10.1007/s11846-024-00738-0>
 34. Passas, I. (2024). Bibliometric Analysis: The Main Steps. *Encyclopedia*, 4(2), 1014–1025. <https://doi.org/10.3390/encyclopedia4020065>
 35. Elsevier. (2025). Scopus content [Dataset]. <https://www.elsevier.com/products/scopus/content>
 36. Boolean operators, search function results and wildcard searches. (n.d.). Springer Nature Support. Retrieved December 15, 2025, from <https://support.springernature.com/en/support/solutions/articles/6000079741-boolean-operators-search-function-results-and-wildcard-searches>
 37. Rau, J. L. (2004). Searching the literature and selecting the right references. *Respiratory Care*, 49(10), 1242–1245.
 38. Atkinson, L. Z., & Cipriani, A. (2018). How to carry out a literature search for a systematic review: A practical guide. *BJPsych Advances*, 24(2), 74–82. <https://doi.org/10.1192/bja.2017.3>
 39. PRISMA statement. (n.d.). PRISMA Statement. Retrieved December 15, 2025, from <https://www.prisma-statement.org>
 40. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. <https://doi.org/10.1136/bmj.n71>
 41. PRISMA 2020 flow diagram. (n.d.). PRISMA Statement. Retrieved December 15, 2025, from <https://www.prisma-statement.org/prisma-2020-flow-diagram>
 42. McCrae, N., Blackstock, M., & Purssell, E. (2015). Eligibility criteria in systematic reviews: A methodological review. *International Journal of Nursing Studies*, 52(7), 1269–1276. <https://doi.org/10.1016/j.ijnurstu.2015.02.002>
 43. Brennan, E. (n.d.). Guides: Systematic Reviews: Inclusion/Exclusion Criteria. Retrieved December 16, 2025, from <https://musc.libguides.com/systematicreviews/eligibilitycriteria>
 44. Ayala, A. P. (n.d.). Research Guides: Knowledge syntheses: Systematic & Scoping Reviews, and other review types: Eligibility Criteria. Retrieved December 16, 2025, from <https://guides.library.utoronto.ca/systematicreviews/eligibilitycriteria>
 45. Cucari, N., Tutore, I., Montera, R., & Profita, S. (2023). A bibliometric performance analysis of publication productivity in the corporate social responsibility field: Outcomes of SciVal analytics. *Corporate Social Responsibility and Environmental Management*, 30(1), 1–16. <https://doi.org/10.1002/csr.2346>
 46. Cvetkoska, V., & Eftimov, L. (2021). Bibliometric analysis for performance measurement in business, management and accounting subject area. *Journal of Engineering Management and Competitiveness*, 11(1), 51–63. <https://doi.org/10.5937/jemc2101051C>
 47. Abramo, G. (2017). Bibliometric evaluation of research performance: Where do we stand? *Voprosy Obrazovaniya / Educational Studies Moscow*, 1, 112–127. <https://doi.org/10.17323/1814-9545-2017-1-112-127>
 48. Baghini, M. S., Mohammadi, M., & Norouzhkhani, N. (2024). Usability Testing: A Bibliometric Analysis Based on WoS Data. *Journal of Scientometric Research*, 13(1), 09–24. <https://doi.org/10.5530/jscires.13.1.2>
 49. Sweileh, W. M., Al-Jabi, S. W., Sawalha, A. F., AbuTaha, A. S., & Zyoud, S. H. (2017). Bibliometric Analysis of Worldwide Publications on Antimalarial Drug Resistance (2006–2015). *Malaria Research and Treatment*, 2017, 1–13. <https://doi.org/10.1155/2017/6429410>
 50. Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *Journal of informetrics*, 5(1), 146–166.
 51. Wijaya, A., Setiawan, N. A., & Shapi'ai, M. I. (2023). Mapping Research Themes and Future Directions in Learning Style Detection Research: A Bibliometric and Content Analysis. *Electronic Journal of E-Learning*, 21(4), 274–285. <https://doi.org/10.34190/ejel.21.4.3097>
 52. Newman, M. E. J. (2004). Coauthorship networks and patterns of scientific collaboration. *Proceedings of the National Academy of Sciences*, 101(suppl_1), 5200–5205. <https://doi.org/10.1073/pnas.0307545100>
 53. Waltman, L., Van Eck, N. J., & Noyons, E. C. M. (2010). A unified approach to mapping and clustering of bibliometric networks. *Journal of Informetrics*, 4(4), 629–635. <https://doi.org/10.1016/j.joi.2010.07.002>
 54. Glynatsi, N. E., & Knight, V. A. (2021). A bibliometric study of research topics, collaboration, and centrality in the iterated prisoner's dilemma. *Humanities and Social Sciences Communications*, 8(1), 45. <https://doi.org/10.1057/s41599-021-00718-9>
 55. Wrigley, J., Carden, V., & Von Isenburg, M. (2019). Bibliometric mapping for current and potential collaboration detection. *Journal of the Medical Library Association*, 107(4). <https://doi.org/10.5195/jmla.2019.764>
 56. Alshammari, M., Alnassry, S., Qaladi, O., Mohamedsalih, W., Mamanao, D., & Mohamed, S. (2024). Mapping collaboration networks in community health nursing research: A bibliometric analysis. *Rawal Medical Journal*, 49(1), 204. <https://doi.org/10.5455/rmj.20230830062226>

57. Maral, M. (2024). A bibliometric analysis of global research on education in the Scopus database, 2013–2022. *Global Knowledge, Memory and Communication*. <https://doi.org/10.1108/GKMC-01-2024-0039>
58. Sony, A., Anjum, M. I., Yadav, P., & Rajshree. (2025). Best Practices in Bibliometric Analysis: A Critical Review. *European Economic Letters*. <https://doi.org/10.52783/eel.v15i1.2509>
59. Marcelin, R. A., Rabarison, K. M., & Rabarison, M. K. (2019). Co-Authorship Network Analysis of Prevention Research Centers: An Exploratory Study. *Public Health Reports*, 134(3), 249–254. <https://doi.org/10.1177/0033354919834589>